वार्षिक प्रतिवेदन
annual report

2003-04

राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली
NATIONAL PHYSICAL LABORATORY, NEW DELHI

CONTENTS

प्राक्कथन

मुझे राष्ट्रीय भौतिक प्रयोगशाला की वार्षिक रिपोर्ट वर्ष 2003–2004 को प्रस्तुत करते हुए हर्ष हो रहा है। इस अवधि के दौरान एन.पी.एल. में किए गए कार्य को प्रस्तुत किया गया है।

एन.पी.एल. के घोषणा पत्र के अनुसार और जैसा कि माप एवं तौल अधिनियम 1956 के कानून के अन्तर्गत प्रावधान किया गया है व संसद के अधिनियम 1976 के अन्तर्गत वर्ष 1998 में पुनः जारी किया गया, एन पी एल की भौतिक माप के मानकों की अपग्रेडिंग और सुरक्षित रखने का वैधानिक उत्तरदायित्व है। राष्ट्रीय भौतिक प्रयोगशाला भारत को राष्ट्रीय माप पद्धति संस्थान के रूप में मान्यता प्राप्त है। यह माप एवं तौल के अन्तर्राष्ट्रीय ब्यूरो (बी आई पी एम) और परस्पर अभिज्ञान अनुबंध (एम आर ए) का हस्ताक्षरकर्त्ता (सिग्नेटरी) है। इसलिए इस प्रयोगशाला को अन्तर्राष्ट्रीय तुलना में भाग लेते हुए इसके माप मानकों की अन्तर्राष्ट्रीय तुल्यता को बनाए रखना होता है। देश के इस परस्पर अभिज्ञान अनुबंध (MRA) की महत्वपूर्ण सार्थकता यह है कि एन पी एल द्वारा जारी अंशांकन प्रमाण पत्रोंको सभी ऐसे देशों, जिनमें एन पी एल, अनुमार्गणीयता (Traceability) मुहैया कराती है, से स्वतः स्वीकृति मिल जाती है। प्रयोगशाला में माप मानकों, इंजीनियरिंग पदार्थों, इलैक्ट्रोनिक पदार्थों, पदार्थ अभिलक्षणन, रेडियो एवं वायुमण्डलीय विज्ञान और अतिचालकता एवं निम्नतापिकी में अग्रगत अनुसंधान भी किया जाता है।

वर्ष के दौरान द्रव्यमान, आयतन और सघनता, प्रकाशीय विकिरण, दाब, जोसेफसन वोल्टेज, डी सी वोल्टेज धारा व प्रतिरोध, ए सी पावर एवं ऊर्जा, एल एफ प्रतिबाधा, एल एफ वोल्टेज व धारा, आर एफ वोल्टेज एवं पावर, आर एफ तनुकरण व प्रतिबाधा के क्षेत्र में एन पी एल की मापन क्षमताओं को अन्तर्राष्ट्रीय तकनीकी विशेषज्ञों द्वारा बी आई. पी. एम. एम. (BIPM) एम. आर. ए. के (MRA) परिशिष्ट 'सी' में समावेश करने के लिए बराबर पुनरीक्षण किए गए। एन पी एल ने दाब एवं वैक्यूम, ताप एवं द्रव्यमान के लिए मापन मानक की अन्तर्राष्ट्रीय अन्तर्तुलना में भी भाग लिया था।

वर्ष के दौरान एन पी एल ने अपने मानकों एवं अंशांकन सुविधाओं को उन्नत किया। क्वांटम हाल प्रतिरोध मानक को स्थापित किया गया और नए स्वचालित गेज ब्लॉक व्यतिकरणमापी को लम्बाई एवं विमा में जोड़ा गया, उसके द्वारा 305 तक गेज ब्लॉक के व्यतिकरणमापी अंशांकन हेतु मापन क्षमताओं को उन्नत किया। एन पी एल ने विभिन्न संगठनों को अंशांकन परीक्षण, पदार्थों के अभिलक्षणन एवं तकनीकी परामर्श के रूप में सेवाएं प्रदान की। एन पी एल ने बी आई एस, एन ए बी एल ट्राय (TRAI) को (अपने वैज्ञानिकों को उनके तकनीकी समितियों, तकनीकी मूल्यांकन आदि में भागीदारी के माध्यम से) तकनीकी सहायता प्रदान की एन पी एल ने एन ए बी एल (NABL) अधिकश्त प्रयोगशालाओं के लिए एन ए बी एल और विज्ञान एवं प्रौद्योगिकी विभाग द्वारा निधि बद्ध (funded) दक्षता परीक्षण कार्यक्रम में भी मिलकर काम किया।

एन पी एल विभिन्न क्षेत्रों के लिए विशिष्ट पदार्थ विकसित करने में सतत् प्रयासरत है। इट्रियम सहित एम जी मिश्र धातु के स्प्रे से बने ब्लॉक की आपूर्ति परीक्षण एवं मूल्यांकन के लिए वी एस एस सी को की गयी थी। एन पी एल ने Mg मिश्र धातु के लिए एक्स्ट्रूजन प्रौद्योगिकी के विकास हेतु जनरल मोटर्स (यू एस ए) के साथ एम ओ यू (MoU) पर हस्ताक्षर किए।

एन पी एल के एक संशोधित $PbZrO_3$ पदार्थ (NPL ZT:5H) विकसित किया है जो डिटेक्टर एवं रिसीवर अनुप्रयोगों के लिए उच्च डाई–इलैक्ट्रिक पर्मिटिविटी व चार्ज कॉनस्टेंट युक्त है। एन पी एल ने स्टेनलैस स्टील आवरण में एक 'अकाउस्टिक एमिशन सेंसर्स, एन पी एल, ए ई को भी डिजाइन एवं विकसित किया है।

Foreword

It is my pleasure to present the Annual report of NPL for the year 2003-2004. It presents the work done by NPL during the period..

As per the NPL charter and as provided under the Legislations of Weights and Measures Act 1956, reissued in 1998 under the 1976 Act of the Parliament, NPL has the statutory responsibility of maintaining and upgrading the standards of physical measurements. As such NPL is recognized as the National Metrology Institute of India. It is the signatory of International Bureau of Weights and Measures (BIPM) and of the Mutual Recognition Agreement (MRA). It has to therefore maintain international equivalence of its measurement standards by participating in international comparisons. The important significance of this MRA to the country is that calibration certificates issued by NPL would automatically get recognition by all such countries wherein NPL provides traceability. The laboratory also carries out advance research in measurement standards, engineering materials, electronic materials, materials characterization, radio and atmospheric sciences, and superconductivity & cryogenics.

During the year measurement capabilities of NPL in fields of mass, volume, and density, optical radiations, pressure, Josephson Voltage, DC Voltage current & resistance, AC power and energy LF impedence, LF Voltage and current, RF voltage and power, RF attenuation and Impedence were peer reviewed by international technical experts for their inclusion in Appendix C of BIPM -MRA. NPL also participated in international intercomparison of measurement standards for pressure and vacuum, temperature and mass.

During the year NPL upgraded its standards and calibration facilities. Quantum Hall Resistance Standard was established and new automatic guage block interferometer was added at length and dimension standard, upgrading thereby the measurement capability for interferometric calibration of Gauge Blocks upto 305 mm. NPL provided services to various organizations in form of calibration testing, material characterization and technical consultancy. NPL provided technical support to BIS and NABL and TRAI (through participation of its scientists in their technical committees, technical assessments etc). NPL also coordinated proficiency testing programme funded by NABL and DST for NABL accredited laboratories.

NPL continued its efforts in developing special materials for various sectors. Spray formed blocks of Mg – Alloy with Yttrium were supplied to VSSC for testing and evaluation. NPL signed MoU with General Motors (USA) for development of Extrusion Technology for Mg Alloy.

NPL has developed a modified $PbZrO_3$ material (NPLZT-5H) possessing high dielectric permittivity and charge constant for detector and receiver applications. It also designed and developed an acoustic emission sensors, NPL AE, in stainless steel casing.

NPL participated in first of its kind nationwide road campaign for study of aerosols levels contributed by traffic on national highways. Besides, some very interesting results have been obtained from magnetic storm studies based on data received from SROSS-C2 and AE-series Satellites. A PC based system was designed and developed for automatic measurement of temperature and humidity vertical profiles for fog studies.

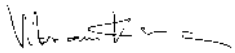
Foreword

NPL contributed to human resource development in various areas by providing facilities to students for project work and training. During the year several students from reputed academic institutions carried out their project work for B.Tech ./M.Sc./ M.Tech. programmes, and some of the students worked for their Ph.D programme/ Postgraduate programme. Training courses were organized for participants from industry and various others organizations.

The laboratory erected a new entrance gate for regulating entry to its premises from Dr K.S. Krishnan Marg. The new gate has an imposing structure especially designed to meeting its functionally requirements.

The laboratory published a total of 175 papers of which majority were in SCI-Indexed Journals. Besides 234 papers were presented at various national and international conferences. The list at Appendix-1 includes those papers published in conference proceedings. Emphasis was also given to present scientific papers in Hindi. A total of 6 patents were filed in India and abroad . 4 patent filed abroad during previous years were granted in this year. The laboratory took up 16 new sponsored projects and generated a sum of Rs. 253.74 lakhs.

It gives me pleasure to acknowledge the contributions of NPL scientists, engineers, and of staff from administration, finance, accounts, stores and purchase, of the supporting staff and the infrastructure services staff for making several notable contributions and achievements. I also acknowledge with great pleasure the contributions made by the publication committees and publication group in bringing out this report. In particular the efforts made in this regard by Dr S. M. Dhawan, Sh. S. K. Chakladar, Dr. S. K. Gupta, Dr. M. K. Goel, Dr. Ravi Mehrortra, Dr. V. N. Ojha, Dr.(Ms.) P.L Upadhyay, Dr. T. D. Senguttuvan, Dr. (Mrs.) Rina Sharma, Dr.(Mrs.) S. Sharma and group, Sh. Sudhanshu Dwivedi, Sh. N.K. Wadhwa and Sh. V. D. Arora are highly appreciated.



(Vikram Kumar)
Director

Preamble

The National Physical Laboratory is one of the earliest national laboratories set up under the Council of Scientific & Industrial Research. Late Shri Jawaharlal Nehru laid the foundation stone of NPL on the 4th January 1947. Late Dr. K. S. Krishnan, FRS, was the first Director of the laboratory. The main building of the laboratory was formally opened by Late Deputy Prime Minister, Sardar Vallabhbhai Patel on the 21st January 1950. The Silver Jubilee Celebration of the Laboratory was inaugurated by Late Prime Minister, Shrimati Indira Gandhi, on 23rd December 1975.

CHARTER

The main aim of the laboratory is to strengthen and advance physics-based research and development for the overall development of science and technology in the country. In particular its objectives are:

- To establish, maintain and improve continuously by research, for the benefit of the nation, National Standards of Measurements and to realize the Units based on International System (Under the subordinate Legislations of Weights and Measures Act 1956, reissued in 1988 under the 1976 Act).

- To identify and conduct after due consideration, research in areas of physics which are most appropriate to the needs of the nation and for advancement of field

- To assist industries, national and other agencies in their developmental tasks by precision measurements, calibration, development of devices, processes, and other allied problems related to physics.

- To keep itself informed of and study critically the status of physics.

CUSTODIAN OF NATIONAL STANDARDS OF MEASUREMENT

National Physical Laboratory has the responsibility of realizing the units of physical measurements based on the International System (SI units) under the subordinate legislations of Weights & Measures Act 1956 (reissued in 1988 under the 1976 Act). NPL also has the statutory obligation to establish, maintain and update the national standards of measurement & calibration facilities for different parameters. The Seven SI base units are metre, kilogramme, second, kelvin, ampere candela, mole (mol) and the SI supplementary units are radian (rad) & steradian (sr). The other derived units for physical measurement that the laboratory currently maintains are: force, pressure, vacuum, luminous flux, sound pressure, ultrasonic power & pressure and the units for electrical and electronic parameters viz., dc voltage; resistance; current and power; ac voltage; current and power; low frequency voltage; impedance and power; high frequency voltage; power; impedance; attenuation and noise; microwave power; frequency. impedance; and attenuation and noise.

NATIONAL APEX BODY FOR CALIBRATION

The laboratory provides apex level calibration services in the country; offering National Accreditation Board for Testing and Calibration Laboratories (NABL), the national accreditation body in the country (i) its qualified assessors

as needed for establishing best measurement capability of the applicant laboratory; in particular its scientific, (ii) its technical input to enable NABL to decide the suitability of the applicant laboratory for accreditation, and (iii) its faculty to train testing laboratories for estimation of uncertainty in their measurements.

Besides, the laboratory is engaged in developing Certified Reference Materials to ensure high quality measurement and traceability of analytical measurements to national/international measurement system (SI unit) in order to fulfill the mandatory requirement of quality systems (ISO/IEC guide 17025) and of the NABL.

R&D ACTIVITIES

In the pursuit of its chartered objectives, the laboratory undertakes sponsored projects, consultancy assignments, and in-house research projects in areas such as physical measurement standards, engineering materials, electronic materials, soft and polymer materials, materials characterization, radio and atmospheric sciences, and cryogenics and superconductivity.

ORGANIZATION AND MANAGEMENT

The laboratory has structured its total activities under seven scientific decision units. These are: (i) Physico-mechanical standards, (ii) Electrical and electronic standards, (iii) Engineering materials, (iv) Electronic materials, (v) Materials characterization, (vi) Radio and atmospheric sciences, and (vii) Cryogenics and superconductivity.

In addition, it has set up nine support units for its organization and management. These are: (i) Director's office, (ii) Administration & house keeping, (iii) Finance & accounts, (iv) Store & Purchase, (v) Library, (vi) Scientific support service, (vii) Technical support service, (viii) Workshop, (ix) Computer centre.

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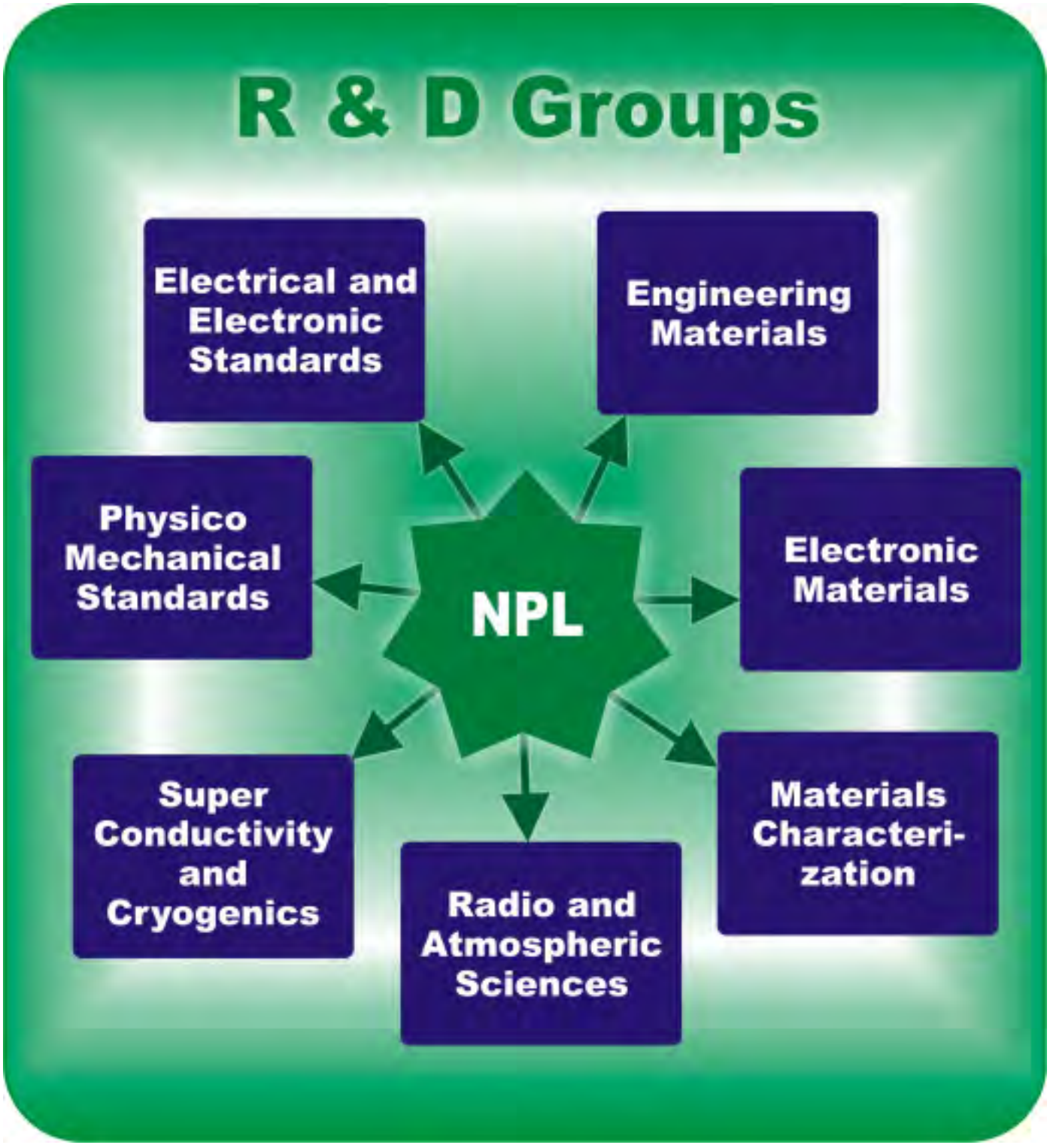

R & D Groups
Electrical and Electronic Standards
Engineering Materials
Physico Mechanical Standards
NPL
Electronic Materials
Super Conductivity and Cryogenics
Radio and Atmospheric Sciences
Materials Characteri-zation

भौतिक – यांत्रिक मानक

PHYSICO-MECHANICAL STANDARDS

भौतिक – यांत्रिक मानक

राष्ट्रीय भौतिक प्रयोगशाला का यह एक प्रमुख प्रभाग है जिसका मुख्य लक्ष्य विभिन्न प्राथमिक/द्वितीयक भौतिक प्राचलों का अनुरक्षण व भारतीय औद्योगिकी को मापन और परामर्श सेवाएं उपलब्ध कराना है। इसके अन्तर्गत द्रव्यमान (आयतन, श्यानता और घनत्व), लंबाई और विमीय मापिकी, ताप, प्रकाशीय विकिरण (दृश्य, परा–बैंगनी व अवरक्त प्रक्षेत्र), बल व कठोरता, दाब (गैस–यांत्रिकी, द्रवचालित तथा निर्वात क्षेत्र में) ध्वनिक, पराश्रव्यिकी, तरल प्रवाह, आर्द्रता, प्रघाती एवम् कंपनिक और प्रकाशीय पैरामीटरों का मापन किया जाता है। इस प्रभाग के निम्नलिखित उत्तरदायित्व है :–

- भौतिक विज्ञान के क्षेत्र में अनुसंधान व विकास
- सभी भौतिक यांत्रिक मानकों का स्थापन, अनुरक्षण और निरन्तर सुधार
- औद्योगिक संस्थान, निजी और सार्वजनिक क्षेत्र के उपक्रम और रक्षा संस्थानों को आंशांकन सेवाएँ उपलब्ध कराना
- नये भौतिक मानको, मापन विधियों और आँकड़ों का परिवर्धन
- जानकारी का सश्जन और उद्योगों तथा संस्थानों के कर्मचारियों को एनएबीएल (NABL) व आई एस ओ प्रमाणीकरण के विषय में प्रशिक्षण देना
- प्रचार कार्यक्रमों का संचालन तथा प्रभावी औद्योगिक सहयोग द्वारा आविष्कारों और शोधो का व्यापारीकरण

वर्ष 2003–2004 में इस प्रभाग ने 2714 अंशांकन और परीक्षण किए और 18398934/– रूपयों की बाहय नकद राशि अर्जित की। इसके अतिरिक्त विभाग ने परामर्श सेवाओं, प्रशिक्षण कार्यक्रमों और बाहरी परियोजनाओं द्वारा भी धन उपार्जित किया है।

वैज्ञानिकों द्वारा अपनी सर्वोत्तम क्षमताओं के अनुरक्षण के प्रयास में विभिन्न राष्ट्रीय व अन्तर्राष्ट्रीय सम्मेलनों/संगोष्ठियों/सेमीनारों में भाग लेते हैं और अपने विषय पर महत्वपूर्ण आमंत्रित व्याख्यान, प्रशिक्षण पाठयक्रमों और कार्यशालाओं के आयोजनो द्वारा जानकारी भी उपलब्ध कराते हैं। वैज्ञानिक अपने विषयों पर अनुंसंधान और विकास कार्य में भी संलग्न रहते हैं। जिसके विषय में विस्तश्त जानकारी आगामी पन्नों पर क्रमशः दी गई है।

इस प्रकार राष्ट्रीय भौतिक प्रयोगशाला, मानकीकरण कार्य के कारण राष्ट्र के एनएबीएल (राष्ट्रीय प्रशिक्षण और अंशांकन) प्रत्यायन बोर्ड की सहायता कर रहा है।

एनएबीएल एम ओ यू (समझौते) के अन्तर्गत प्रशिक्षित निर्धारकों द्वारा जागरूकता और प्रशिक्षण पाठयक्रमों का आयोजन इत्यादि भी किया गया है। इस प्रभाग के वैज्ञानिकों की एनएबीएल की प्रत्यायन और तकनीकी समितियों और ब्यूरों ऑफ इंडियन स्टैण्डर्डस की तकनीकी कमेटियों में महत्वपूर्ण भूमिका है।

वर्ष 2003–2004 के दौरान, द्रव्यमान, आयतन और घनत्व, प्रकाशीय विकिरण तथा दाब और निर्वात मानको की मापन क्षमतओं का पिअर पुनःअवलोकन हुआ और 24 सीएमसी को बीआईपीएम की डाटाबेस परिशिष्ट में सम्मिलित किया गया है।

PHYSICO-MECHANICAL STANDARDS

This division is one of the major operating units of the National Physical Laboratory. Its mission is to maintain primary/secondary standards of various physical parameters and to support Indian industry by providing measurement and consultancy services for Mass (including volume, viscosity and density), Length and Dimensional Metrology, Temperature, Optical Radiation (visible, ultra violet, infrared region), Force and Hardness, Pressure (pneumatic, hydraulic and vacuum region), Acoustics, Ultrasonics, Fluid Flow, Humidity, Shock and vibrations and Optical measurements. The responsibility of this division include :-

- Research and development in the physical sciences;
- Establish, maintain and continuously upgrade National Standards of all physico-mechanical measurements
- Provide calibration services to industry, institutions, private and public sector, defense etc,
- Develop new physical standards, measurement methods, and data;
- Develop knowledge, & train the personnel from industry, institutions in obtaining NABL accreditation and ISO certification.
- Conduct aggressive dissemination program; and
- Collaborate with industry to commercialize inventions and discoveries.

The division performed 2714 calibrations and tests in the year 2003-2004 and realized an External Cash Flow (ECF) of about Rs 18398934/-. Besides, the division earned considerable ECF by providing consultancy, training and executing externally funded projects.

Scientists strive to the best of their capability and keep themselves abreast by attending national and international conferences/symposia/seminars/ etc. and disseminate the knowledge by delivering the invited talks, arranging training courses and workshops and in-house seminars. Scientists pursue R & D work in the field of their expertise. These are reported under the details of respective activities in the following pages.

NPL, through standards activities helps the nation by providing scientific and technical support to NABL (National Accreditation Board for Testing and Calibration Laboratories). In line with NPL-NABL MoU, the division provides support to NABL in form of trained assessors, faculty for their awareness programs and training courses etc,. The scientists of this division play an important role in technical and accreditation committees of NABL and technical committees of Bureau of Indian Standards.

During the year 2003-2004, measurement capabilities of Mass, volume and density; optical radiations and Pressure and vacuum have been peer- reviewed and 24 CMC's have been included in Appendix of BIPM database.

Mass Standards

Re-established National Standards of Mass by calibrating four 1 kg Transfer Standards of Mass against the new values of the National Prototype Kilogram with expanded uncertainty of 40 μg at k=2. Revised mass values of the transfer standards are given in Table 1.1 and their stabilities since 1955 are given in the Control Charts as shown in Fig. 1.1(a) to Fig. 1.1(d). Present status of our measurement capability at 1 kg level compared to other NMIs of the world is given in Table 1.2. Re-calibrated multiples and sub multiples of 1 kg (National Standards of Mass) against new values of 1 kg transfer standards. Updated best measurement capability in mass measurement (Table 1.3).

Peer Review of CMCs of NPLI in the BIPM Database

NPL's calibration and measurement capabilities (CMCs) in mass, volume and density were peer reviewed and included in Appendix C of BIPM database. The results of key comparisons in mass (APMP.M.M.K1) and in viscosity (CCM.V.K1) were included in Appendix B of BIPM database. APMP.M.M.K1 results have been linked to BIPM key comparision (CCM.M.K1) in March 2004 and the results of this linkage were published in Appendix B of BIPM database in April 2004. This linkage is graphically represented in Fig. 1.1(e).

All of the CMCs as mentioned at Table 1.3 have successfully undergone the process of peer evaluation by NMIs expert in January 2004. These capabilities of NPLI have helped the Government and the industry with a secure technical foundation for wider agreements related to international trade, commerce and regulatory affairs.

International key comparisons and metrological equivalence:

- Participated in CCM.V-K1 International Intercomparison in Viscosity measurements in June 2002. Final Report of the results of this intercomparison were published by Klingenberg G., Bauer H. in Metrologia, 41 Tech. Supplement in January 2004. Our measurement results in viscosity have established degree of equivalence between the participating laboratories and have been incorporated in Appendix B of BIPM database.
- Coordinated and prepared Technical Protocol of the APMP.M.M-K2 key comparison in Mass for which APMP- TCM has nominated NPLI as the Head of the Management Group responsible for organizing this Intercomparison
- Measurement capabilities have been extended up to 2000 kg in mass measurement and 2000 dm^3 (litres) in volume measurement. For this NPLI has

Table 1.1: Mass Values of 1kg Transfer Standards of Mass (1955/57 to 2003)

Year	Mass value of S	Mass value of Ṡ	Mass value of N	Mass value of Ṅ
1955/57	999.996 890 g ± 0.000 050	999.999 700 g ± 0.000 050	999.999 120 g ± 0.000 050	999.999 42 0 g ± 0.000 050
1981	999.996 790 ± 0.000 090	——— ± 0.000 090	999.998 470	———
1988	999.996 788 ± 0.000 013	99.999 628 ± 0.000 015	999.998 462 ± 0.000 014	999.999 530 ± 0.000 015
1999	999.996 801 ± 0.000 028	999.999 572 ± 0.000 028	999.998 441 ± 0.000 026	999.998 463 ± 0.000 026
2001	999.996 752 ± 0.000 028	999.999 611 ± 0.000 028	999.998 369 ± 0.000 026	999.998 322 ± 0.000 026
2003	**999.996 847** ± 0.000 040	999.999 635 ± 0.000 040	999.998 431 ± 0.000 036	999.998 405 ± 0.000 036

established a 2000 kg mass comparator. By using this facility NPL recently calibrated a 2000 litre volume vessel with a combined uncertainty of 32 ml. This facility is first of its kind in the country.

- NPL-NABL Proficiency Testing Program organized two proficiency testing programmes under NPL-NABL MoU. 20 NABL accredited laboratories participated. This program was started in August 2002 and was completed by the end of March 2004.

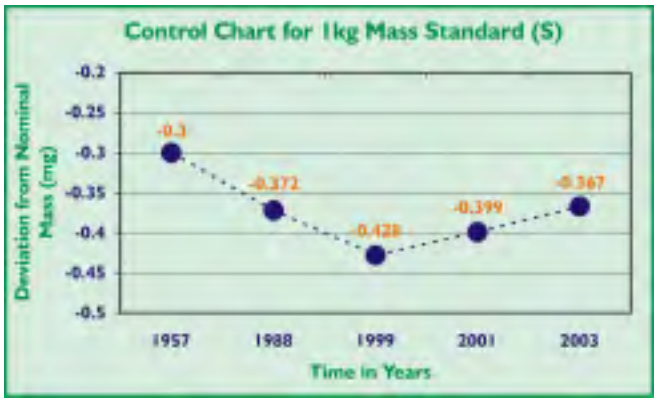


Fig. 1.1 (a)

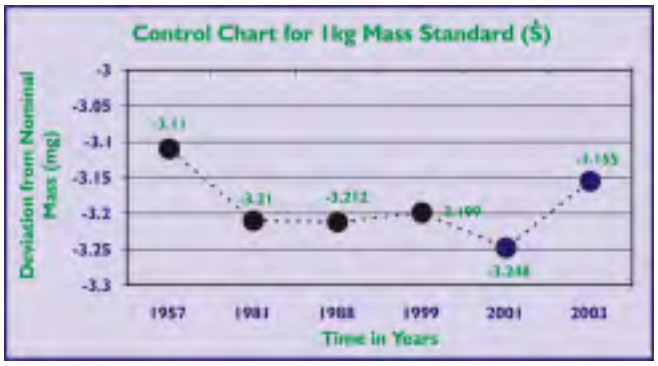


Fig. 1.1 (b)

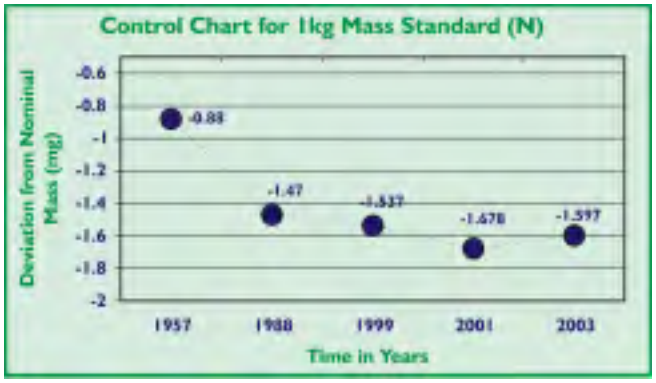


Fig. 1.1 (c)

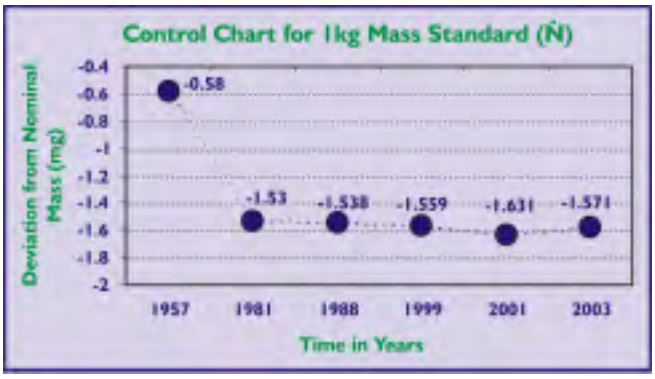


Fig. 1.1 (d)

CCM.M-K1 and APMP.M.M-K1

Measurand : Mass Nominal Value : 1 kg

Degrees of equivalence D_i and expanded uncertainty U_i expressed in µg

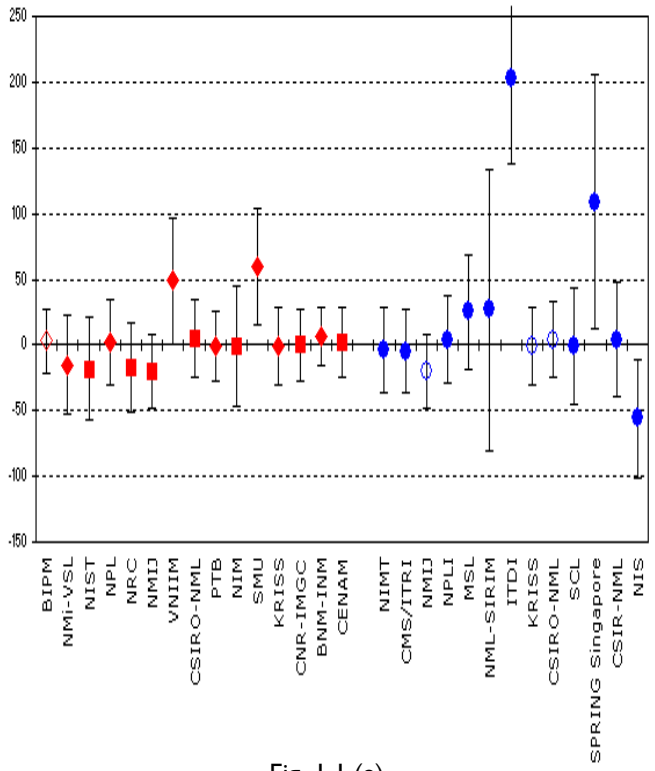


Fig. 1.1 (e)

Note:
Red diamonds: CCM.M-K1 participating laboratories having measured the mass of the travelling standards VSL-1 and J2 (Package 1)
Red squares: CCM.M-K1 participating laboratories having measured the mass of the travelling standards VSL-2 and J3 (Package 2)
Unfilled red diamond: CCM.M-K1 Pilot laboratory
Blue circles: APMP.M.M-K1 participants
Unfilled blue circles: Linking laboratories

Table 1.2: CMCs of Various NMIS at 1 kg Level

(Taken from Appendix C of BIPM database)

Sr. No.	Country	NMI	Uncertainty (k-2)	Sr. No.	Country	NMI	Uncertainty (k-2)
1	Australia	CSIRO	30 μg	14	New Zealand	MSL	40 μg
2	Canada	NRC	40 μg	15	Poland	GUM	30 μg
3	China	NIM	30 μg	16	Russian Federation	VNIIM	50 μg
4	China Taipei	CMS-ITRI	33 μg	17	Singapore	PSB	46 μg
5	France	BNE	30 μg	18	Slovakia	SMU	80 μg
6	Germany	PTB	28 μg	19	South Africa	CSIR-NML	500 μg
7	Hong Kong	SCL	40μg	20	Sweden	SP	70 μg
8	**India**	**NPLI**	**40 μg**	21	Switzerland	METAS	50 μg
9	Italy	IGMC	28 μg	22	Neitherland	VSL	100 μg
10	Japan	NMIJ	50 μg	23	Turkey	UME	60 μg
11	Korea	KRISS	28 μg	24	U.K.	NPL	30 μg
12	Malaysia	SIRIM	150 μg	25	U.S.A.	NIST	32 μg
13	Mexico	CENAM	50 μg				

Table 1.3: (Appendix C) Calibration and Measurement Capabilities Mass, India, NPLI (National Physical Laboratory of India)

Calibration or Measurement Service			Measurements Level or Range			Measurement Conditions/ Independent Variable		Expanded Uncertainty					
Class	**Instrument or Artifact: Measurand**	**Instrument Type or Method**	**Min. value**	**Max. value**	**Unit**	**Parameter**	**Specifications**	**Value**	**Unit**	**Coverage factor**	**Level of confidence**	**Is the expanded uncertainty a relative one?**	**NMI Internal Service provider**
Mass	Mass standards	Comparison in air	1	1	kg			40	μg	2	95 %	No	1
Mass	Mass standards :*m*	Comparison in air	0.001	50 000	g	*m*	excluding 1 kg	(2+0.3m) ; *m* in g	μg	2	95 %	No	2
Mass	Mass standards : *m*	Comparison in air	100	2 000	kg	*m*	100 kg, 200 kg 500 kg, 1000 kg 2000 kg	5m: m in kg	mg	2	95 %	No	3
Density of solids	Solid density Artifact: density *d*	Weighing in liquid	1000	22000	kg. m^{-3}	Temp.	15 °C, 20 °C and 27°C	0.03d ; *d* in kg.m^{-3}	g. m^{-3}	2	95 %	No	4
Density of liquids	Density measuring device	Weighing in liquid	600	2000	kg. m^{-3}	Temp.	15 °C, 20 °C and 27 °C	0.4	kg.m^{-3}	2	95 %	No	5
Volume of liquid	Standard volume vessel : *v*	Weighing	0.01	50	L	Temp.	27 °C	0.1*v*; *v* in l	ml	2	95 %	No	6

Entered in BIPM Key Comparison Database, March 2002, and Technical Ly Peer Reviewed in January 2004.

Length and Dimension Standards

Length and Dimension standard maintains national standards of length and is actively involved in the dissemination of traceability by way of calibration and testing services. The services were provided to clients from industries and other organizations. 623 reports were issued in 2003-2004. Studies were carried out for development of electro-optic displacement sensors using gratings. A new data processing method has been developed for on line measurement of test sieve parameters using wavelet transform. The measurement was non-contact optical method based on image acquisition using CCD camera. The method was validated by comparing the results with those obtained by using profile projector. The uncertainty in measurement was evaluated and was found to be 0.001 mm at 95% confidence level.

The consultancy in setting up a calibration laboratory was provided to M/s Mitutoyo Asia Pvt. Ltd., New Delhi

Work was carried out on measurement of BLIND HOLE using fiber optic probe in conjunction with optical CMM. The measurement range was 50nm to 100 μm for surface topography measurement like surface roughness and for Depth setting standards in the range of 10 nm to 100 μm.

The length measurement capability by interferometric method was enhanced to 305 mm from present 100 mm. The uncertainty of measurement was improved to 0.08 μm from 0.5 μm. The uncertainty in length measurement using length measuring machine (LMM) was improved to 0.6 μm from 1.5 μm for the range of 1000 mm length.

Proficiency testing program for calibration of length of ceramic gauge blocks and for measurement of diameter of Ring gauges was completed. 24 (12 + 12) NABL accredited laboratories participated in these programs. This program was funded by NABL, DST.

Temperature Standards

The fixed point of Freezing Point of Indium (156.5985°C) was assembled and realized using existing low temperature furnace (50°C to 500°C) with the expanded uncertainty of ± 1.3 m°C. All the fixed points in the range of 0°C to 962°C are established as per ITS-90, thus completing the Temperature Scale in this range at NPL, New Delhi.

Thermometry Resistance Bridge, model F-900, Automatic System Laboratories, U.K was installed, tested and put in to operation for precise temperature measurements with a digital resolution of 0.01 m°C. Two Water Triple Point Cells were fabricated calibrated and one of them was supplied to M/s Electronics International, Bangalore. Calibration of 10 nos. of Thermisters at 17 points in the range of 0 to 40°C for fog–temperature studies for the project of Radio Science Division.

The ECF of Rs17 lakhs was generated during the year by providing calibration services primary and comparison calibration to Research & Calibration Laboratories, and Industry. The work includes calibration of standard platinum resistance thermometer, TPW cells, heat pipe immersion coolers, resistance temperature detectors, RT / Thermister based temperature indicators/ controllers, dry block baths etc.

The fixed points in the temperature range from -196°C to 962 °C are being checked and maintained through experimental runs. The Primary Standard Group of Temperature Standards is participating in the APMP-T-K4 intercomparison at fixed points of Al and Ag being coordinated by KRISS, Korea. The artifact HTSPRT is due to arrive at NPL, New Delhi in the last week of April, 2004.

Optical Radiation Standards

Under BIPM, MRA and for the implementation of the quality system as per the ISO/IEC guide 17025, the Photometry and Radiometry activity was peer reviewed for its calibration and measurement capability for the

CMCs (14 in number) listed in the Appendix C of BIPM. The activity was Peer Reviewed as per the ISO/IEC guide 17025 in December 2003.

Light emitting diodes have started making their place for lighting applications. The research and developmental work on studying the photometric characteristics of light emitting diodes (LEDs) including their color characteristics, wavelength and intensity variations on the environmental conditions was carried out. Calibration facilities for the photometric parameters were extended to various lamp and lighting industries, R and D institutions etc.

Facility for calibration of broad band UV intensity meters has been established as ultraviolet radiation emitted from natural and artificial sources has found applications in many fields including industrial, agricultural, scientific, medical, technological, health and safety etc. High intensity UV Source has been installed and it is being used for the calibration of UV Meters in UV-A, UV-B and UV-C spectral region. Calibration of IR systems like thermometers and thermovision camera were carried to cater for the needs of industries and defense organisations, and the FT-IR and FR-Raman measurement facilities were provided to various developmental programmes of NPL.

Analysis of raw sugarcane juices in mid infrared region using attenuated total reflectance accessory has been done in detail. Analysis of raw sugarcane juice has been done for individual components of sugar using FTIR spectroscopy in mid infrared region. The spectra of these samples were recorded in near infrared range. Calibration was performed on NIR data using the reference values obtained by oven drying method.

Variable-temperature Fourier-Transform Infrared measurements have been performed on a Bruker IFS-28 spectrophotometer for thermal unfolding in a,b-dehydrophenylalanine containing model peptides Studies based on the thermal denaturation of dehydrophenylalanine containing peptides using variable-temperature FTIR spectroscopy... Mid-infrared spectra of anthracene and phenanthrene from 2000-400 cm-1 are being investigated in wax films. Solid wax film technique is employed for vibrational study in infrared region for the first time.

NIR spectroscopy technique for cellulosic materials

Cellulose fibers (for textile) and technical yarns are produced traditionally in wet spinning process. To maintain stable mechanical and physical properties of the cellulose fibers, the constituents of the spinning bath, in general and the spinning solution, in particular, have to be maintained in an optimal range. The testing for these constituents has traditionally been done in the textile industry by a variety of gravimetric and wet chemical methods. While these standard techniques are reliable, they are often time consuming, operator-dependent and involve use of hazardous reagents. Infrared spectroscopy is an useful technique for qualitative and quantitative analysis of raw materials and finished textile products. Feasibility study of a number of samples of pulp, viscose and alkcell were analysed in Infrared and near infrared region. The preliminary results are very promising. This project is sponsored by M/s Birla Management Corporation Limited, Bombay.

Optical and spectral properties of organic compounds used as building blocks for nanostructures

Acetylenic compounds have recently gained importance in design and synthesis of nanomaterials. Functionality of self-organized molecular species promises interesting properties of resulting materials being fabricated for electronic and sensing applications. Infrared studies of few acetylenic compounds deposited as thin films on Zinc Selenide substrate were done. The spectra were subjected to rigorous mathematical analysis in order to pick differences in vibrational frequencies C°C of stretching vibrations of two compounds. This project is sponsored by CSIR.

Studies on the effect of dynamic multiple scattering on the frequency shift of spectral lines and applications

Doppler-like wavelength shift proposed in dynamic multiple scattering theory by Roy et al (the source and the medium are at rest with respect to the observer) has been tested using the results of experimental studies of the redshift and broadening of Hg lines on scattering of the light emanated from Hg discharge source from an anisotropic plasma medium. These results are consistent with the theoretical results and are expected to produce new insights for the astronomical domain, particularly for discordant redshifts in quasars.This is a DST sponsored project.

Force and Hardness Standards

Inter-comparison of Force Standard Machines in the static force region

1-5 kN between NPL(I) and PTB(G)

An Inter-comparison of the experimentally determined force values realised in the region 1 to 5 kN using different force standard machines within the force laboratory at NPL (5 & 50 kN) was carried out with the force values realised at PTB Germany (20 kN). Such inter-comparisons establish the degree of equivalence of standards in these laboratories to a certain extent and reveal possible systematic errors, if any, or reaffirm the uncertainty within which the laboratory can make relative force measurements. The results of inter-comparison have revealed close agreement as the En values are always less than 0.5 through out the range of comparison.

Realization of 50 kN force scale through Dead Weight Force Machines at NPL(I)

An inter-comparison was carried out between the 50 and 100 kN dead weight force machines over the range 5-50 kN, at NPL (I) during Nov. 2001 to March 2003 using three force transfer standards to their full capacities of 10,20 and 50 kN. The comparison results between the two NPL(I) force machines show a relative differences from 20 ppm to a maximum of 30 ppm in the observed mean values of the force applied in ascending order. The normalised standard deviation En is less than 0.5 almost through out the range of force comparison made indicating thereby good coherence between the forces generated by these force machines.

Further, the closeness of the mean force values is within 50 ppm throughout the increasing force range of 5-50 kN when compared with the values obtained by direct calibration of these force transfer standards against the dead weight force machines of PTB, Germany. These values are in good agreement with the statements of uncertainty of the force machines i.e.± 20 ppm (PTB, Germany) and ± 30 ppm and ± 40 ppm (k=2) belonging to NPL(I).

Pressure and Vacuum Standards

A study of the variation of sensitivity of hot cathode Ionization gauges as a function of gas adsorption.

Hot cathode ionization gauges of the Bayard – Alpert inverse triode design are the most widely used gauges for pressure measurement in the high and ultra high vacuum range. Several different envelope geometries are available commercially, for example, nude gauges, gauges with glass envelopes, and the more recent gauges having metal envelopes. The sensitivity of this particular type of metal envelope ion gauge (designated by suffix SI in the Figure 1.2) is claimed to be highly repeatable, typically within a few percent over the period of one year. However, it was noticed that sensitivity shifts were much larger in these gauges during routine operation. A systematic study of the change in sensitivity for two glass envelope ionization gauges (TT), six metal envelope ionization gauges (SI), and one extractor gauge (Exg) over the pressure range $2x10^{-6}$ Pa to $7x10^{-3}$ Pa has been carried out. An orifice flow (dynamic expansion) system generated the nitrogen and argon calibration pressures, and a spinning rotor gauge was used as a check standard for pressures above 10^{-3} Pa. For both argon and nitrogen, it was found that

each gauge's sensitivity was dependent on the quantity of gas the operating gauge was exposed to prior to calibration, i.e., the product of pressure and time. For argon gas, sensitivity shifts of up to 8 % were observed between an initial calibration and one performed after exposing the gauges to 0.028 Pa of argon for about five hours. For nitrogen, the shifts were as large as 14 %. Interestingly, for argon the sensitivity shifts occur towards the high-pressure end of the calibration range, while for nitrogen the shifts occur at the low pressure range. It is now believed that ionic pumping of gas and its subsequent release by the walls of the metal envelope is responsible for the observed sensitivity shifts.

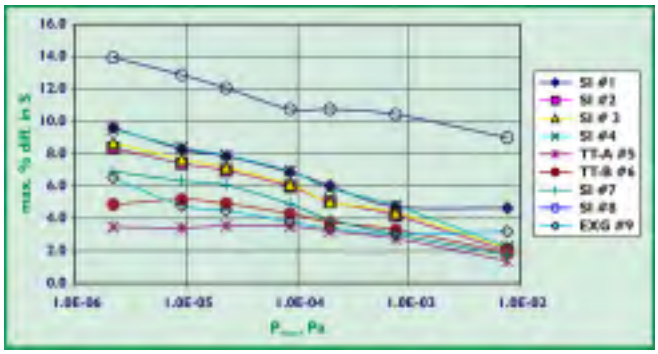


Fig. 1.2 : Plot of max percentage difference in sensitivity of different gauges on different days for nitrogen

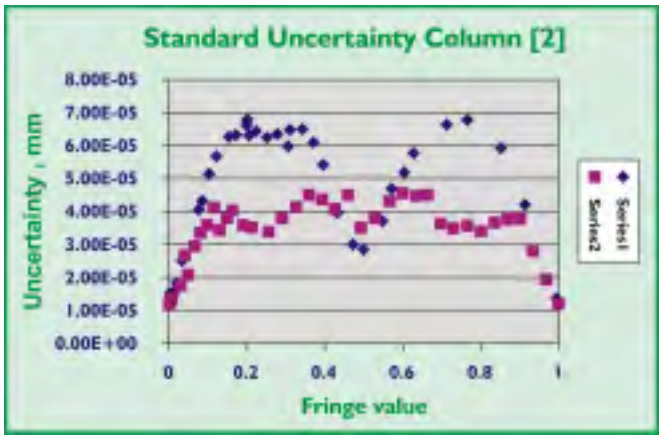


Fig. 1.3 : Improvement in measurement uncertainty of UIM

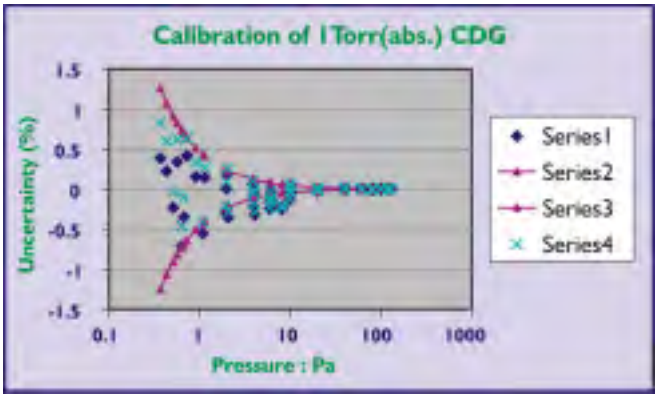


Fig. 1.4 : Measurement uncertainty of UIM in low pressure range established through calibration of 1 torr CDG

- **Improvements in the Primary Vacuum Standards i.e. Ultrasonic Interferometer Manometer (UIM)**

a) Re-evaluation of Measurement uncertainty of primary pressure standard, i.e UIM (1Pa-130kPa).

a) Uncertainty of UIM has been evaluated using 14 contributing parameters / factors as shown in Figures 1.3 and 1.4.

b) Contribution of some of the parameters, i.e tilt, verticality, fringes and zero stability etc. is estimated experimentally.

c) Uncertainty budget including degree of freedom prepared

b) Software for uncertainty estimation of UIM experimentally

A software programme has been developed using which the uncertainty of measurement of UIM is automatically estimated for each pressure point. As a result of this programme the uncertainty of UIM is further improved at low pressure using proper tuning of PSD signals.

- **Peer Review:**

Peer Review of one of our CMCs in the absolute pressure range 1Pa - 130 kPa was carried out during Dec. 2003 by the technical expert from NIST,USA. The accepted/ recommended CMC value is Q(0.0092 Pa,7.2 ppm of Rd) at k=2 (1Pa -130 kPa).

- **Characterization of air piston gauge, a newly procured primary standard in the range of 10 kPa - 350 kPa** .

Effective Area of the gauge is determined at different pressure from 10 to 130 kPa (absolute pressure) using UIM. Measurement uncertainty of the gauge is estimated as 10 ppm at k=2.

- **Development of Software in Windows environment:**

Some Software is developed in Windows Environment using MS Access and Visual BASIC for "Calibration of Pressure gauges Using Direct comparison and Least Square Error Fitting Methods". The salient features of this software is as given under:

- Works with Database support, which prompts for raw data in increasing and decreasing pressure cycles for each Pressure Gauge calibrated along with all relevant details regarding client details, instrument /gauge details and calibration details.
- Computes repeatability, hysteresis for the raw data fed in
- Computes effective degrees of freedom
- Computes expanded measurement uncertainty using calculated effective degrees of freedom for 95.45 % confidence level.
- Generates "Calibration Report" from the information already fed into the database as per the format suggested in our Quality Manual.

- **Results of APMP Pressure Key Comparison in Gas Media and Gauge Mode from 0.4 to 4.0 MPa (APMP-IC-2-97)**

The results of a regional key comparison (APMP-IC-2-97) for pressure measurements in gas media and in gauge mode from 0.4 to 4.0 MPa have been published. The study was undertaken under the aegis of Asia Pacific Metrology Programme (APMP) in October 1998 and was completed in May 2001. The pilot laboratory processed the information and the data provided by the participants, starting with the information about the standards as provided in point three above. Based on this information, the participating laboratories were classified into two categories: (I) laboratories that are maintaining primary standards, and (II) laboratories that are maintaining standards loosely classified as secondary standards with a clear traceability as classified by BIPM.

It was observed that out of the11 laboratories, six laboratories have primary standards (Category I), the remaining five laboratories are placed in Category II. The obtained data was compiled and processed under the same programme following Consultative Committee for Mass and Related Quantities (CCM)/BIPM guidelines.

From the data in Category I, it was evaluated that the APMP reference value is a function of p'/MPa (Fig. 1.5). The relative difference of A'p' value with reference to APMP reference value for all participating laboratories was estimated. It was observed that they agree well

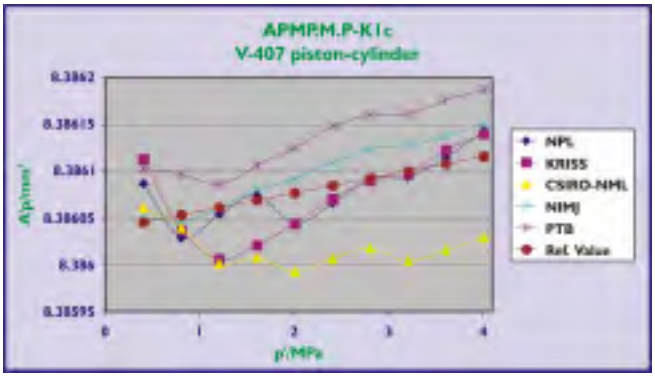


Fig. 1.5: Estimation of the reference value from the results of the laboratories which are maintaining primary standard

within their expanded uncertainty statement (Fig.1.6). The degree of equivalence between any two participating laboratories following the matrix mechanism was also estimated in tabular form (Table 1.4). It is shown there that the degree of equivalence between any two participating laboratories is agreeing extremely well within their estimated relative standard uncertainty.

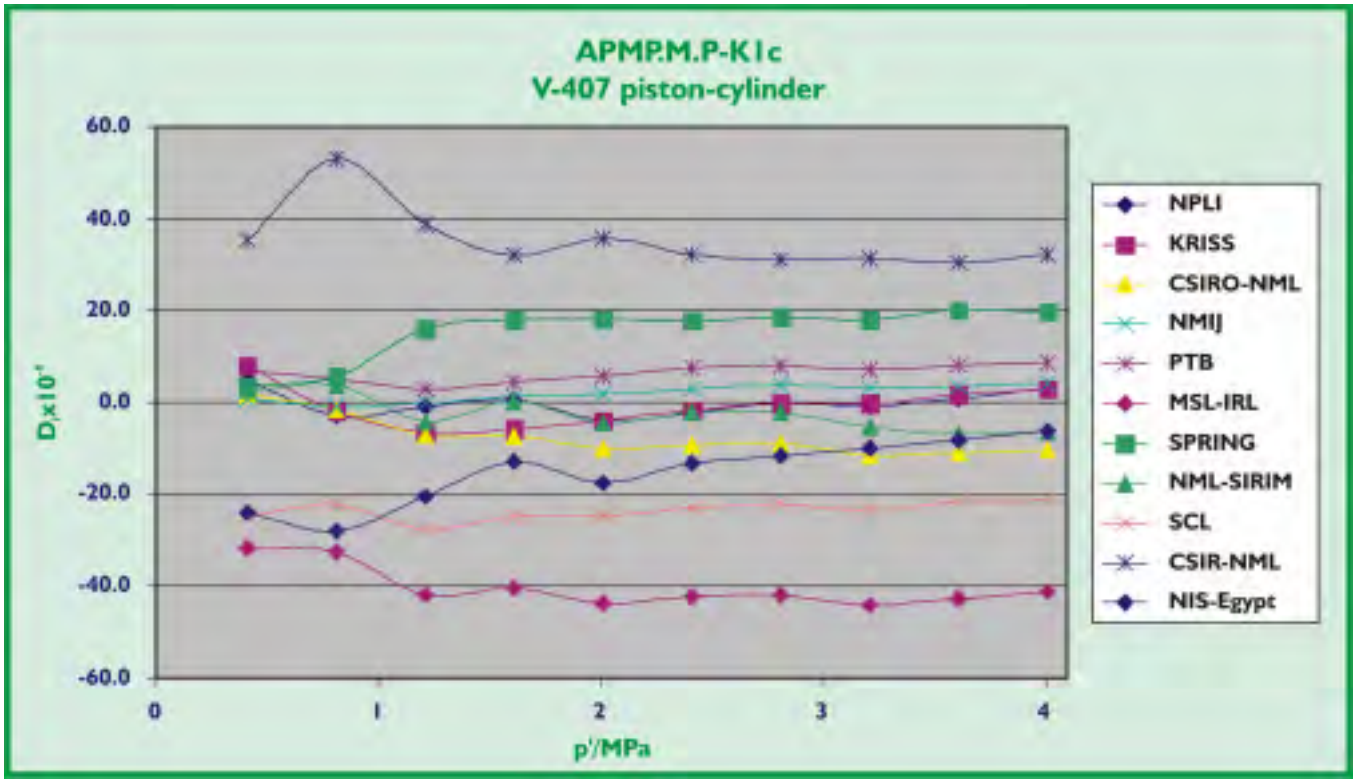


Fig. 1.6 : Differences relative to reference value for all participating laboratories $D_i \times 10^{-6}$ = (Lab. val. - ref. val.)/ref.val.

Finally, a new method was introduced to evaluate these results and establish (shown in Table 1.4) a link to CCM.P-K1c and EUROMET.M.P-K2 at two nominal pressures, near 1 MPa and 4 MPa. Again the results show an agreement of all participating laboratories in the present comparison to within the estimated expanded uncertainties using a coverage factor k=2 [Figure 1.7].

The detailed report can be obtained at the following website:http:/èkcdb.bipm.org/AppendixBÈKCDB_ApB_result.asp?cmp_idy=134&cmp_cod=APMP. It has also been published in *Metrologia, Technical Supplement* **40**, 07002 (2003).

- **Implementation of Quality System**
  - Peer Review for 3 CMC's: Gas pressure upto 12 MPa and differential pressure 0-150 kPa
  - and Hydraulic Pressures up to 500 MPa.
  - 52 x 10^{-6} for pneumatic pressure upto 12 MPa at k=2
  - 100 x 10^{-6} for differential gas pressure 0-150 kPa at k=2
  - 86 x 10^{-6} for Hydraulic pressure upto 100 MPa at k=2

    128 x 10^{-6} for Hydraulic pressure upto 500 MPa at k=2

- **Internal Intercomparisons**
  - Intercompared Ruska 2465 with D&H 80 in pneumatic pressure range 0.4-4 MPa
  - Re-calibrated Pneumatic primary pressure standard.
  - Automatic data acquisition software in BASIC language using a IEEE interface card was developed for calculating fall rate of the piston using a non-contact fall rate measuring device. This consists of a 0.1 mW laser focused onto the piston. The light reflected from the surface is detected and the signal generated in the transducer

Table – 1.4 CCM.P-K1c and APMP.M.P-K1.c

p'=1MPa Lab/ →

	IMGC-CNR		BNM-LNE		PTB		NIST		NMU	
	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}
IMGC-CNR			-3	24	-6	25	+2	27	-13	29
BNM-LNE	+3	24			-3	13	+5	17	-10	20
PTB	+6	25	+3	13			+8	18	-7	21
NIST	-2	27	-5	17	-8	18			+15	24
NMU	+13	29	+10	20	+7	21	-15	24		
NPLI	+0	50	-3	46	-6	46	+2	48	-13	49
KRISS	-6	44	-8	39	-12	40	-4	41	-19	42
CSIRO-NML	-6	37	-9	31	-12	31	-4	33	-19	35
MSL-IRL	-41	67	-44	63	-47	64	-39	65	-54	65
SPRING	+17	70	+14	67	+11	67	+19	68	+4	69
NML-SIRIM	-3	53	-6	49	-9	49	-1	51	-16	52
SCL	-27	47	-29	42	-33	42	-25	44	-39	45
CSIR-NML	+40	49	+37	45	+34	45	+42	47	+27	48
NIS-Egypt	-19	69	-22	66	-25	66	-18	67	-32	68

Lab/ ↓

EUROMET M.P-K2 and APMP.M.P-K1.c

p'=1MPa Lab/ →

	BEV		MIKES		CEM		SP/FFA	
	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}	D_{ij} 10^{-6}	U_{ij} 10^{-6}
BEV			+32	47	+18	55	+22	47
MIKES	-32	47			-14	45	-10	35
CEM	-18	55	+14	45			+4	45
SP/FFA	-22	47	+10	35	-4	45		
NPLI	-24	61	+8	53	-6	60	-2	53
KRISS	-30	57	+2	47	-12	55	-8	47
CSIRO-NML	-31	51	+1	41	-13	50	-9	41
MSL-IRL	-66	75	-34	69	-48	74	-44	69
SPRING	-8	78	+24	72	+10	77	+14	72
NML-SIRIM	-28	64	+4	56	-10	63	-6	56
SCL	-51	59	-19	50	-33	57	-29	50
CSIR-NML	+15	61	+47	52	+33	59	+37	52
NIS-Egypt	-44	78	-12	71	-26	77	-22	71

Lab/ ↓

APMP.M.P-K1c

V-407 piston cylinder

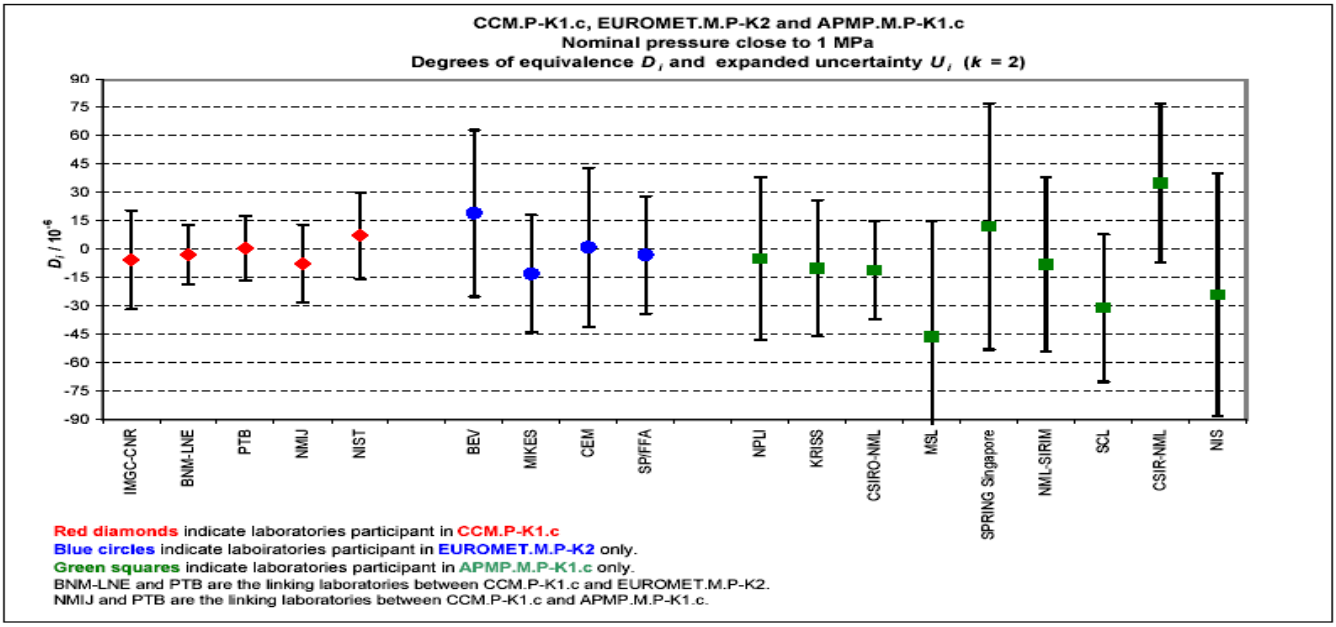


Fig. 1.7 : Link of APMP.M.P-K1c data with CCM.P-K1c and EUROMET .M.P-K2.

The BIPM key comparison database, September, 2003

fed to the data acquisition system though an IEEE interface card and the software developed.

- **<u>High Pressure Phase Transition Studies</u>**

  - High pressure studies on Eu_2O_3 powder using Raman and X-ray diffraction studies. Cubic Eu_2O_3 was found to convert to monoclinic Eu_2O_3 at around 2.0 GPa

  - XPS of Eu_2O_3 for showed the presence of divalent europium also apart from the dominant trivalent europium in the system.

- **Studies On Controlled Clearance Type Hydraulic Primary Pressure Standard**

The use of controlled clearance piston gauge (CCPG) as primary pressure standard is now well established for realizing practical pressure scale up to 1.0 GPa. However, the rheological properties, mainly, the viscosity and density of the pressure transmitting fluids contributes significantly above 500 MPa. Therefore, for characterization of this CCPG above 300 MPa, it is required to study the effect of different pressure transmitting fluids in the performance of the gauge. The laboratory undertook a comparative study on the measurement of piston fall rate as a function of the applied jacket pressure (p_j) for each of several loads (50 kg.) using three different working fluids i.e. pure J-13, mixture of J-13 and aviation turbine fuel (ATF) (one part of J-13 and 2 parts of ATF) and pure di (2 eithyl hexyl) sebacate as pressure transmitting fluids. The results thus obtained on these fluids were compared with the values reported by the manufacturer using mixture of di (2 eithyl hexyl) sebacate and Coleman Fluid in the ratio of 2:1, respectively.

The cube root of the fall rate was plotted as a function of applied p_j and extrapolating the linear portion of the curve to zero fall rate, which provided

us the values of p_z for different loads. From the p_z at different loads, the zero clearance between the piston and cylinder was determined. The values of jacket coefficient are computed by analyzing the dependence of effective area and the jacket pressure, p_j using: a) a theoretical method as suggested and b) an experimental method being used at NIST, USA. The uncertainty budget of the primary standard is prepared by estimating all the influencing parameters at 100 MPa and 500 MPa. The results thus obtained on these fluids are compared with the values reported by the manufacturer using mixture of di (2 eithyl hexyl) sebacate and Coleman Fluid in the ratio of 2:1, respectively. These studies conclude that i) J-13 fluid is suitable to measure high hydrostatic pressure up to 300 MPa, ii) mixture of J-13 and aviation turbine fuel (ATF) (one part of J-13 and 2 parts of ATF) is useful up to 500 MPa and iii) di (2-eithyl hexyl) sebacate gives good results up to 680 MPa. A detailed discussion is made on the results. The metrological characteristics thus obtained were utilized to calibrate another national transfer hydraulic pressure standard, designated as NPL100MPN by cross-floating against CCPG.

- **Participation in CCM Sponsored Key Comparison**

Participated in the CCM Sponsored International Key Comparison (CCM.P-K7) in the pressure range 10 to 100 MPa. NPL, India is selected among the best nine laboratories [PTB, Germany; LNE, France; IMGC, Italy; NPL, UK; NIST, USA; CENAM, Mexico; NRC, Canada; NMIJ, Japan and NPLI, India] to participate in this comparison. PTB, Germany is working as Pilot Laboratory in this comparison. The measurements on the artifact were completed well within the stipulated time and results are under evaluation.

- **Participation in Bilateral Comparison With NIST, USA**

Participated in the bilateral key comparison with NIST, USA in the pressure ranges 40 to 80 MPa and 80 to 200 MPa using two NPL transfer standards namely NPL100MPN and NPL500MPN. The measurements on the artifacts have already been completed and results are under evaluation.

- **Coordination of NABL Sponsored Proficiency Testing in the Hydraulic Pressure Measurements up to 70 MPa**

NPL, New Delhi has coordinated three NABL sponsored proficiency testing program, namely PT001, PT002 and PT003 in the pressure range 0 – 700 MPa using dead weight tester, digital pressure calibrator and pressure dial gauge, respectively as artifacts. The total number of 25 NABL accredited pressure laboratories form all over India participated in this programme. All the participants have completed the measurements and 23 laboratories have already submitted their results. The results are under evaluation for the equivalence.

Acoustic Standards

The Acoustics Section undertook the following activities:

1. Participated in bilateral key comparison of standard condenser microphones (sound pressure) with Danish Primary Laboratory for Acoustics(DPLA, Denmark). Under this programme two half–inch standard condenser microphones were calibrated on NPL Reciprocity Calibration System in the frequency range 31.5 Hz to 25 kHz using plane wave couplers. The measurement results showed that the microphone pressure sensitivity values were within + 0.03 dB of DPLA values.

2. Compliance testing of firecrackers was undertaken to ascertain the noise levels produced by a variety of crackers available in the local market. The measured noise levels were well above the allowable limits of 125 dB (Al) or 145 dB $(C)_{pk}$ @ 4 m distance , as per CPCB norms.

3. Type approval / Compliance testing of DG sets with enclosures, both portable and stationary, were undertaken to ascertain the noise level emitted at 75% loading during normal operation.

Most of the models tested complied with CPCB norms of i) 75 dB(A) SPL @ 1 m distance from the enclosure for stationary sets and ii) 86 dB(A) SWL @ 1 m distance from the enclosure for portable sets.

4. Calibration and testing of Electro-acoustical equipments and acoustic products were undertaken under controlled conditions to maintain the tractability chain and to assertion the quality of indigenously produced items. In all 150 calibration/Test Reports were issued and the ECF earned was about Rs. 11.0 lakh.

5. A sponsored project of mixing height studies was undertaken in the North Eastern Region in collaboration with IIT, Delhi and G.B. Pant Institute, Gangtok.

6. The section participated in 3 Field experimental campaigns in collaboration with other sections in NPL These were

   i) Sodar studies in Hill Areas in Darjeeling

   ii) Sodar studies in relation to Bio-mass Burning in Pant Nagar.

   iii) National Road Campaign on aerosol and trace gas measurements in Delhi-Hyderabad corridor.

7. The section published 10 papers in national/ international journals/ conference proceedings and presented 4 papers in national conferences.

Fluid Flow Standards

Digital pressure transducers have been fitted in 15mm size pipe line replacing analogue dial type pressure transducers of domestic water meter test rig for reducing the differential pressure measurement uncertainties from ± 0.0541 bar to ±0.0006 bar.

Arrangements were made to calibrate the on-line density meter, which is an integral part of the flow measurement facility.

The problems related load cell based weighing systems, water level control systems, compressor unit, dedicated computer for flow measurement etc in the main water flow facility were addressed to and some of these have been solved. Load cell based weighing tank systems have been provided with new power back up (special battery) and are under calibration. The defective auto drain valve has been replaced in compressor unit. Switching amplifier was procured from Germany and has been installed in the facility. Work is in progress to bring back the system in operation.

Ultrasonic Standards

An acoustic method has been developed to evaluate the parallelism between faces of any block even if it is opaque to light. It is based upon echoes received from two surfaces when incident upon by a short duration high frequency ultrasonic pulse. The method requires only one side to be accessible. Theoretical and experimental study was made. The study is useful for calibration of ultrasonic NDT V-2 blocks.

The dimensional parameters of reference cylindrical NDT blocks have been related to ultrasonic response. Based on this observed correlation, a methodology has been developed for checking these calibration blocks.

Facilities for calibration of ultrasonic medical scanners were upgraded for the evaluation of parameters as per IEC: 60601-2-37 (Sept. 2001).

Experimental work was conducted on the development and fabrication of high power transducers based on flexural vibrating stepped plates. Transmitting response, quality factor and the beam characteristics of these transducers have been measured. Transducers are applicable for generation of parametric sources for directional transmission.

Effect of changes in ultrasonic properties of carbon fibre composite due to absorption of moisture was studied in depth. Theoretical model has been developed to estimate variation in time of flight of ultrasonic waves

as a function of moisture concentration for a sample having Fickian distribution.

Humidity standards

Calibration of relative humidity hygrometers against aspirated psychrometer in the range 10-95% RH has been continued to several Indian industries.

Two-pressure cum two-temperature relative humidity (RH) generator has been completed. The preliminary results are quite encouraging. Fig. 1.8 depicts the developed RH generator. Rigorous testing is in progress. The interfacing for automation is also in progress. It will improve our accuracy of measurement. Efforts are being pursued to bring this unique facility at par with the International level (PTB, Germany).

Fig. 1.8 : Two-pressure cum two-temperature RH generator

R&D on Shock and Vibration Sensors

Piezoelectric Accelerometers

The constant R&D efforts of laboratory, in the development of a complete family of accelerometers to capture the entire diversified range of applications, has further resulted in the successful development of yet another high shock accelerometer capable of withstanding shock environments up to 5000g, without any degradation in its performance. This is the fifth generation of the family of accelerometers developed at the laboratory and is designated as accelerometer type PL-812S in addition to PL-810, PL-811, PL-900 and PL-901 previously reported. Characteristic specifications of accelerometer type PL-812S are given in the Table 1.5. Accelerometer PL-812S has been successfully employed in the quality assurance of automobile helmets for the safety of human lives, and to maintain the quality norms for helmets as per Indian Standards Specifications. The accelerometer PL-812S can also be used in many other applications, equally well, for monitoring and control of shock environments. Technological Process Know-How for the commercial production of all these types of piezoelectric accelerometers are readily available from the laboratory. Work on the development of a seismic accelerometer, featuring very high sensitivity and very low frequency response, is also in progress at the laboratory.

In view of the growing demand of technology in both core and strategic sectors, apart from industrial partners, the team of experts working in this field at the laboratory have further taken up work on the development of vibration instrumentation. A suitable charge pre-amplifier has already been developed. This will be extended to the development of Integrated Circuit Piezoelectric (ICP) accelerometers. To take up further developmental work of more advanced nature, the laboratory has recently been equipped with an advance accelerometer characterization system. This includes, reference sensitivity calibration and back to back frequency response calibration of accelerometers in the frequency range 200 Hz to 100 kHz. The laboratory has plans to improve further its measurement capabilities for the left over parameters, like extended dynamic and frequency range validation, amplitude range and linearity, transverse response, high and low temperature sensitivity etc.

Optical Measurement

Tested and calibrated components of optical microscope. 50 Test / Calibration Reports were issued on the samples received from the industry and calibration laboratories. The section earned considerable ECF by rendering calibration and testing services.

Table1.5 Piezoelectric Accelerometers Developed at NPL

MODEL No.	PL- 810	PL- 811	PL- 900	PL- 901	PL-812S
Weight	40 gm	19.35 gm	24.5 gm	18 gm	36 gm
Sensitivity	22 mV/g	10 mV/g	15 mV/g	~5 mV/g	18 mV/g
Resonance	39 kHz	-	>30 kHz	>60 kHz	-
Freq. Range	10 Hz–15 kHz	20 Hz-20 kHz	10 Hz–10 kHz	1 Hz – 20 kHz	1 Hz – 18 kHz
Linearity	0.1%	0.1%	0.47%	0.2%	0.5%
Max. Shock	3000 g	-	3000 g	3000 g	5000 g
Dimensions mm	19 Hex X 23H	14 Hex X 20H	19Hex X 21H	16Hex X 20H	19Hex X 20H
Case Material	SS 316	SS 316	SS 316	SS 316	SS 316

PL-810, PL-811, PL-900 and PL-901 models were developed in previous years

❑❑❑❑❑

विद्युत तथा इलेक्ट्रॉनिक मानक
ELECTRICAL AND ELECTRONIC STANDARDS

विद्युत तथा इलेक्ट्रॉनिक मानक

विद्युत और इलैक्ट्रॉनिक मानक प्रभाग एस आई (काल) प्राथमिक विद्युत और इलैक्ट्रॉनिक और चुंबकीय प्राचलों के विभिन्न राष्ट्रीय मानको को ज्ञात करने, स्थापना, विकास और अनुरक्षण में संलग्न है। हाल ही में इस प्रभाग द्वारा प्रतिरोध प्राथमिक मानक क्वान्टम हॉल प्रतिरोध की स्थापना की गई है। यह सुविधा राष्ट्रीय प्रतिरोध मानकों की अनिश्चितता और अनुमार्गणीयता को अन्तर्राष्ट्रीय स्तर की उपलब्ध कराती है। इस प्रभाग ने कई बी आई पी एम और ए पी एम पी अन्तर्राष्ट्रीय संस्थानों द्वारा आयोजित अन्तः तुलनात्मक और द्विपक्षी सादश्य कार्यक्रमों में भाग लिया है, अन्तर्राष्ट्रीय अनुमार्गणीयता को स्थापित करने के लिए इस डिवीजन द्वारा एनपीएल और एनएबीएल एम ओ यू के तहत परीक्षण प्रोग्राम भी किये गए हैं।

यह राष्ट्रीय भौतिक प्रयोगशाला का प्रथम प्रभाग है जिसने अन्तररर्राष्ट्रीय पिअर–पुनः अवलोकन आईएसओ/आईईसी 17025 के अनुसार 426 प्राचलों की तुलना का कार्य सफलतापूर्वक पूर्ण किया।

ELECTRICAL AND ELECTRONIC STANDARDS

The Electrical & Electronic Standards Division is engaged in the realization, establishment, development and maintenance of SI unit (Time), Primary and National Standards of various electrical, electronic and magnetic parameters. Recently the division has established Quantum Hall Resistance Standard – primary standard of Resistance. This facility will help to strengthen the uncertainty value & traceability of National Standards of Resistance at par to international level. The division has participated in many international intercomparisons organized by BIPM, APMP and bilateral comparison to establish international traceability. It has also coordinated various proficiency testing programme under MoU between NPL and NABL.

This division is the first in NPL to have successfully completed the International Peer Review of as many as 426 parameters as per ISO/IEC 17025.

Time & Frequency Standards

NPL maintains Indian Standard Time (IST) through a bank of Cesium Atomic Clocks. Time scale of NPL is continuously traceable to UTC of BIPM through GPS Network and has a stability of 6.4×10^{-13} for averaging over one day according to Circular T. To further improve the time scale, some studies on development of algorithm of Time Scale with the ensemble of Cs Atomic Clocks are in progress.

The study on the effect of scintillation on GPS Timing accuracy has been carried out for first time. Besides calibration work of different user clocks, studies on determination of Calibration Measurement Capability and Uncertainty have been carried out.

A Rubidium Frequency Standard in the section has been indigenously upgraded and further development of Coherent Population Trapping (CPT) based clocks is being planned.

NPL disseminates IST via INSAT known as STFS Service providing time transfer accuracy of the order of 1 μs and also through Telephone Network called Teleclock Service having accuracy of the order of 1 s. There are now more than 50 dedicated users of STFS time service located all over the country. In this year, setting up of time transfer facilities in eight North Eastern states and in Indian Parliament in Delhi has been in progress. NPL has already taken up the project on initiation of time service via telephone line in Nepal. Design & Development of STFS System was further improved for National Informatics Center with IRIG-B output and its integration with Timing Receiver.

An optimization of Physics Package of a Rubidium Frequency standard for Dept of Lighthouse & Lightships was taken up and completed.

To further improve the stability and accuracy of primary clock, work on indigenous development of Laser Cooled Cesium Fountain Clock have started. For this purpose, ultra-low noise cavity stabilized X-band oscillator and Precision Temperature Controller with PID control have been developed. A 9.192 GHz microwave synthesizer for Cs-Fountain was completed and tested. A conjugate regenerative divider for low noise frequency synthesis was also designed and developed. Theoretical studies on the use of Squeezed vacuum to achieve higher cooling force in Cesium Fountain Clock were undertaken.

One of our scientists visited Northwestern University in USA to work on generation of quantum states of light. A Rubidium Raman Laser system for generation of entangled atomic states was developed. Besides a super efficient absorption filter for quantum memory using atomic ensembles in a vapour was demonstrated.

Quantum Hall Resistance Standard & Superconducting Devices

Quantum Hall Resistance Standard

NPL has established Quantum Hall Resistance Standard (Fig. 2.1) as a primary standard of resistance. The system comprise of a QHR device, cryostat with integrated superconducting magnet and a room temperature dc current comparator bridge. The QHR device is a GaAs-AlGaAs hetero-junction, that contains a two-dimensional layer of electrons (2D-gas) which when cooled to about 1K and subjected to a magnetic field of several Tesla, perpendicular to the layer of 2DEG, yield quantized Hall resistance as shown in Fig. 2.2. A series of plateaus appear in the Hall resistance as a function of magnetic field, also the longitudinal resistance accurately falls to zero at the center of each step and oscillates to non-zero values between steps. This is the Integer Quantum Hall Effect (IQHE). The steps occur at incredibly precise value of resistance, and only depend on the fundamental constants: e the electric charge and h Plank's constant and are related by the relation $R_{xy}(i) = R_{K\text{-}90} / i$, where $R_{K\text{-}90}$ is the von Klitzing constant, defined to be 25 812.807 Ω, and i is an integer 1,2,3…. In a well quantized device, the precision with which this relation holds is at least

2×10^{-9} for the plateaus of metrological interest. The laboratory calibrated its 1 kΩ resistance at 24^0 C. The standard type A uncertainty is calculated to be 0.008 ppm while the combined standard uncertainty is found to be 0.036 ppm. The combined standard uncertainty at coverage factor at k=2 (which approximately corresponds to 95 % confidence level) is 0 .073 ppm. The laboratory also calibrated a 1 kΩ resistance of DC standards of NPLI, which was earlier calibrated at NPL, UK, at different temperatures. The resistance values along with standard uncertainties are given in table 2.1

SQUID remains at 77K whereas the sample's temperature can be varied from 77K to room temperature. Programs are written for the automation and measurement. SQUID output, temperature of the sample and noise of the SQUID are recorded in the computer. The sensitivity of the high-T_c SQUID is $10^{-11}T/\sqrt{}$ Hz. Direct measurement of the magnetic noise of $La_{0.67}Ba_{0.33}MnO_3$ (LBMO) bulk sample has been carried out using the high-T_c SQUID setup.

The temperature dependence of magnetic noise at 7 Hz and 12 Hz is shown in fig. 2.4. As the material

Table - 2.1

Temperature (^{0} C)	Resistance (Ω)	Stand. Dev. (ppm)	U_c (ppm)	U (k=2)
20.04±0.02	999.9987682	0.0047	0.0091	0.0182
22.01±0.02	999.9989265	0.0027	0.0083	0.0166
23.98±0.02	999.9990963	0.0080	0.0112	0.0224
26.05±0.02	999.9992914	0.0064	0.0101	0.0202

Fig. 2.1 : Fully automated QHRS system

High-T_c SQUID setup for measurement of magnetic fluctuations

High-T_c SQUID setup for measurement of magnetic noise in manganite/superconducting sample is developed. Fig. 2.3 shows the schematic of measurement set up. During the measurement, the

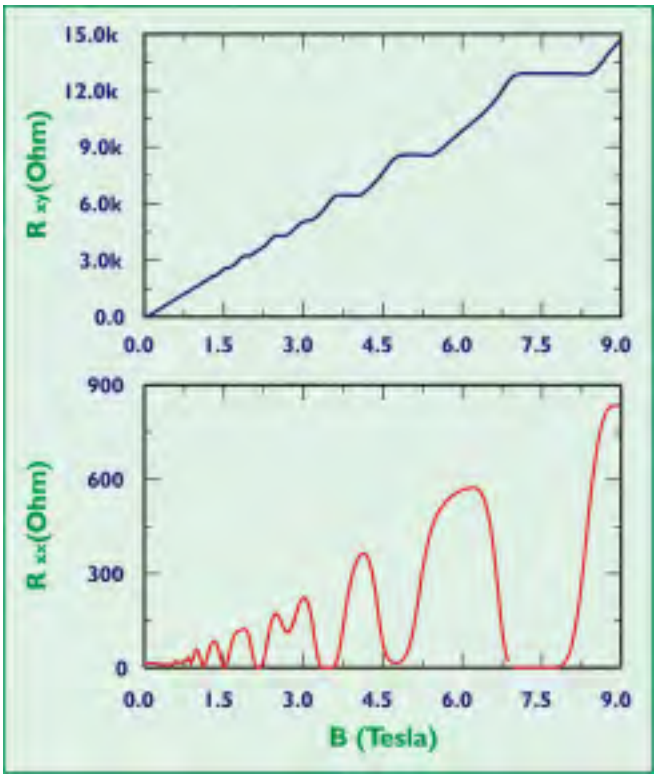


Fig. 2.2 : Magnetic Field dependence of R_{xy} and R_{xx} of GaAs-$Al_xGa_{1-x}As$ (x=0.3) Heterostructure Sample at 1.25 K.

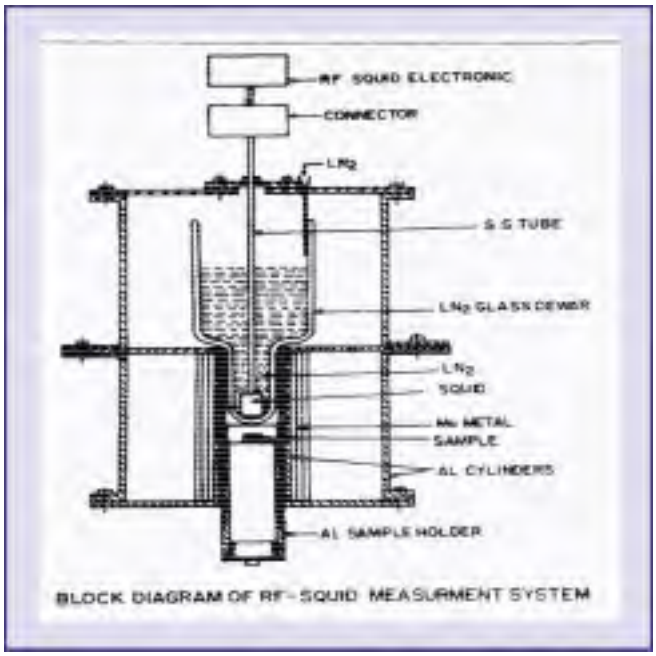


Fig. 2.3 : Block diagram of High Tc rf-SQUID measurement system

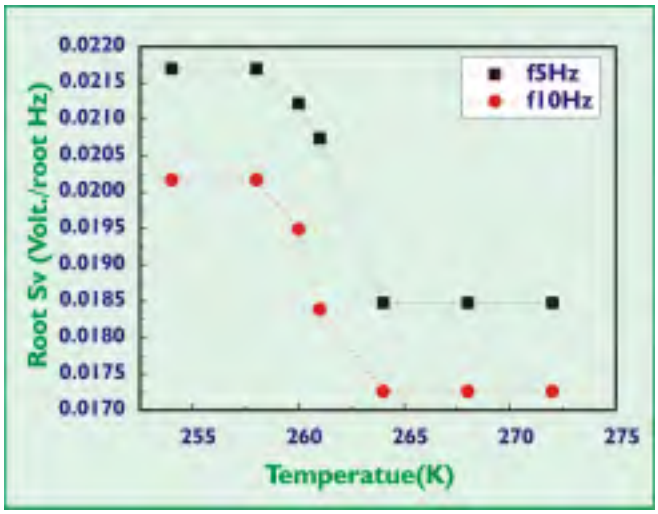


Fig. 2.4 : Variation of SQUID noise with temperature of the LVMO sample

becomes ferromagnetic, an increase in the noise due to magnetic fluctuation is observed.

Study of antiferromagnetic ordering in $ErNi_2B_2C$

$ErNi_2B_2C$ is a magnetic borocarbide superconductor which has superconducting transition temperature at 11.5 K and the antiferromagnetic (AFM) ordering temperature at 6.5 K. In order to find the affect of AFM transition on the magnetic noise produced by the superconducting sample, a measurement is performed using high-T_c SQUID. Fig. 2.5 shows the schematic in which $ErNi_2B_2C$ bulk sample is placed just over the high-T_c SQUID and both are cooled together. The noise of the SQUID remains constant in the temperature range from 4.2 K to 35 K. Fig. 2.5 presents the variation of magnetic noise at 7 Hz with the temperature. It clearly shows the noise from $ErNi_2B_2C$ sample decrease as the antiferromagnetic ordering occurs.

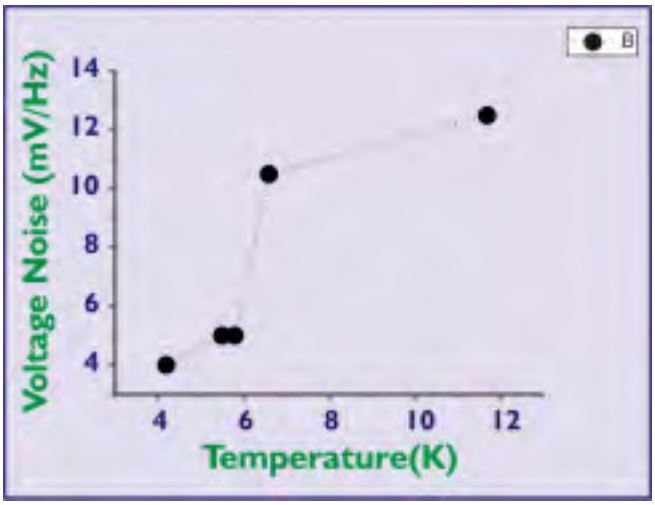


Fig. 2.5 : Variation of SQUID noise with temperature of $ErNi_2B_2C$

Evidence of presence of few weaklink grain boundaries in MgB_2 superconductors

Polycrystalline samples of MgB_2 superconductors are found to have large critical current and thereby it has been suggested that natural grain boundaries in this superconductor are strong links. Recently some structural studies such as STM, TEM indicates the presence of some weak link grain boundaries. However no direct evidence of the presence of weak link grain boundary was provided. In order to explore nature of grain boundary, SQUID studies in MgB_2 has been performed. RF-SQUID voltage-flux oscillations are observed in polycrystalline bulk MgB_2 superconductor (Fig. 2.6) which provides a direct evidence of the presence of weaklink Josephson

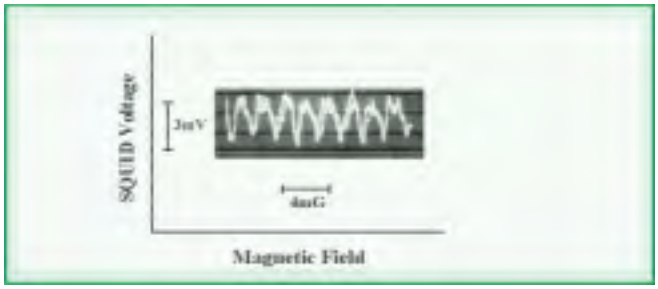


Fig. 2.6 : V-Φ characteristics of MgB_2 superconductor

junction type grain boundaries in MgB_2. The analysis of the SQUID modulation indicates that only a few grain boundaries are weaklink type whereas the others are strong links.

Investigation of conduction noise due to grain boundries in Colossal magnetoresistance (CMR) film

In order to understand the role of grain boundary in the conduction noise of CMR material a single artificial grain boundary in $La_{0.7}Ba_{0.3}MnO_3$ (LBMO) epitaxial film is prepared by growing the film on $SrTiO_3$ bicrystal substrate. Figure 2.7 shows conduction noise of the two microbridges (one is across the grain boundary and the other one is away from the grain boundary) in the absence and presence of magnetic field. Presence of a single grain boundary increases the noise of the epitaxial film of LBMO by one order of magnitude. Application of magnetic field suppresses noise of the grain boundary for temperatures lower than 250 K. The observed results are explained in the framework of two

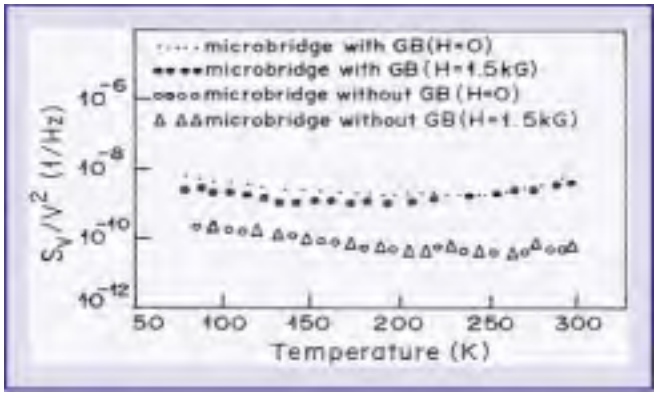


Fig. 2.7 : Variation of normalized noise of LVMO micro bridge with grain boundary and without grain boundary

type of conduction channels present across the grain boundary.

Josephson Voltage and DC Current, Voltage & Resistance Standards

Josephson Voltage Standard

Josephson series array voltage standard is maintained at 1 volt level. The 'National Standard' of volt is being calibrated at regular interval of six months against the Josephson Voltage Standard (JVS). JVS was the first Standards Laboratory's in NPL, which was assessed for International Peer Review as per ISO/IEC-17025 and successfully completed. 2 CMCs (calibration measurement capabilities) of JVS was assessed and are now in Appendix-C of BIPM website. Integration and testing of instruments for establishment of Josephson Voltage Standard at 10 V level is at final stage.

DC Current, Voltage and Resistance Standards

DC Standards was the first Standard Laboratory's in NPL which were assessed for International Peer Review as per ISO/IEC-17025 and it was successfully completed. 23 CMCs of dc voltage, dc current & dc resistance parameter were assessed and are now in Appendix -C of BIPM website.

An automated bank of Zener Reference Standard has been re-established as a 'National Standard' of DC Voltage. Now the laboratory is providing the calibration services to the user laboratories organizations / institutes with an uncertainty of ≤ ±1.0 ppm (earlier it was 2-3 ppm). The drift rates of modules and average output voltage of the newly establishedbank of Zener reference standard were studied for 60 days (Fig.2.8). The drift rate of average output of voltage was calculated as -20nV/day.

Precision DC voltage divider (Fluke 752A) was procured and is regularly used for calibration of dc voltage from 100 mV to 1000 V with an uncertainty of ±1.5 ppm.

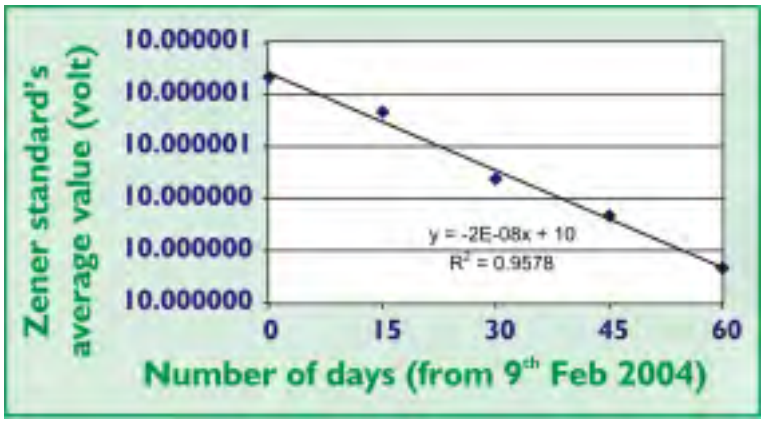


Fig. 2.8 : The graph shows the drift rate of average output of newly established Zener bank

AC Power & Energy Standards

Quality System has been implemented as per ISO/IEC guide 17025. All the related Documents have been prepared as per the requirement of Quality Manual of NPL.

There are 32 CMC entries in the Appendix C, for which Peer Review was conducted from 12th January 2004 to 16th January 2004. Out of these 24 entries have been cleared while 8 entries are postponed and will be cleared after repair of the concerned instrument.

Proficiency Testing programs (under NPL-NABL) on DC Resistances (1Ω, 100Ω, 1kΩ and 10kΩ) has been completed and report is under preparation. There were 47 accreditated laboratories, which took interest in this program. However, due to time constraint, 17 laboratories all over India were selected based on their technical excellence. NPL is the nodal laboratory. As an example, Fig. 2.9 shows the graph for E_n-values of all 17 participants laboratory at 1 Ω (code numbers assigned for confidentiality). 91% of the total results (1Ω, 100Ω, 1kΩ and 10kΩ) were having $E_n \leq \pm 1$ in accordance with the international practice.

A Bialteral intercomparison was done during the technical Audit from 12th January to 16th January with PTB Geramny. The artifact, C-1/2 Wattconverter was compared at 120 V, 5A for Unity power factor, 0.5PF (lag and lead) 0.25PF (lag & lead), 0.1PF (lag & lead) and 0.01PF (lag & lead).The results at Unity power factor , 0.5PF (lag & lead) and at 0.25 (lag & lead) are in very close agreement with PTB, Germany while remaining results are still awaited.

A five position Calibration Bench is installed with Uncertainty ± 100ppm related to Apparent power (Fig. 2.10).

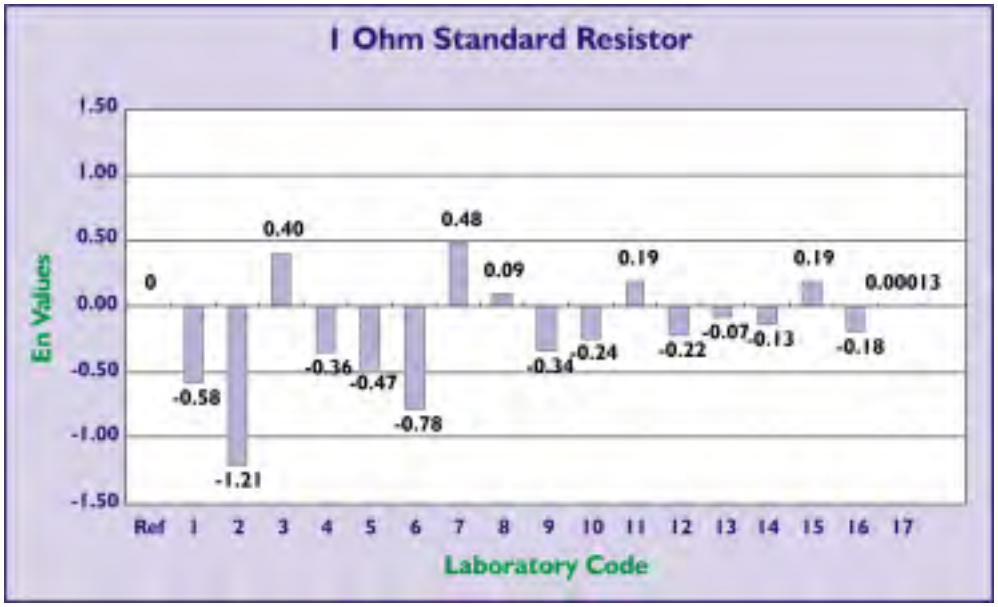


Fig. 2.9 : E_n values of the Laboratories for 1 Ohm

AC High Current & High Voltage Standards

This section is maintaining National Standards of AC High Current and High Voltage Ratios at power frequencies (50 Hz) by using Reference Standard Current Transformers and Reference Standard Voltage Transformers. Calibration services were provided for Current Transformers, Current

Fig. 2.10 : High accuracy electricity meter calibration bench

Transformer Testing Sets, Clamp Meters, Weld Testers, CT Burdens, Voltage Transformers, Voltage Transformer Testing Sets, HV Probes, Electrostatic Voltmeters (ESVMs), HV Breakdown Test Sets and Voltage Transformer Burdens etc.

The calibration facilities for the calibration of Current Transformer Testing Sets have been improved from ± 0.005% to ± 0.001% and all the Current Transformer related measurements are now traceable to International Standards.

The facility for the calibration of Voltage Transformers has been upgraded. The calibration range of voltage ratios has been extended from 40 kV/100 V to 100 kV/100 V (Fig. 2.11) and from 3 kV/100 V down to 100 V/100V at 50 Hz. The voltage ratio measurements

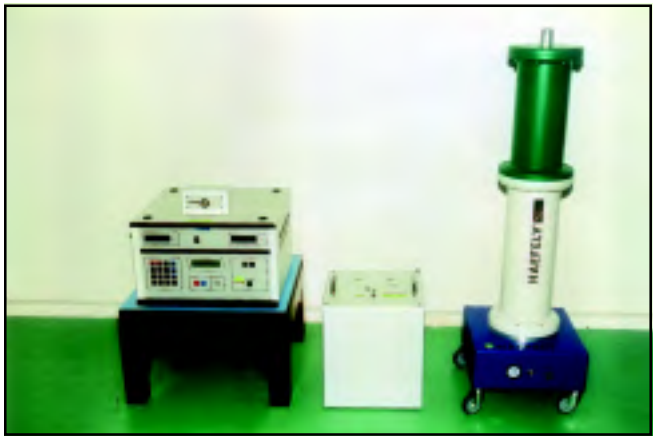


Fig. 2.11 : National Standards of AC High Voltage Ratio up to 100 kV/100 V at 50 Hz

are traceable to International standards with an uncertainty of ± 0.005%.

LF and HF Impedance Standards

This Group is maintaining primary standards of capacitance, Calculable Cross Capacitance, based on Lampard-Thompson theorem. The unit of inductance, Henry, is realized from capacitance using Maxwell-Wien Bridge. The unit of resistance, Ohm, is also realized from capacitance using Quadrature Bridge and other precision ac bridges. The ac voltage ratio is derived through absolute calibration of Inductive Voltage Dividers. This activity also provides apex level calibration for the above parameters at low and high frequency, to various calibration laboratories and R & D organizations.

As primary standards of HF impedance, a set of high precision coaxial reference air lines with traceability to calculable cross capacitor has been set up.

Quality System is implemented for LF Impedance. Peer was successfully conducted by technical expert of NML Australia, for 22 entries in Appendix C of BIPM.

Second proficiency testing in capacitance measurement for NABL accredited laboratories has been conducted in collaboration with NABL. In this programme 16 laboratories are participating including NPLI as Reference Laboratory. A 10 pF air capacitor is being used as traveling standard.

LF&HF Voltage, Current & RF Power Standards

Quality System as per ISO/IEC 17025 has been implemented. For this several documents such as Document Manual and all other quality system documents relating to requirements as per ISO/IEC 17025 have been prepared.

There are 303 CMC's in low frequency voltage and current parameters and 31 CMC's in RF voltage and power parameters in the appendix 'C' from this activity. Peer Reviews of all the 334 CMC's have been successfully completed during the months of January and

March 2004. Better measurement capability than what has been claimed in CMC table was demonstrated to the technical experts during these peer reviews.

An informal bilateral inter-comparison of ac-dc voltage transfer standard of 10 volt rating has been carried out at the frequencies of 1 kHz, 20 kHz, 50 kHz, 100 kHz, 300 kHz, 500 kHz and 1 MHz with the 10 volt thermal voltage converter of PTB, Germany. The results of this bilateral comparison show a very close agreement in the values of ac-dc transfer difference assigned to PTB thermal converter by both the laboratories at all the above frequencies.

RF Attenuation and Impedance

The calibration facilities in attenuation and impedance parameters established in the frequency range 30 MHz to 40 GHz in 50 ohm coaxial system and 3.95 to 40 GHz in waveguide system (G-band, Xn-band, X-band, Ku-band, K-band and Ka-band) are being used for the calibration of transfer standards of attenuation and impedance of various user organizations e.g. AMSE Air Force, Palam, ERTLs/ETDCs, BEL, ISRO, Naval Dockyard etc. Various documents have been prepared for the implementation of the quality system in the activity and five CMC entries included in the Appendix C of MRA have been peer reviewed during 22 – 26 March, 2004 for uncertainty values ± 0.02 dB/10 dB in attenuation and from ± 0.002 to ± 0.003 in reflection coefficient magnitude. An overview of the microwave laboratory is shown in Fig. 2.12.

Fig. 2.12 : An overview of the microwave laboratory

Magnetic Standards

NMR Gaussmeter, primary standard for the measurement of magnetic field was calibrated for frequency against the National Standard maintained by Time & Frequency Division. This NMR Gaussmeter was used to calibrate all the internal secondary & reference standards of the laboratory. The measurement uncertainty was evaluated. The calibrated instruments are used to provide calibration services to various industries, R&D organization etc.

The magnetic susceptibility of a small part of the F_2 class weight made by Austentitic stainless steel was measured in accordance with OIML recommendation R-111. This measurement is based on Guoy balance and susceptibility measured was 0.41 in SI unit.

To implement the quality system in our laboratory as per BIPM-MRA, calibration & test procedures were prepared.

Biomedical Measurements and Standards

Research on the electrical, ultrasonic, and physical characteristics of biological tissues was continued, to develop 'safety standards'. Acoustic lithotripsy research was also pursued to understand the actual mechanisms of disintegration of the stones under focused ultrasound. The development and establishment of standards and calibration facilities for electro-medical equipment is in progress, for better health care in the country. Study of biochips and MEMS-based pressure sensor has also been carried out.

Study of Biochips

Biochips are being studied to develop new type of sensors for biomedical and scientific applications. Different types of biological materials like bone, proteins and physiological liquids have been chosen for the basic measurements to identify a particular material for novel bio-sensing devices and systems.

MEMS Based Sensors

Basic measurements have been made on the semiconductor silicon material for the development of MEMS and micro-sensors for biomedical and industrial applications. Basic structure of the cantilever MEMS-based pressure sensor has been designed. The fabrication of the system is in progress.

A transducer analyzer is being procured for setting up the calibration and standardization facilities for the sensors and transducers and MEMS- based devices. The facility is to be unique in a country for checking the performance evaluation of various types of sensors and transducers. This would assist in the better design of the devices and for quality assurance of the equipment.

Bio-Simulator System

A new facility is being created by a using a standard Bio-Simulator System for the calibration and standardization of different types of electro-medical equipment like ECG, EEG, ENG, EMG, etc. The system has standard inbuilt calibrator. The facility is also been planned to be online with frequency, time, voltage and other necessary standard parameters available at NPL.

Basic Tissue Characterization

The ongoing research on ultrasonic, acoustic, electrical, thermal, dielectric and electro-optical parameters has been extended further on new biological tissues and materials media like skull and physiological cerebrospinal fluid, etc. The data obtained is useful to identify the type of abnormality of a particular tissue under such environments. The results are also useful to develop safety standards for the electrical and non-electrical parameters to be utilized for soft and hard tissues. Porosity and XRD studies on the teeth and dentures are made. Ultrasonic properties of bone cyst, malignant bone with osteosarcoma, uterine tumours, in vitro, have been studied further by using a double-probe through-transmission technique.

Evaluation of Coating Materials for the Preservation of Ancient Monuments

Different types of materials are being studied to be used as coating materials on the exposed walls of the ancient monuments, to protect them from weather conditions and to maintain their originality for longer period. This project is in collaboration with National Institute of Museology, New Delhi. XRD analysis has been made for different stones, with and without polymer as preservatives, for the elemental analysis. Ultrasonic properties of red stone samples, with and without the application of preservative materials, in this case polymers and chemicals, have also been studied.

ECG Standard facility

In order to have better healthcare in the country, an appropriate ECG calibration facility is being established, to avoid different measurements with different systems at different places. The patients will be comfortable if such facility is established for the country for better healthcare. The ECG machine has already been procured and studied for its standardization for various parameters against standard signals in the Laboratory.

Lithotripsy Research

The study of disruption due to transient cavitation phenomenon from the extracorporeal-shock-wave lithotripsy (ESWL) on the stone surface has been made. The shock wave from the ESWL, due to focussed ultrasound, is used to disintegrate the stone fragmentation faster. Based on experimental data, theoretical modelling of stress wave propagation in the renal calculi under focussed ultrasound has been studied and proposed.

New Knowledge Generated

The biological tissues, both soft and hard, have been characterized for thermal, ultrasonic and electrical properties. Modelling of stress wave propagation in the kidney stones under focused ultrasound has been studied. New programme on the establishment of biomedical standards is in progress.

इंजीनियरी पदार्थ
ENGINEERING MATERIALS

इंजीनियरी पदार्थ

इंजीनियरिंग पदार्थ प्रभाग के अन्तर्गत धातु एवम् मिश्रधातु, उन्नत कार्बन उत्पाद, मश्दु और पालीमरिक पदार्थ व द्रव्य क्रिस्टल अनुभागों का समूह है। यह विभाग पदार्थो के संसाधन और घटकों, युक्तियों तथा यंत्रो इत्यादि के विकास में कार्यरत है इन उच्च कोटि के निष्पादित और महत्वपूर्ण पदार्थो का उपयोग वैमानिक पदार्थो, मिश्रण, उन्नत कार्बन उत्पादों, विद्युत–प्रकाशीय–इलैक्ट्रॉनिक युक्तियों के निर्माण में किया जाता है। इनमें द्रव्य–क्रिस्टल, स्वास्थ्य संबंधी और विषैली–गैसों की मानीटरन युक्तियां भी शामिल हैं।

विभिन्न अनुसंधान और परिवर्धन संस्थानों व निजी तथा सार्वजनिक सेक्टरों द्वारा प्रयोजित, सहायक और परामर्श परियोजनाओं का संचालन सफलतापूर्वक पूर्ण किया है। इस वर्ष सीएसआईआर नेटवर्क की चार नयी परियोजनाएं शुरू की गई हैं।

ENGINEERING MATERIALS

The Division of Engineering Materials mainly comprises of Metals & Alloys, Advanced Carbon Products, Soft & Polymeric Materials and Liquid Crystals Groups. The division has been actively engaged in the material, process and technology development for components, devices and systems, in a variety of areas. These materials, for high performance and strategic applications, include aerospace metallic materials, composites, advanced carbon products, and electro-optical and opto-electronic devices, including liquid crystals, health-care and toxic gas monitoring devices.

Several development projects, including sponsored, grant-in-aid, collaborative and consultancy projects have been successfully completed for different R & D organizations, both, in the public and private sectors. This year four new CSIR Network projects have also been initiated.

Metals & Alloys

Development of different grades of Magnesium and Aluminium light weight alloys and their components

The work was mainly concentrated in developing light weight Magnesium and Aluminium alloys and their components mainly to evaluate their application for aerospace and automobile applications. The synthesis of Mg-alloy, with rare earth alloying additions (Mg-Zn-Y-Zr and Mg-Y-Zn), using spray forming followed by secondary processing, was taken-up under an on-going VSSC sponsored project. Under the In-house project, work was carried out to synthesize magnesium structural alloys (Mg-Al-Zn) using spray forming and characterize the products. Other project on secondary processing of Mg-alloys using Equal Channel Angular Extrusion Process (ECAP), which is state-of-the-art metal forming technology, was initiated.

The synthesis of Al-alloys (Al-12Si) employing spray atomization and deposition technique was also undertaken in order to obtain refined and equiaxed microstructure resulting in improved properties.

Magnesium Alloys

The main attractive feature of Mg-alloys is its low density (1.72 gm/cc) as it is one of the lightest engineering alloys and thus possesses high specific strength leading to potential weight saving in aerospace and automobile industry. The opportunities offered by magnesium alloys in terms of high specific strength, improved chemical resistance, good hot-forming, machinability and weldability characteristics have opened new avenues for their usage in aerospace and automobile industry.

The main driving force for the development of Mg-alloys using spray forming is the quest for lighter materials with better microstructural features leading to improved mechanical properties, which have prompted the development of these alloys. Currently, Mg-alloys are synthesized using conventional liquid metallurgy technique, which have an inherent problem of defects in form of microporosity arising due to gas entrapment, dendritic microstructure associated with casting and surface oxidation due to its affinity for oxygen, all of which are detrimental for its mechanical properties. However, these alloys synthesized employing spray forming have fine and reduced grain size resulting in a refined and equiaxed microstructure with no indication of dendritic features normally observed with cast alloys. The inert conditions required for atomization and deposition minimizes surface oxidation and other deleterious surface reactions, especially for reactive materials like Mg-alloys. All these lead to enhancement of mechanical properties of Mg-alloys synthesized using spray-forming technique.

Vikram Sarabhai Space Centre (VSSC) sponsored project entitled, "Spray forming technology of Magnesium alloys"

The main objective of this sponsored project was the development of spray forming technology for different Mg-alloy systems by optimization of process parameters for each system and to secondary process these spray formed products using hot forging and to supply 20 blocks of spray formed /forged plates to VSSC after characterization.

Under this project, work was taken up to spray-form Mg-alloys with Yttrium as rare earth alloying element, which increases the temperature capability of these alloys. Experiments were conducted to spray-form two systems of these alloys, namely, Mg-Zn-Y-Zr and Mg-Y-Zn alloy on the existing spray atomization and deposition unit using about 5–7 kgs of melt. Various process parameters such as melt temperature, gas pressure, flight distance, delivery tube etc., are being optimized in order to obtain as-spray deposits with good density, yield and fine equiaxed microstructure. The spray- formed products were secondary processed using hot-forging on the 500-ton vertical hydraulic press.

Complete metallurgical, microstructural characterization and mechanical testing of these spray-formed products is also being carried out at NPL and simultaneously these are characterized at VSSC,

Thiruvananthapuram. It was observed that the elongation improved on spray forming followed by forging, but the tensile strength only improved marginally. Efforts are presently underway to improve the tensile strength by optimizing the primary and secondary processing parameters.

12 spray-formed blocks of Mg-alloys, with Yttrium as rare earth alloying element, in two different alloy systems, have already been supplied to VSSC for testing and evaluation. Work is currently underway for completing the process parameter optimization of spray forming for Mg-alloys with Yttrium as alloying additions based on the mechanical and metallurgical characterization results and to finally supply the remaining spray-formed blocks of Mg-alloy to VSSC, Thiruvananthapuram.

Development of Light Metals/Alloys and their Component

Under this in-house project, work was carried out to spray-form Mg-alloy (Mg-Al-Zn) using the existing spray atomization and deposition unit. Various process parameters were optimized in order to obtain dense product with low grain size. Typical yields of the spray formed Mg-alloy deposits were found to be in the range of 60-65% of the weight of the melt. Microstructural characterization using optical microscopy, scanning electron microscopy, X-ray diffraction, and mechanical characterization using universal testing machine has been carried out on the spray formed products. The as-sprayed deposits of these alloys had a fine-grained microstructure with a density of about 93-95% of the theoretical density.

These as-sprayed Mg-alloy deposits were secondary processed employing forging technique using the specially designed forging tooling on a 500-ton vertical hydraulic press. Various forging parameters were optimized so as to obtain a dense product without any cracks. The density of the sprayed Mg-alloy deposits after forging was found to increase to near the theoretical density. The mechanical properties of the hot-forged Mg-alloy were found to be slightly higher than those of the equivalent ingot product. However, the hot-forged alloy exhibited high elongation values (~10 %) over those of the equivalent ingot product (~7-8%) which could be attributed to microstructural refinements achieved by spray forming and forging processing.

The optical microscopy of the cast Mg-alloy starting material indicated a non-uniform microstructure with average grain size of about 200–300 μm. Fig. 3.1 shows the microstructure of the spray-deposited and forged Mg-Al- Zn alloy. This figure clearly shows equiaxed microstructure consisting of 40–90 μm cells of magnesium. Efforts are underway to further optimize the process parameters in order to obtain fine-grained microstructure throughout the as-sprayed deposit and to improve the mechanical properties of the spray-formed and forged products.

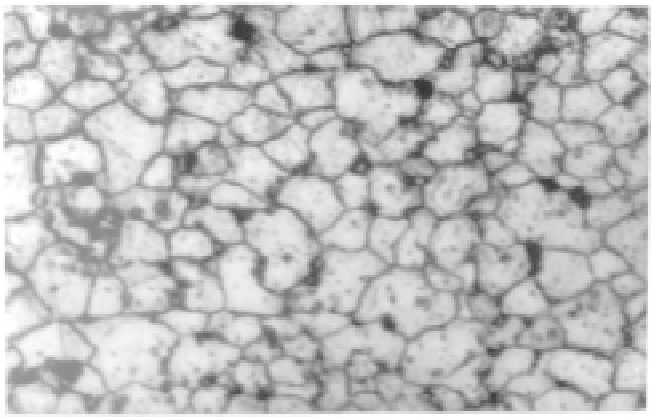


Fig. 3.1 : Microstructure of spray formed Mg-alloy AZ 31 (X 300) (etched in acetic-picral)

Secondary processing of Magnesium Alloys using Equal Channel Angular Extrusion

Equal Channel Angular Extrusion Process (ECAP) is an important state-of-the-art metal forming technique that is capable of producing uniform severe plastic deformation in a variety of materials, without causing significant change in geometric shape or cross section. ECAP realizes the method of 'Simple Shear' which can be considered as a 'near ideal' deformation method for

structure and texture formation in metal-working. One of the main advantages of this technique is the uniform and unidirectional deformation that can be produced under relatively low pressure for massive products. Multiple passes in ECAP leads to high plastic strain in the bulk material, thereby refining the microstructure. More importantly, by changing the orientation of the billet between successive passes, complex microstructures and textures can be developed.

Developmental work has been initiated to produce ultra-fine grained microstructures in bulk Mg-alloys using Severe Plastic Deformation (SPD) technique. Experiments are underway employing Equal Channel Angular Extrusion to obtain finely-grained microstructures in Magnesium alloys (Mg-Zn & Mg-Al) in order to improve their mechanical properties. The total set-up consisting of the die assembly for ECAP experiments was designed and got fabricated for an included angle of 120° and a few trial runs for the processing of Mg-alloys using this technique were conducted. Initial trial experiments using the 120° angled die were carried out on Mg-alloys. Work is presently underway to modify the die design and fabricate fresh sets of die assemblies with 105° and 90° die-angles for further experiments. Furthermore, the hydraulics of the existing set-up is also being modified by incorporating hydraulic back pressure to the existing system for more effective performance.

Extrusion Technology for Magnesium Alloys

A MoU was signed by Dr. Vikram Kumar, Director, NPL and Dr. Alan Taub, Executive Director, General Motors (USA) for a project on the Development of Extrusion Technology for Magnesium alloys, to be undertaken by NPL. The main objective of this project is to optimise extrusion process parameters (die design, temperature, strain rate and extrusion ratio) and to carry out detailed characterization to obtain high quality extrusions with improved strength and ductility. This project although has been sanctioned, in principle, but a final approval from General Motors, USA, is still awaited.

Aluminium alloys

The synthesis of Al-alloys (Al-12Si) employing spray atomization and deposition technique was undertaken in order to refine the microstructure resulting in improved mechanical properties. Some preliminary work was also done to synthesize Al-Si alloys/SiCp metal matrix composites, using stir-casting technique.

Spray forming of Al-Si alloys (Si~12%)

Al-Si is an important material due to its properties, like high wear resistance, low CTE, high thermal conductivity and good strength. These properties make it suitable for automobile piston application.

Under an in-house project, a few preliminary experiments were conducted to spray deposit Al-Si alloys (Si ~12%) on the spray forming unit. The mother alloy used for spray forming exhibited a typical dendritic microstructure with needle-shaped Si embedded in a Al-alloy matrix, as shown in Fig. 3.2. However, on spray

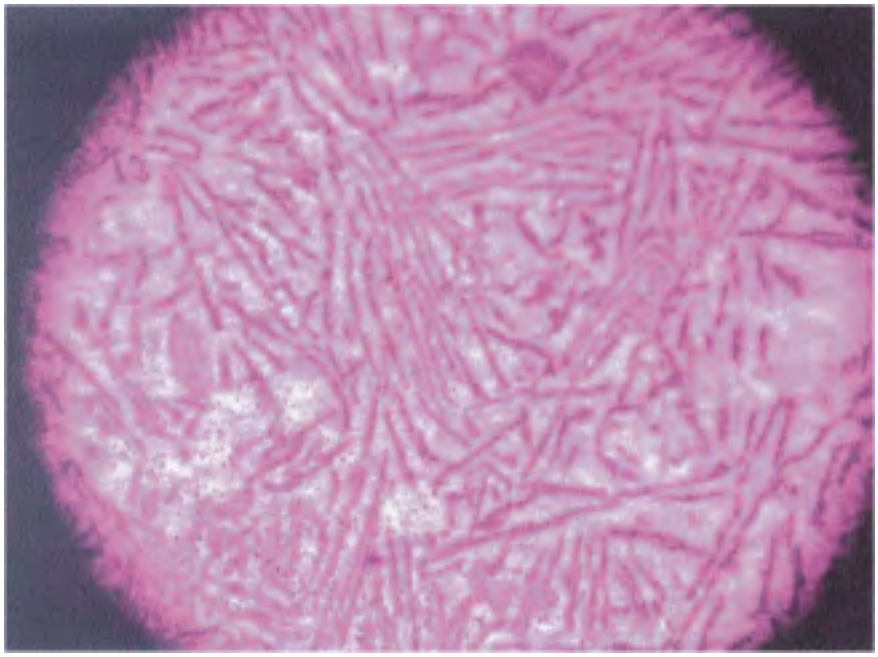


Fig. 3.2 : Microstructure of cast Al-Si alloys (X 200)

forming the cast dendritic structure of the mother alloy was broken down and a finely grained necklace-type microstructure was obtained, with finely shaped micron sized Si particles nucleating on the grain boundaries of the Al-matrix, as is clearly evidenced from Fig. 3.3. This work will be continued to spray deposit hypereutectic compositions of Al-Si alloys (Si > 12 wt%) employing rapid solidification processing.

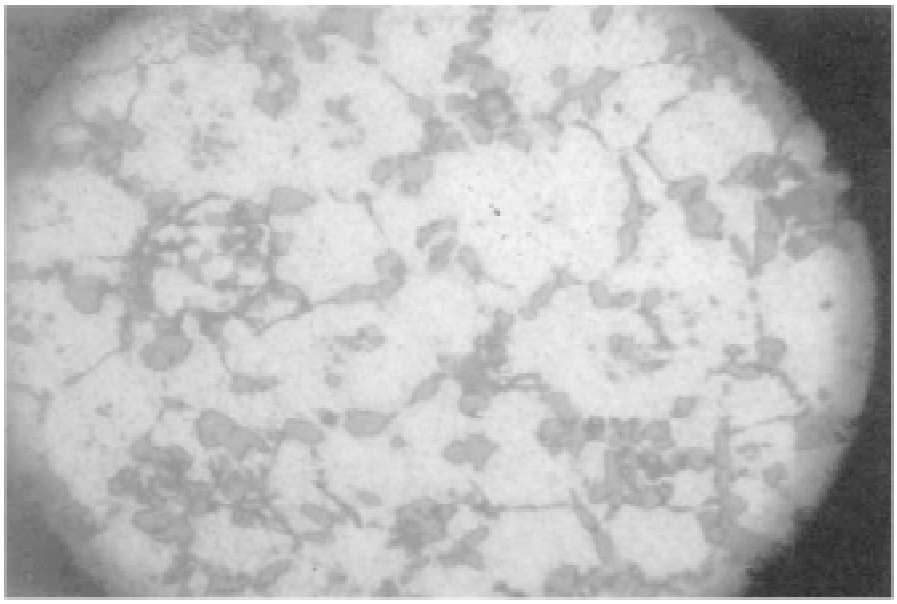


Fig. 3.3 : Microstructure of spray formed Al-Si alloys (X 500)
(Etched in Kellers Reagent)

Synthesis of Al-Si/SiCp Metal Matrix composites using stir-casting technique

Efforts were continued in an in-house project for the development of Metal Matrix Composites using stir-casting vortex technique employing mechanical stirring. Preliminary experiments were carried out to synthesize metal matrix composites with Al-12Si as the matrix material and 5 wt% of SiCp as the reinforcement. The results indicated a non-uniform dispersion of the reinforcement in the Al-Si matrix with a lot of agglomeration of reinforcement particulates in the matrix. Work is underway to improve the dispersion of SiCp in Al-Si to improve the distribution of reinforcement in the Al-Si matrix.

Development of Oval Shaped Tube as Skid Landing Gear for Advanced Light Helicopter

This project was sponsored by Hindustan Aeronautics Limited, Bangalore, and was sanctioned in two phases and formed the technology development package for the development of oval shaped tube as skid landing gear for Advanced Light Helicopter. After successfully demonstrating the technology developed for the Oval Shaped Tube as Skid Landing Gear for Advanced Light Helicopter, an official communication has been received from Hindustan Aeronautics Limited, Bangalore, mentioning that the development of oval skid tube followed by subsequent annealing and heat-treatment of skids have been successfully completed.

Advanced Carbon Products

Development of Carbon-Ceramic Composites

C-SiC-B_4C composites refer to a special class of carbon based materials which cover the main drawbacks of carbon, particularly its proneness to air oxidation, while essentially retaining its good properties. Several series of experiments were conducted to develop C-SiC-B_4C composites exhibiting high oxidation resistance at temperatures in the range of 800-1200°C. The aim of the experiments was to study the effects of carbon-to-ceramic and ceramic-to-ceramic ratios on the oxidation behaviour and other characteristics of the C-SiC-B_4C composites. Good compositions of composites made in the form of small rectangular plates using unidirectional moulding have been found out, which have shown almost zero weight loss (<0.5%), or even weight gain, referring to high oxidation resistance at temperatures of 800-1200°C

for a residence time of 3–10h. Significant improvement in the strength of C-SiC-B_4C composites has been observed which increases with an increase in the total ceramic content and the SiC : B_4C ratio. Further work including isostatic moulding of the C-SiC-B_4C composites is in progress.

Carbon Nanotubes

Carbon nanotubes were synthesized using different systems. Various parameters, e.g., He gas pressure, voltage, current etc., were optimized and good reproducibility was established to produce carbon soot containing nanotubes. Detailed characterization through SEM, TEM, TGA and XRD revealed that the soot contained at least 50% of carbon nanotubes. Systematic studies are in progress to isolate the pure nanotubes from these carbon deposits.

Synthesis of Silicon Carbide Nanofibres

Silicon Carbide (SiC) nanomaterials possess excellent oxidation resistance apart from improved mechanical properties and are suitable candidates for the development of metal matrix and ceramic matrix composites with superior mechanical and thermal properties. Preliminary investigations were carried out to synthesize SiC nanofibres by combining polymer blend and sol-gel techniques.Silicon alkoxides were hydrolysed along with the thermoplastic polymer having a carbon residue on pyrolysis and the resulting polymer incorporated with sol-gel silica was heat treated to 1400°C to get a mixture of SiC nanofibers, carbon and traces of silica. Carbon in the mixture was removed by oxidation at 700°C and the formation of SiC nanofibres was confirmed through SEM and TEM studies. Further work is in progress to synthesize SiC nf using different alkoxides and polymers.

High Thermal Conductivity Carbon-Carbon Composites

PAN based T-300 carbon fibres were used to develop carbon-carbon composites of size 150 mm x 50 mm x 5mm. The main objective of these studies was to improve the density of the carbonized composites after first carbonization cycle (HTT = 1000°C) to at least 1.5 g cm^{-3}. Experiments were performed with different fibre volume % , namely, 50%, 55%, 60% and 65%. A modified pitch with a softening point of 214°C and coking yield of 76% was developed and used for the fabrication of green composites. It was observed that by increasing the fibre volume content to 60%, the density of the carbon-carbon composites after two impregnation cycles got increased to a value of 1.47 g cm^{-3} which is a significant achievement. Further experiments are in progress in this direction.

Development of Low-PAH Coal Tar Pitch

Work was initiated on development of coal tar pitches with a reduced content of polycyclic aromatic hydrocarbons (PAHs), under a project sponsored by the Ministry of Environment & Forests, New Delhi. Two methods, both involving the physical removal of B(a)P, namely, (1) distillation under partial vacuum and (2) solvent extraction of coal tar pitches, were employed. It was observed that both the methods are able to reduce the B(a)P content in both the varieties of coal tar pitches – a binder-grade pitch and an impregnating-grade pitch. However, the solvent extraction method appears to be better of the two because, for similar yield of the resultant pitch, it causes a considerably higher decrease in the B(a)P content along with a much lower increase in the other characteristics of the resultant pitches. Further work including the use of inexpensive/ industrial solvents for the purpose of solvent extraction is in progress.

Consultancy Project

The on-going consultancy project, sponsored by M/s. Graphite India Limited, Bangalore, on the 'Upscaling of green coke based high density graphite technology' was continued. The company's engineers were advised to develop the intermediate coal tar pitch and imparted training to develop the green coke on a 3 kg batch size. The green coke was ground into a fine powder and

characterised. The isostatic moulding of the green coke powder into blocks and their subsequent carbonisation to 1000 °C, followed by graphitisation to 2600 °C, are in progress.

Polymeric & Soft Materials

Conducting Polymers

Synthesis of Conducting Polymers

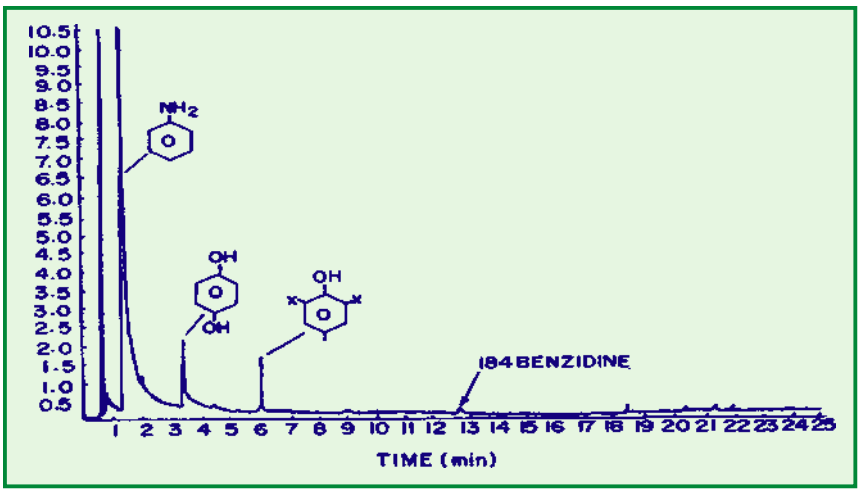


Fig. 3.4 : GC-Mass Spectra of filtrate obtained during synthesis of polyaniline using inorganic protonic acid

There are number of conducting polymers that have been developed so far but polyanilines, poly (3,4-ethylenedioxythiophene) and substituted poly (phenylene- vinylenes) have been the subject of intensive research because of their technological applications in number of devices, such as, electrostatic charge dissipation (ESD), electro-magnetic interference (EMI) shielding, organic light emitting diodes (OLED), opto-electronic devices, corrosion prevention, super capacitors and sensors.

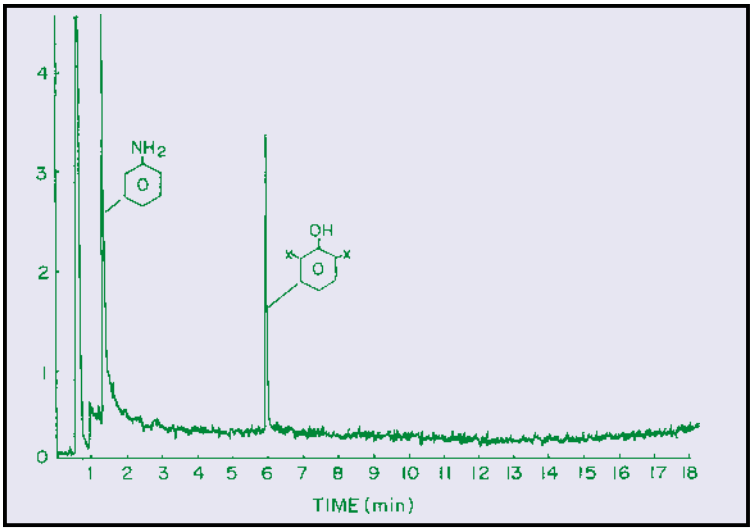


Fig. 3.5 : GC-Mass Spectra of filtrate obtained during synthesis of polyaniline using organic protonic sulphonic acid

Polyaniline stands for its ability to form processable conductive form which is environmentally stable. However, the presence of benzidine moieties is the polymer backbone, which might yield toxic products, have hampered its technological utility in numerous industrial groups. We, at NPL, have synthesized polyaniline which is processable and free from benzidine and thus can be used for many industrial devices. GC-mass spectra of the polyaniline, synthesized in conventional inorganic acid medium (Fig. 3.4) and that synthesized in specific organic dopant system, shows the absence of benzidine (Fig. 3.5.)

Polymerization of aniline in the presence of mixed dopants has yielded a polymer which is processable and soluble. It has been observed that the resultant conducting polymer possesses better thermal stability and processability compared to when the synthesis had been carried out in the presence of conventional aromatic dopant system. Blending of conducting polymers doped with mixed dopants was carried out with conventional insulating polymers like low-density polyethylene (LDPE), acrylonitrile-butadiene-styrene (ABS), polystyrene (PS) etc. Blends so obtained have been tested for their utilization as antistatic composite materials.

Synthesis of conducting polymer polyaniline in the presence of ferrofluids and ferro-organic dopants have yielded quite interesting polymers and the resultant polymers are under investigations and their characterization is being carried out. Flexible conducting polymer ferro-fluid composites have been

designed which can find applications in EMI shielding, ESD, microwave absorption and radar absorbing materials (RAM)

Conjugated polymers based on benzene have been of interest for their applications in organic light emitting diode devices. These polymers may challenge the conventional materials used in the fabrication of OLED devices. NPL has synthesized some of these conjugated polymers and the devices are being tested in OLED lab for electroluminescence studies.

Organic Light Emitting Diode

There is a growing interest all over the world in the electroluminescence of organic materials. This is due to the prospect of it being used in high density flat panel displays. NPL is working in the field of organic electroluminescence for the last four years. We have the facility to synthesize small molecules and conjugated polymers as well as the facility to fabricate organic LEDs using these materials.

Among these electroluminescent conjugated polymers, poly(2-methoxy), 5-(2'-ethyl-hexyloxy-p-phenylene vinylene) (MEH-PPV) is a very important polymeric material which has got high luminescence properties as well as the required electrical and mechanical properties for polymer LED applications. NPL has succeeded in synthesizing this key material. The photoluminescence spectra of NPL synthesized MEH-PPV is given in Fig. 3.6.

The electrical and photoluminescence characteristization of MEH-PPV are in progress. Blue electroluminescent materials are very important for the development of full colour organic light emitting diodes. The laboratory is also working on the synthesis, characterization, and fabrication of devices based on small molecules. One of the important material in this regard is the blue emitting aluminum complex material $AlqM_2OH$. This material has been prepared by the reaction of methyl substituted hydroxy quinoline with aluminum hydroxide. The new material has been characterized using optical and infrared spectroscopy, thermo-gravimetric analysis and luminescence spectroscopy.

A comparative study of luminous efficiency of our new materials with Alq_3 obtained from Aldrich (Fig. 3.7) was done. The PL efficiency of $Almq_2OH$ and Mg (mq) were compared with Alq_3 obtained from Aldrich (99.5%).

Our result shows that the PL efficiency of $Almq_2$ (OH) is about four times more fluorescent than commercially available Alq_3. The device fabrication and performance analysis of organic light emitting diodes is in progress at NPL.

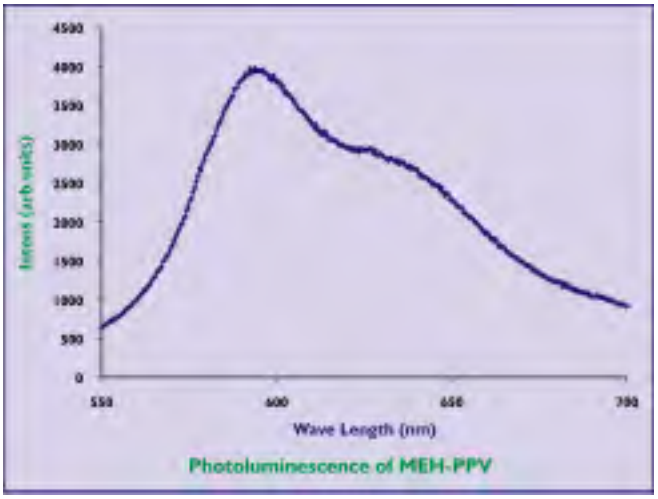


Fig. 3.6 : Photoluminescence of MEH-PPV

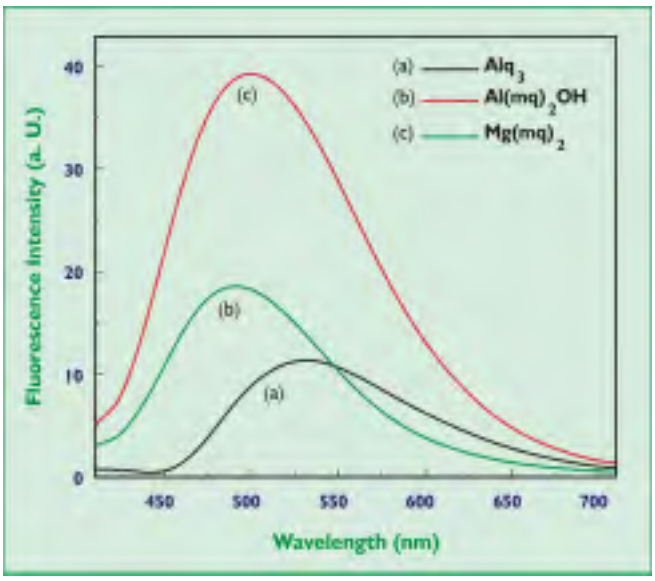


Fig. 3.7 : Solid state fluorescence spectra; excitation 400nm

Development of Polymeric Sensors

Prepared doped and undoped polyaniline thin film sensors for detection of geotricum (bacteria responsible for milk spoilage) and microbacterium Tuberculosis (TB). We have studied at NPL the optical, electrical and structural characterization of the vacuum deposited ployaniline thin films by SEM, X-ray and electron diffraction techniques. These thin film polymer based microbial detectors are inexpensive, and are operated at room temperature, and thus have the advantage of remote positioning and monitoring at hazardous places. We have also studied the preparation of behavioural acceptance test on the above mentioned sensors for sensitivity, selectivity, specificity, response time, decay and recovery towards geotricum and microbacterium tuberculosis. Initiated the necessary electronics for development of audio/ visual alarm. Basic studies on vacuum deposited polyaniline thin films like measurement of thermal properties form room temperature to 170^{0}C and band gap determination from reflectance measurement have been carried out.

Biomolecular Electronics

Polyaniline Based Micro-actuator

An experimental set-up has been designed and fabricated to study the electrochemical properties of a thick film of conducting polymer under load (Fig. 3.8). Extension of the films versus voltage has been measured in terms of change in capacitance of parallel plate capacitor constituted by metals pan and a fixed metal plate. HP 4284A impedance analyzer measures absolute value of the capacitance. Change in capacitance is related to change in distance by pre-calibrating the assembly using travelling microscope. A computer programme is developed to convert the capacitance value with the corresponding distance and simultaneously plotting the graph between changes in length of polymer film versus applied voltage (Fig. 3.9). The assembly has been used to study the electrochemome-chanical behaviour of solution cast polyaniline films (~50μm thick). During first cycle the length is enhanced by about 6% of the original value, while repetitive value of extension is ~2.8% in subsequent cycles.

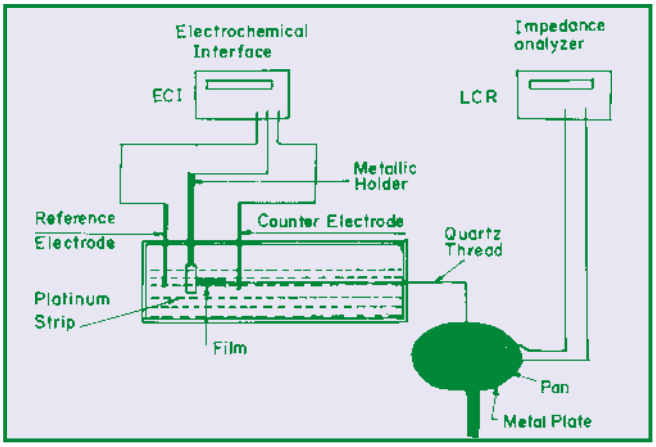


Fig. 3.8 : Experimental set-up for studying the ECM properties of conducting polymer films.

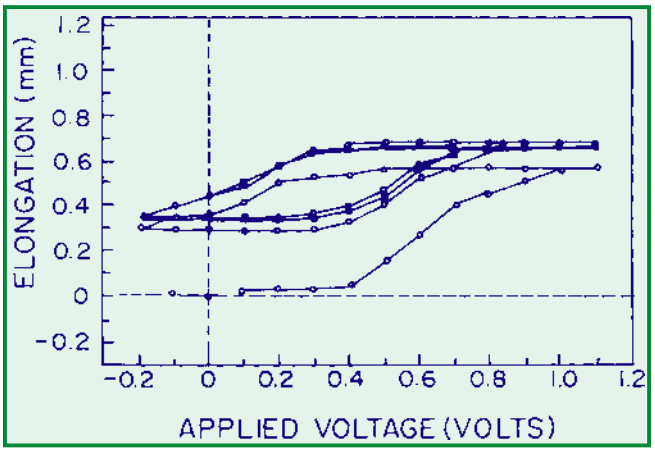


Fig. 3.9 : Plot of distance versus capacitance (i.e. calibration of the instrument)

Cholesterol Biosensor

Cholesterol esterase (ChEt) and cholesterol oxidase (ChOx) enzymes have been physically adsorbed on electrochemically prepared Poly (An-FAn) polymeric films (Fig. 3.10). ITO glass plates have been used as substrate for film deposition. The attempts were made to characterize these Poly (An-FAn) based enzyme films with respect to the effect of cholesterol palmitate and cholesterol concentration, applied potential, pH, temperature and storage time, using spectrophotometric and amperometric techniques.

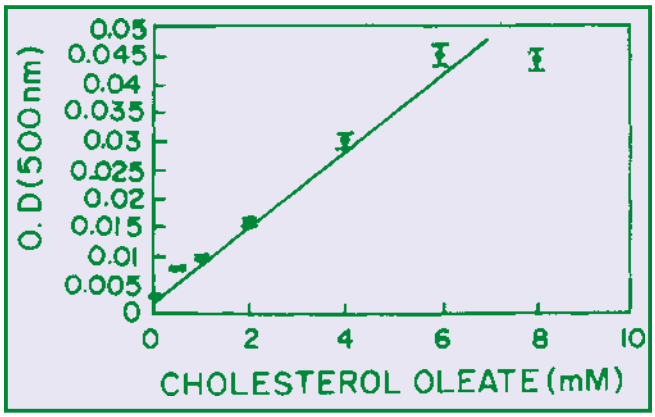


Fig. 3.10 : Photometric response of poly(An-FAn)/ChEt/ ChOx enzyme films as a function of cholesterol oleate concentration (mM)

DNA Biosensor

Polypyrrole films have been synthesized electrochemically on platinum disc electrode and DNA was physically adsorbed on it. After the immobilization of DNA on polymeric films, it was used to study the effect of various toxicants such as o-chlorophenol on oxidation current. DNA has conducting property due to movement of electrons through oxidation of guanine base. When o-chlorophenol forms an associated molecule with DNA it obstructs the flow of electrons. This causes reduction in oxidation of guanine and reduced current is observed. The effect of o-chlorophenol on the oxidation peak is shown in Fig. 3.11.

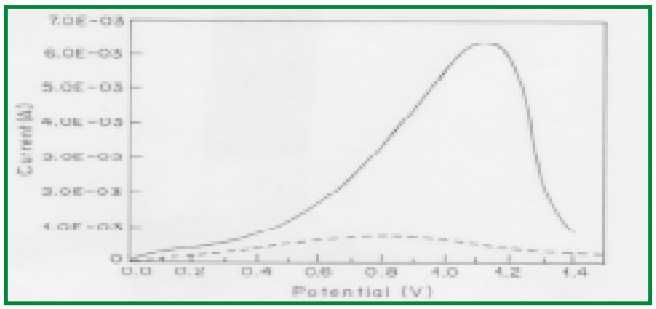


Fig. 3.11 : Effect of 100 ppm O-Chlorophenol on oxidation of DNA

Glucose Biosensor

Glucose biosensor based on poly-3-hexyl thiophene

Glucose biosensor based on poly-3-hexyl thiophene Langmuir-Blodgett films has been fabricated. These Langmuir-Blodgett films have been prepared by simultaneous entrapment of glucose oxidase and transferred onto the indium-tin-oxide coated glass plates. The P3HT/SA/GOX electrodes have been characterized by FTIR spectroscopy and response studies have been performed with respect to glucose concentration, temperature and storage time. The linearity was achieved in the range of 100 to 500 mg/dl with shelf life of about 75 days. Fig. 3.12 shows the response current of a P3HT/SA/GOX electrode as a function of temperature. These electrodes could withstand the thermal stability up to 45°C. It can be observed that these P3HT/SA/GOX electrodes can be used for the estimation of glucose over a wide range of temperature, i.e., from 30°C to 45°C.

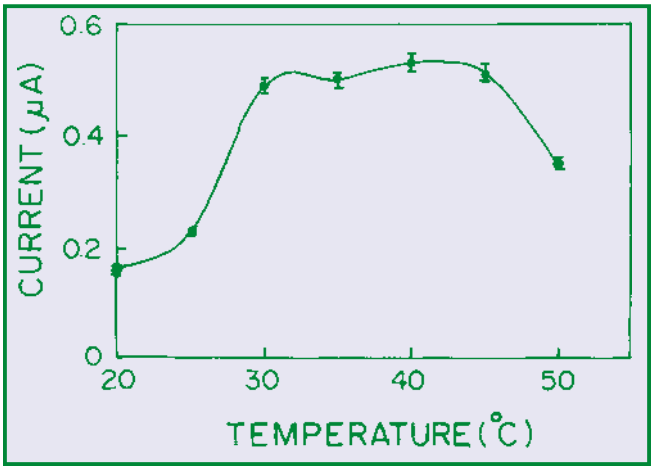


Fig. 3.12 : Response current of a P3HT/SA/GOX electrode as a function of temperature in presence of 100 mg/dl glucose concentration

Glucose biosensor based on the poly(2-fluoroaniline)

Poly(2-fluoroaniline) has been electrochemically deposited on the ITO coated glass plates in the forms of thin films using 4M perchloride acid as electrolyte. Glucose oxidase (GOX) has been immobilized on to these electrochemically deposited conducting poly(2-fluoroaniline) films by physical adsorption method. The redox characterization of Poly(2-fluoroaniline) and Poly(2-fluoroaniline)/GOX films has been carried out by cyclic voltametry techniques. The electrode carrying

GOX was found to be stable upto 32 days. The amperometric response of the Poly (2-fluoroaniline)/ GOX electrodes at different glucose concentartion (1.0-33 mM) and found to be linear from 1.0 to 18 mM (Fig. 3.13). The response time of these Poly (2-

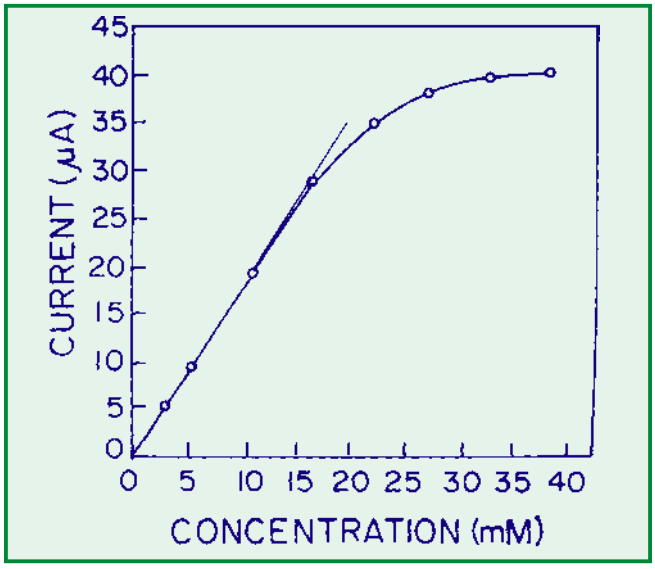


Fig. 3.13 : Amperometric response of poly(2-fluoroaniline)/GOX films obtained as a function of glucose concentration

fluoroaniline)/GOX electrodes was found to be about 70 s.

Lactate biosensor

Lactate biosensor has been developed based on electrochemically entrapped polyaniline into sol-gel derived tetraethyl orthosilicate (TEOS) films coated on ITO glass plates. The ITO/sol-gel/PANI electrodes were utilized to fabricate a lactate biosensor based on actate dehydrogenase. A sol-gel/PANI composite obtained through elector-entrapment was found to provide environmental stability to the biosensor. Increased stability and linearity as the biosensor were also observed before and after polyvinyl chloride (PVC) coating. The amperometric response of the electrodes under optimum conditions exhibited a linear relationship from 1mM to 4mM. These sol-gel/PANI/LDH electrodes have a response time of about 60 s, a shelf life of about 8 weeks at 0-4°C. The linearity of the sol-gel/PANI/LDH electrodes obtained by coating an external layer of PVC on to these electrodes has been found to be up to 10 mM for lactate with a correlation coefficient of 0.89.The effect of the pH on the response of sol-gel/PANI/LDH films with and without a PVC coating is shown in Fig. 3.14. Table 3.1 represents the effect of interferents

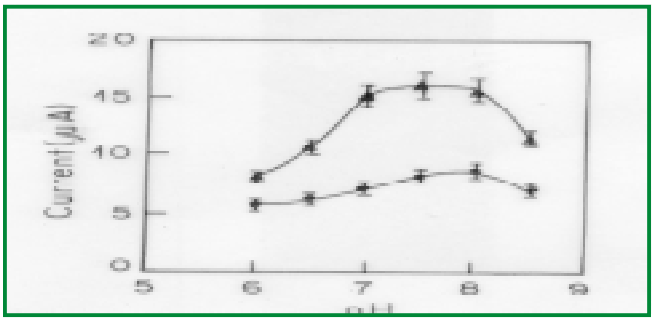


Fig. 3.14 : Effect of the pH on sol-gel/PANI/LDH electrode to 5 mM lactate before a PVC coating and after a PVC coating

i.e. glucose, uric acid, ascorbic acid and glutamic acid etc. The response of sol-gel/PANI/LDH films with and without PVC coated in the presence of glucose (100 mg/dl), ascorbic acid (25 mg/dl), uric acid (35 mg/dl) and glutamic acid (25 mg/dl) were observed. Results were obtained that the effect of interferents was much more in the sol-gel/PANI/LDH films compared to films coated with PVC.

Table 3.1 : Effect of common interferents on the response of sol-gel/PANI/LDH electrode

Interferent	Response without PVC coating A		Response with PVC coating A	
	Before addition	*After addition*	*Before addition*	*After addition*
Glucose (100mg/dl)	*15.6*	*16.8*	*7.2*	*7.58*
Uric acid (35mg/dl)	*15.6*	*16.4*	*7.2*	*7.60*
Glutamic acid (25mg/dl)	*15.6*	*15.9*	*7.2*	*7.48*
Ascorbic acid (25mg/dl)	*15.6*	*17.1*	*7.2*	*7.63*

Liquid Crystals

Liquid crystals constitute a fascinating phase of condensed matter in between isotropic liquid and anisotropic solid.

There are several types of liquid crystalline phases like nematic, smectic, discotic etc. In smectic structure the molecules are packed in layers, side by side within the layer but end to end from one layer to another. The chiral tilted smectic phases show the ferroelectric behaviour. In ferroelectric liquid crystal molecules, where the layers are arranged in the form of helix and can be suppressed either by surface effect or by applying an electric filed. It (helix suppression) can be achieved by making thickness of the cell less than the pitch value so that surface effect is strong enough to unfold the helix. Such a phenomena is known as surface stabilized ferroelectric liquid crystals (SSFLC) and shows bistable or memory effects.

Another kind of chiral smectic phases, where pitch value is very short i.e. less than 1μm, are called deformed helix ferroelectric liquid crystal material. It uses a short-pitch mixture, where the smectic planes are oriented perpendicular to the bounding glass substrates. It is a linear effect and has no inherent bistability and as consequence, DHFLC exhibit no inherent optical threshold voltage. Another greatest advantage over the other FLCs is that the grey scale can easily be obtained using DHFLC material. It has been predicted and demonstrated at NPL that bistability is also possible in DHFLC at certain critical voltage and frequency region.

Bistability or Memory effect in surface stabilized ferroelectric liquid crystals (SSFLC) has been studied well but very few studies have been reported in the literature in case of Deformed helix ferroelectric liquid crystal (DHFLC). Recently at NPL, it has been tried to find out the critical conditions for bistability in DHFLC material. Bistability in DHFLC is based on electro-mechanical effect of helix deformation due to electric field. Bistability in DHFLC can be thought in a similar way, like the difference between ferromagnetic material and permanent magnet. It is a well established fact that when a ferromagnetic material is placed in uniform magnetic field, then small domains coalesce to form single domain. The spin-spin interactions come into play when the magnetic field is switched off and the sample becomes permanent magnet. On the same analogy, it might be possible that bistability in DHFLC exists due to helix unwinding under the application of electric field in which the dipolar interactions play a dominant role. As supported by the experimental results, elastic deformation may not be the only reason behind the memory since the memory is not transient. As experimentally observed, the memory effect is long lasting which implies that the elastic deformation energy is getting balanced by the dipolar interactions.

Fig. 3.15 shows the optical response of DHFLC at 20 volts and 10 Hz frequency. As one can see from the figure, optical transmission changes from maximum to minimum or vice-versa as applied field pulse reverses its polarity and there is almost no change when the applied pulse attains its 0 volt state. At higher frequency of 500 Hz (Fig. 3.16), there is degradation in the optical transmission at 0 V state, suggesting that at higher frequencies the memory state is not favoured. The memory effect in DHFLC material is also dependent on the applied voltage as shown in Fig. 3.17, even if the applied frequency is low (100 Hz). Therefore, the memory effect in deformed helix ferroelectric liquid crystal material depends on applied voltage and frequency unlike in other types of memory devices based on liquid crystal materials. The detailed dynamic study of such memory devices of DHFLC material is being carried out by electro-optical and dielectric spectroscopic methods.

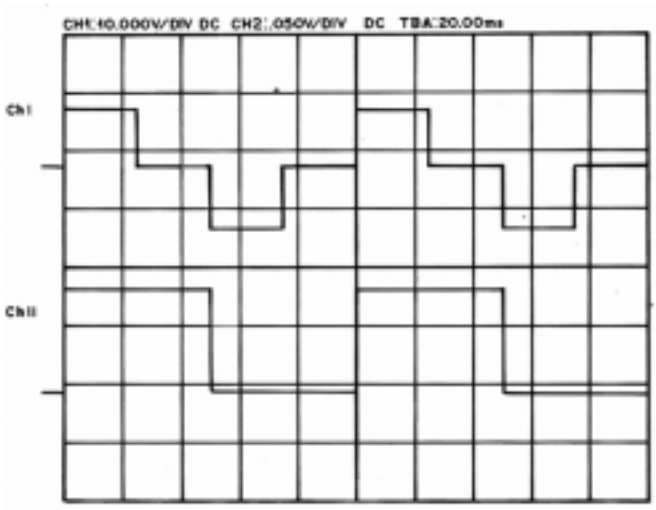


Fig. 3.15 : Optical response of deformed helix ferroelectric liquid crystal (DHFLC) at 25°C in 3µm cell at 20V and 10Hz

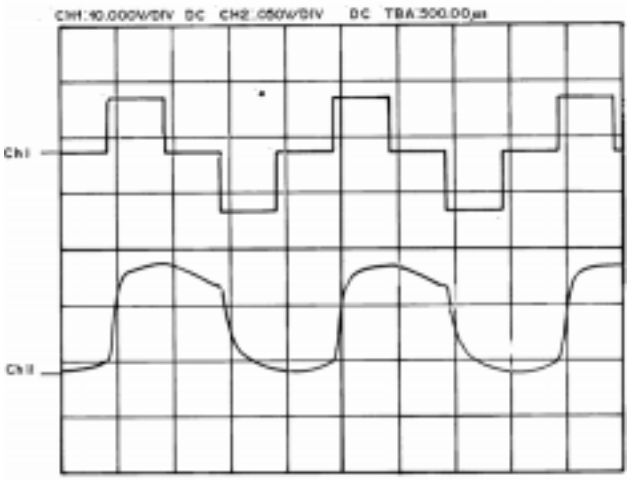


Fig. 3.16 : Optical response of deformed helix ferroelectric liquid crystal (DHFLC) at 25°C in 3µm cell at 20V and 500Hz

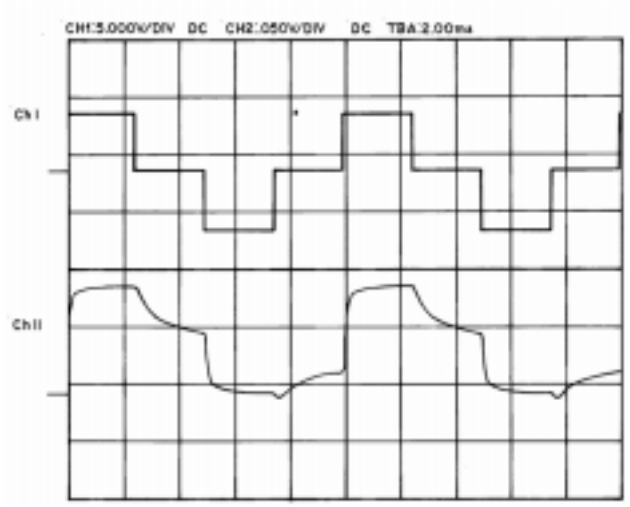


Fig. 3.17 : Optical response of deformed helix ferroelectric liquid crystal (DHFLC) at 25°C in 3µm cell at 10V and 100Hz

Development of Sun Reflecting Glass

The essential optical coating in sun reflecting glass is palladium, silver or gold doped titanium dioxide film on glass substrates. The titanium dioxide film with high refractive index controls the reflectance where as the addition of Pd/Ag/Au dopands controls the absorption of solar sun spectrum. In this manner, buildings appear outwardly uniformly reflective.

Aesthetic appearance: White light transmission is controlled in accordance with sun exposure to minimize the cooling costs.

Presently, the titanium dioxide films can be prepared by physical vapour deposition technique, such as, vacuum evaporation and sputtering technique, chemical vapour deposition at normal and reduced pressure, sol-gel process by dip coating and spraying processes. In the vacuum coating technique, the substrate is held in a vacuum chamber and titanium dioxide is evaporated and then allowed to deposit on the surface of the substrate. The deposition can be carried out in vacuum unit in different ways, e.g., thermal evaporation, cathode sputtering, DC sputtering, RF sputtering and magnetron sputtering etc.

Dip coating process competes with vacuum coating method, spraying process and chemical vapour deposition process. The dip coating method has been explored and tested for technical feasibility and cost viability and has many advantages over the vacuum coating technique. The advantages of sol-gel process are:

(i) High degree of film thickness uniformity.

(ii) Simple thickness control

(iii) Better controlled stoichiometry

(iv) Low processing temperature

(v) Bigger sizes of substrates can be coated uniformly

(vi) Multi-layer deposition with widely varying optical characteristics

(vii) Applied to odd shaped substrates like tubes, pipes and rods.

Liquid Crystals and Self-Assembled Monolayer

Development of soft lithographic techniques for micro and nano-fabrication

Creation of small structures with feature sizes ranging from a few microns to sub-micron is of great technical relevance to materials science & engineering and biological sciences. Conventional photo-lithography is used routinely to fabricate

structures down to ~0.50 micron features in VLSI. The facility is prohibitively expensive and poses severe limitations for smaller feature sizes. Moreover, it has very little control over the surface properties of the structures that are very vital for chemical and biological applications. Soft lithographic technique utilizing micro-contact printing (μCP) of self-assembled monolayers (SAMs) has great potential in micro and nano-fabrication and would greatly compliment conventional photolithography.

Micro-patterning using micro contact printing, one of the variants of soft lithography, has been exploited to fabricate small structures on solid surfaces for microfabrication, sensors-arrays, MEMS and biological applications. It is an alternate (non-photolithographic) technique to create patterns in metal thin films on a substrate with feature sizes in sub-micron to micron range. It comprises of soft contact printing of SAM precursor solution using an elastomer stamp that contains the relief structures. The SAM solution is transferred to the well-defined regions on substrates having micron and sub-micron sizes. The surfaces derivatized with SAM serves as nano-thick etch resist and the uncoated surfaces could be etched in standard metal etchants. Micro-contact printing can be used repeatedly without invoking the costly equipment required in photolithography and is experimentally convenient and cost-effective. We, at NPL, are amongst the first ones to have initiated work on soft lithography and micro-contact printing in our country. We describe below the salient features of our work on soft lithography that would have direct relevance in device fabrication and biological applications.

Self-assembled monolayer of hexadecanethiol (HDT) is selectively transferred to the specific regions of the substrate with an elastomer stamp that is prepared by casting the liquid prepolymer of the elastomer against a master mask that has patterned relief structure on its surface. The elastomeric stamp was molded from a master (e.g., silicon chip) wherein structures with very small features were created by conventional photolithographic techniques. We have used poly dimethyl siloxane (PDMS) as the stamp material. The cured polymer could be easily peeled off from the master. The relief structure on the stamp is a replica of the pattern structure on the master and the depressions in the masters are the raised structures in the polymer stamp. The quality of the relief structure on the stamp has been found to have very high fidelity.

The stamp was 'inked' with HDT solution and ink was transferred to the surface of the gold/silver films (500–5000 Å thick) films, deposited by thermal evaporation on glass or silicon substrates, by physical contact. The reaction of HDT molecules with gold/silver led to the formation of organized structure in the regions of contact leading to 'autophobicity' and exhibits contrasting physical and chemical properties. The 'inked' regions of the substrate act as good nano-resist film and the non-inked regions on the metal films could be easily etched by aqueous $Na_2S_2O_3$, $K_3[Fe(CN_6)]$ and $K_4[Fe(CN_6)]$ solution.

Fig. 3.18 (Pl. see at next page) shows a SEM picture of an elastomer stamp cast from a silicon master. Fig. 3.19 shows a SEM picture of a pattern with feature sizes ranging from a few microns ($<3\mu$m) to several hundred microns ($>100\,\mu$m) over large area (a few cm^2) created on gold coated silicon substrate. Fig.3.20 (a & b) show the patterns of $<3\mu$m created in silver film on glass with sharp edge defintition.

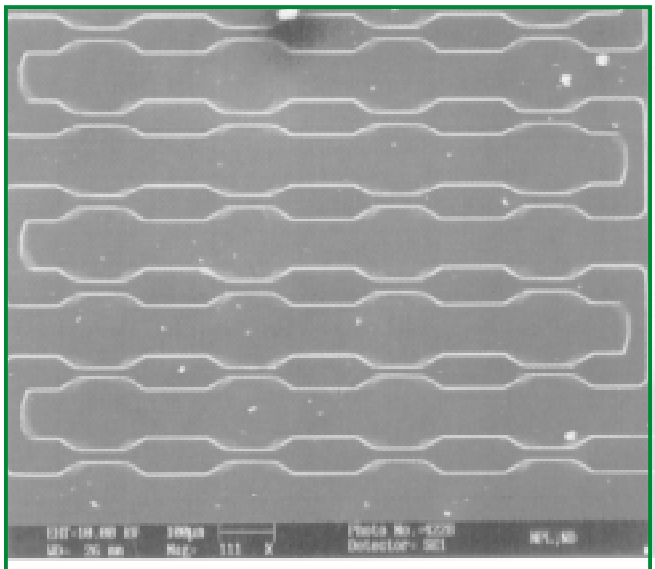


Fig. 3.18 : SEM pictures of a PDMS stamp used for micro contact printing

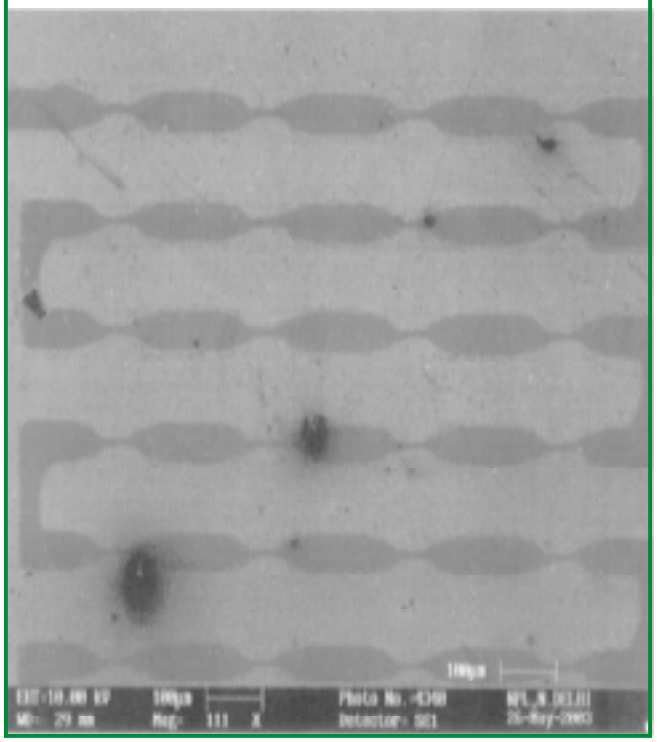
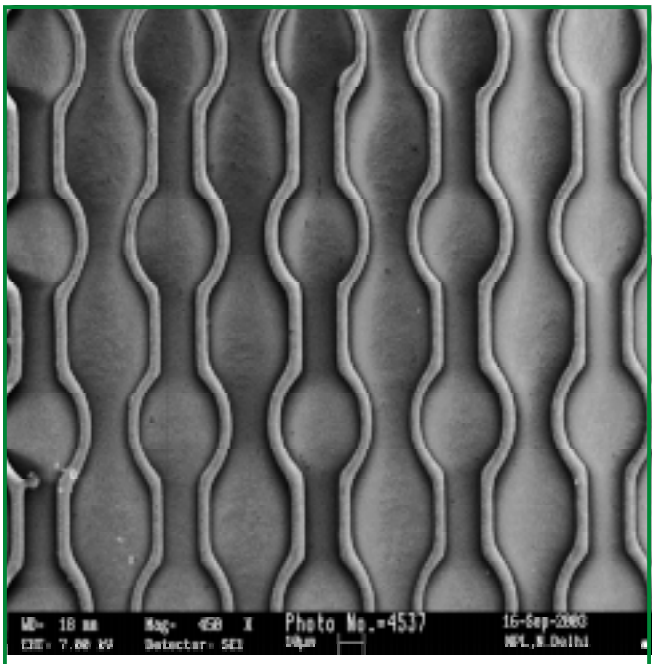
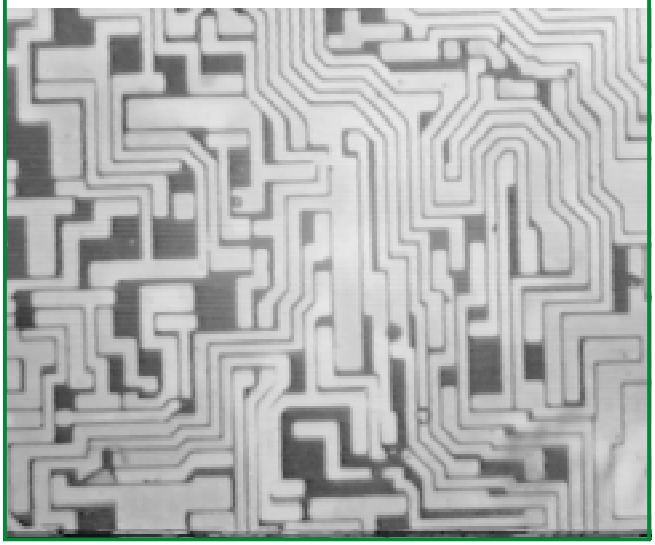


Fig. 3.19 : Etched patterns in Au films on Si substrate with feature sizes ~15–60 micron using the PDMS stamp shown in Fig.3.18



a



b

Fig. 3.20 : (a & b) Etched patterns in silver films on glass substrates with feature size <3 micron using microcontact printing.

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इलेक्ट्रॉनिक पदार्थ

ELECTRONIC MATERIALS

इलेक्ट्रॉनिक पदार्थ

पिछले कई दश्कों से राष्ट्रीय भौतिक प्रयोगशाला का इलैक्ट्रनिक पदार्थ प्रभाग विशेष पदार्थों के परिवर्धन और युक्तियों व यंत्रों के निर्माण में संलग्न है। आजकल इस विभाग का मुख्य लक्ष्य है एनपीएल का इन कार्यो पर अद्वितीय अवसंरचना और प्रवीणता स्थापित करना। इस वर्ष निम्नलिखित विषयों के क्षेत्रों में कार्य हुआ है :

- संदीप्तिशील पदार्थ और युक्तियां: नैनो संदीपक पदार्थो का परिवर्धन, विभिन्न तकनीकों का निर्माण, संवधित पदार्थो का विस्तश्त अभिलक्षण, नील और हरित वरन दीर्धकाल दीप्ति नैनो उत्सर्जक, उत्सर्जक पट्टियों और प्रदर्शन पाटों का निर्माण, कम्प्यूटरीकश्त कण विश्लेषक, प्रकाश चालक पाउडर और संवेदक इत्यादि विषयों पर कार्य हुआ।

- प्लाज्मा पदार्थ संसाधन : डीएलसी हीरक जैसी कार्बन परतो में अवशिष्ट प्रतिबल और प्रकाशीय अवशोषण तीक्ष्णता में सह संबंध, कठोर बोरॉन नाइट्रइड घनाकश्त परतो का उद्योगों के लिए परिवर्धन, फिल्टरित निर्वात आर्क विसर्जन तकनीक का डिजाइन और निर्माण इत्यादि क्षेत्रो में अनुसंधान कार्य किया है।

- सिलिकन एवं सिलकन युक्तियां, मैम्स, संवेदक : सरंध्र सिलिकन की बलगतिकी वश्द्धि की स्थापना, सिलिकन के अल्पसंख्यक वाहको की आयु का मापन, पी आई एन प्रकाश चालकीय डायोडो का विकास और एल एच जंक्शन पर अदीप्त धारा के निरोध प्रभाव इत्यादि विषयो पर अध्ययन किया गया है।

- विद्युतवर्णिक, नैनो संरचनात्मक प्रकाशीय और बहुलक पदार्थो, परतो व युक्तियों का परिवर्धनः प्लाजमा बहुलक यंत्र का विभिन्न प्रकाशीय और तनु परतों के परिवर्धन के लिए निर्माण, सी डब्ल्यू डी एम प्रणालियों के लिए संकर प्रकाशीय बैंड फिल्टरों का विकास, नवल पदार्थो और विद्युत वर्णिक भ्रामिकाएं, बहुलक चालक, टीन आक्साइड नैनो कणों की तनु परतों पर आधारित गैस संवेदक तथा विभिन्न गैसों की सुग्राहिता अभिलक्षण की सुविधाएं इत्यादि पर कार्य हुआ है।

- उच्च ताप अतिचालक पदार्थ और अग्रगत सिरेमिकः के अन्तर्गत उच्च ताप अतिचालकों के कम लागत के लघु धारा संपर्क प्रतिरोधको का निर्माण, 200 से 300 मि.मी. लंबाई की Bi-2223 समष्टि नलिकाओं, उच्च धारा की तारो, पिनिंग युगलन क्रियानिधि पर मूल अनुसंधान, इत्यादि और उच्च चार्ज स्थिरांक व पैरावैद्युतांक दाब–विद्युत सिरेमिक पदार्थो का संवर्धन ध्वनिक उत्सर्जन संसूचकों में ट्रांसड्यूसर अवयवो के रूप में व ठोस ईंधन सेलों के लिए आयनिक चालको का परिवर्धन आदि विषयों पर कार्य किया है।

ELECTRONIC MATERIALS

The development of electronic materials has been a very important area of activity in NPL for the past several decades, since the development of novel materials, devices and systems depends on this activity. The focus in recent years has been in those areas where NPL has been able to create some unique infrastructure and expertise. These areas and the activities carried out under them during the year are:

- **Luminescent Materials and Devices :** Development of nanophosphor materials, various techniques for their fabrication, exhaustive characterization of the developed materials, blue and green emitting long after-glow nano-phosphors, fabrication of phosphor tapes and display panels, computerized particle size analyzer, photoconducting powders and sensors, etc.

- **Plasma processing of materials** : Correlation of residual stress with optical absorption edge in DLC (Diamond like Carbon) films, development of hard coatings of cubic Boron Nitride for industrial applications, design and fabrication of a filtered vacuum arc discharge (FVAD) technique, etc.

- **Silicon and silicon devices, MEMS, Sensors** : Establishment of growth kinetics of porous silicon, measurement of minority carrier lifetime in silicon, and development of process of fabrication of silicon PIN photodiodes, effect of L-H junction on suppression of dark current etc.

- **Development of electrochromic, nanostructured, optical and polymeric materials, films and devices:** Development of plasma polymerization system for optical and other thin film coatings, fabrication of narrowband optical filters for CWDM applications, development of novel materials and processes for fabrication of electrochromic windows, development of conducting polymers, development of thin film gas sensors based on tin oxide nanoparticles and facilities for characterizing the sensitivity to various gases, etc.

- **High Temperature Superconducting materials and Advanced Ceramics**: Development of low cost process to achieve low current contact resistance, development of 200 and 300 mm long Bi-2223 bulk tubes for cryogenic free magnetic systems, coupling of tubes, high current leads, basic research studies on pinning, mechanism of pairing, etc. in high T_c superconductors, development of piezoelectric ceramic material possessing high dielectric permittivity along with high charge constant, fabrication of transducer elements for Acoustic Emission sensors; ionic conductors for solid fuel cells, etc.

Luminescent Materials and Devices

The Luminescent Materials and Devices Group has gone full steam towards its objective of development of nanophosphor materials after receiving funds under the programme of Networked Projects of CSIR [in the category of custom tailored special materials] and from DST. Nanophosphors are being prepared using three techniques, viz. chemical precipitation, sol-gel and auto-combustion.

The chemical co-precipitation method was used to synthesis nanophosphor samples of ZnS:Mn capped with polyvinyl pyroledone (PVP) and zinc oxide. Zinc acetate, manganese acetate and sodium sulphide were used as reactants. A capping agent is used for controlling particle size. The samples were observed to have cubic structure over the Mn concentration range studied. Optical absorption at room temperature was used to study the band gap of the material. The material had a direct bandgap of about 5.6 eV. Photoluminescence intensity in ZnS:Mn showed significant enhancement due to Mn incorporation. There were two extra PL peaks after Mn incorporation in the nanocrystalline ZnS: Mn. The phosphor is also being studied by using ZnO as the capping agent (inorganic capping). Fig. 4.1 shows the TEM of the ZnO capped ZnS: Mn nanophosphor. Studies on other dopants like Cu and Ag have been initiated.

Considering the importance of nanocrystalline materials embedded in some templates, ZnS:Mn nanophosphor was made in a porous and transparent silica matrix by sol-gel technique.. There are some advantages associated with this kind of nanophosphor preparation technique. There is no organic capping agent used to control ZnS nanoparticles size, which is not amenable to fabrication of some devices. The silica gel cages the nanoparticles in its purest form inside the pores and arrests the particle growth. Another advantage of this method is that silica of the matrix acts as a suitable binder for glass substrates. By varying the molar ratio of ZnS/SiO_2 from $3.11x10^{-4}$ to $1.5x10^{-1}$, appreciable changes in physical properties such as photoluminescence and crystallite sizes of ZnS:Mn were observed. The sample with molar ratio of ZnS/SiO_2 less than $9.3x10^{-2}$ shows considerably less luminescence under UV excitation of 365 nm. However, as the molar ratio of ZnS/SiO_2 increases, the intensity of emitted visible radiation also increases. The observation of a shift in the absorption edge towards smaller wavelengths with the decrease of ZnS/SiO_2 molar ratio indicates the formation of ZnS:Mn crystallites in the quantum confinement regime. It was found that with increasing ZnS/SiO_2 molar ratio the absorption peak shifted towards higher wavelength as size of particle increases. Fig. 4.2 shows the PL spectrum of the samples studied. Several techniques like photoluminescence, X-ray diffraction and electron microscopy have been used to analyze the ZnS:Mn silica composite.

Long persisting blue emitting Europium and Neodymium doped Calcium Aluminate ($CaAl_2O_4:Eu^{2+},Nd^{3+}$) phosphor has been studied and its synthesis parameters have been optimized, following the solid-state reaction technique. The effect of Al_2O_3 content in calcium aluminate phosphor has been studied systematically for various luminescent properties. It was observed that less than 0.8 mole of Al_2O_3 per mole $CaCO_3$ resulted in phosphor with acceptable brightness with afterglow time of about 1 hour, whereas more than 1.0 mole of alumina resulted in a phosphor with lower initial brightness and decay times around 45 min. The best combination of initial brightness and afterglow times (> 2 hour) has been achieved by using Al_2O_3 content in the range of 0.8-1.0 mole. The chemical composition with respect to amount of flux-boric acid, concentration of activator (Europium) and co-activator (Neodymium) has been studied systematically and optimized. The X-ray diffraction technique has been used to identify different phases of the calcium aluminate system. Al_2O_3 content in the range of 0.8-1.0 mole resulted in formation of the monoclinic $CaAl_2O_4$ system. The luminescent properties have been analyzed by spectral energy distribution and decay profiles of the phosphor. It was found that all the samples had emission peaks in the range 430-450 nm. The decay properties varied with Al_2O_3 and boric acid content and concentrations of activator

and co-activator. The sample with higher decay times (> 2 hour) was obtained with Al_2O_3 content in the range of 0.8-1.0 mole, $1.5x10^{-1}$ mole of boric acid, $5.0x10^{-3}$, $1.0x10^{-2}$ moles of activator and co-activator respectively.

Further refinements in the auto-combustion synthesis route are being made to reduce the process steps for preparing green emitting long after-glow nanophosphor samples. The experience gained is being employed for developing the process for blue emitting $CaAl_2O_4$:Eu;Nd phosphor.

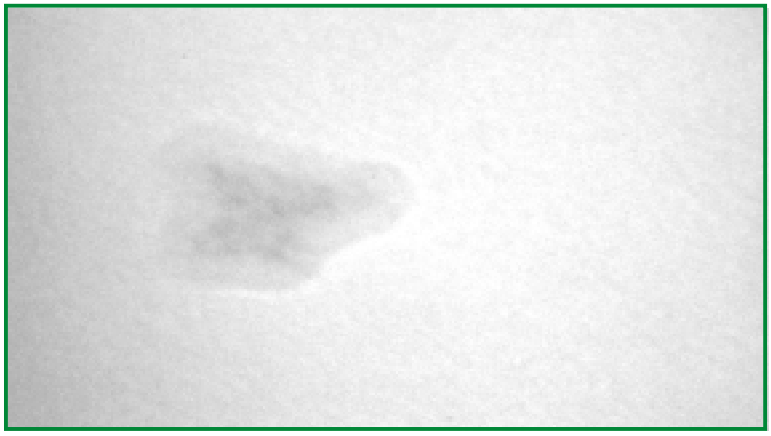

Fig. 4.1 : TEM of ZnO capped ZnS:Mn nanophosphor

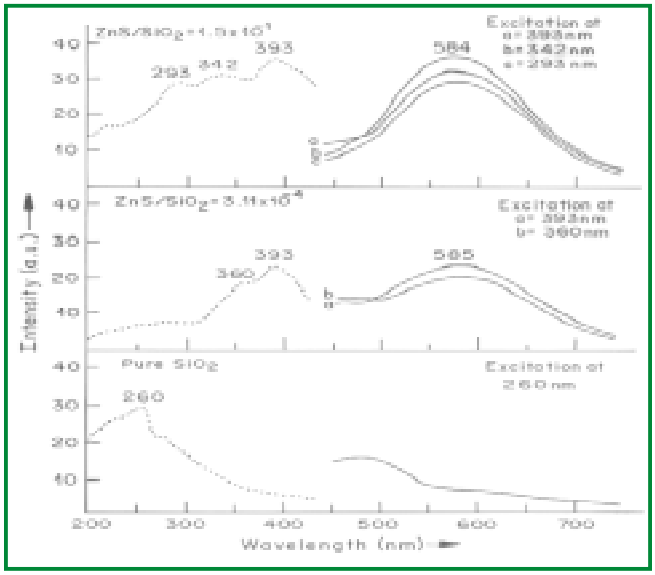

Fig. 4.2 : Photoluminescence excitation (dotted line) and emission (solid line) spectra of pure SiO_2, nanophosphors made from lower ($3.11x\ 10^{-4}$) and higher ($1.5x10^{-1}$) ZnS/SiO_2 molar ratios.

Plasma Processing of Materials

Correlation of residual stress with optical absorption edge in DLC (Diamond like Carbon) films

A correlation has been observed between the residual stress and the optical absorption edge of DLC films. On the basis of the observed results, an empirical relation has been formulated to express the dependence of Urbach energy (E_o) on the residual stress (s) present in these films. This relation is expressed as $E_o = E_{oo} + ms$, where E_{oo} = 140 meV and m = 37meV/GPa. Thus, the Urbach energy (E_o) for the DLC (hydrogenated amorphous carbon, a-C:H) films has a minimum at 140 meV. However, in a-Si:H films, this limit is at~40 meV. Since, E_o is the measure of the disorder in the material, higher the value of E_o, higher will be the disorders in the films and the film quality will be poor. Thus, a-Si:H films are much superior to a-C:H films.

The presence of a higher value of E_o in a-C:H films shows the futility of DLC films in electronic device applications. Unless the Ubach energy of the a-C:H films equals 40 meV or even lower, we cannot achieve device quality comparable to a-Si:H based devices from this material. However, the use of a-C:H in device fabrications offers some exciting advantages when such devices are intended to be used in hostile environments such as high electric fields and temperatures.

This correlation can be used to simulate the various processes for getting optimum values of the residual stress and optical absorption in DLC films. This will aid in decreasing the time of experimentation and we may optimize various process parameters to yield quality output. We also plan to use these films in devices operated at high field and high temperature in near future.

Development of hard coatings of cubic Boron Nitride for industrial applications

Hard and optically transparent (in the visible region) cubic Boron Nitride (cBN) films were deposited using RF-

PECVD technique. These films have very good potential for industrial applications like protective coatings on watch glasses, ophthalmic lenses, and decorative brass articles, etc. We are in the process of depositing these films using the ECR technique, which may yield c-BN films with high cubic fraction.

Design and fabrication of a filtered vacuum arc discharge (FVAD) technique

A sophisticated filtered vacuum arc discharge (FVAD) system has been designed and fabricated, which is suitable for the deposition of undoped and doped ta-C, titanium nitride and various other nanocomposite films. The deposition of hydrogenated and nitrogenated ta-C films was also carried out to study the effect of hydrogen and nitrogen dilution on the film properties. This study includes measurements such as hardness, XPS, spectroscopic ellipsometry, conductivity, Raman measurements, SEM, field emission, photoluminescence, XRD, hardnesss, optical band gap, sp^3 and sp^2 content, density of states etc. on both undoped and doped ta-C films.

Silicon and Silicon Devices, MEMS & Sensors

The growth kinetics of porous silicon (PS) were established. For this, PS was grown in a single compartment cell using a mixture of hydrofluoric acid, alcohol and water (HF: CH_3–CH_2 - OH : H_2O : : 2 : 1 : 1 by volume) as the electrolyte and silicon as the anode. The counter electrode was made of platinum wire mesh. PS was grown at constant currents of 5,10 and 20 mA/cm^2 for 2-16 minutes at intervals of 2 minutes. The effective thickness (x) of PS and refractive index (n) were determined by laser ellipsometry. The values of n were constant at around 1.9. The values of x on the other hand varied considerably and are plotted in Fig. 4.3. Curves were also fitted to the data points by using the least square method to the equation

$$x = at^c \qquad (1)$$

where x is in nm, t is in minutes and c is a dimensionless constant which is different for different etching currents. The values of a, c and the coefficient of correlation (r^2) are given in Table –4.1.

The fitted curves are also given in **Fig.4.3**. In an earlier work oxidation data were fitted to the equation

$$x^{c'} = kt \qquad (2)$$

and it was shown that when c' is equal to 1 the growth is reaction limited, when c' is equal to 2 the growth is diffusion limited and when c' lied between 1 and 2 the growth is reaction as well as diffusion limited. In the present work $c' = 1/c$ and the values are 2.43, 2.43 and 2.08 when anodization currents are 5, 10 and 20 mA/cm^2 respectively. During PS growth the charged oxidizing species face two barriers viz., diffusion barrier in the electrolyte and space charge barrier near the silicon anode. At lower anodization currents e.g., 5 and 10 mA/cm^2, the charged oxidants face both the barriers and so the value of c' is more than 2. However, at higher anodization current i.e., 20 mA/cm^2, the charged oxidants face only the diffusion barrier because they overcome the other barrier by tunneling as they have higher energy. Therefore the value of c' in this case is close to 2.

In another experiment PS was grown on silicon wafers and nano particles of silicon were separated from the substrate. The particle size was ~ 30 nm as

Table – 4.1 : Fitted parameters by least square method to anodized thickness (x) as a function of time(t) to the Eqn. $x = at^c$ where a and c are constants.

Anodization current density (mA/cm^2)	a (nm min^{-c})	c (dimensionless)	r^2
5	47.08	0.41	0.994
10	53.02	0.41	0.995
20	63.30	0.48	0.999

measured by transmission electron microscopy (TEM). Photoluminescence measurements at room temperature reveal that these nano-particles have a peak at 592.41nm, which corresponds to orange-red light emission.

Studies on the measurement of minority carrier lifetime in chemically etched silicon wafers using photocurrent generation methods were also carried out without heat treatment of wafers.

Silicon PIN photodiodes were fabricated on n-type wafers by diffusing P at the back to provide back surface field (BSF) by creating a low-high (L-H) junction there, followed by B diffusion at the front for emitter formation. The sheet resistivity at the back was gradually decreased (85.0-0.8 Ω/□) by increasing diffusion time and temperature of P diffusion. This gradually increased the depth of the L-H junction and so also the effective BSF, resulting in increase in open circuit voltage when the photodiode is operated in the

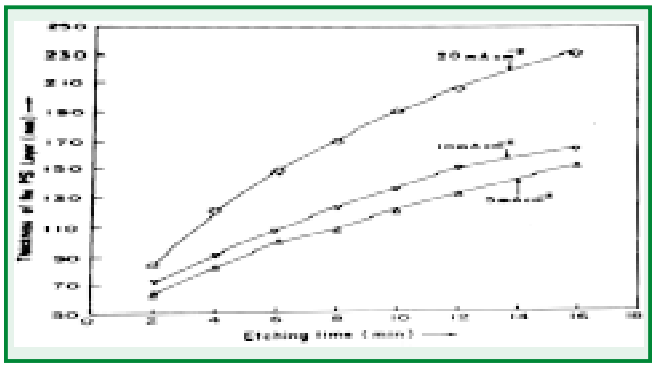

Fig. 4.3 : Thickness of porous silicon grown at 5, 10 and 20 mA/cm^2 for 2-16 min

photovoltaic mode, decrease in leakage current and improvement in spectral response.

Electrochromic, Nanostructured, Optical and Polymeric Materials, Films and Devices

A completely home-made system has been developed for the deposition of plasma polymerized films for optical coatings and other applications. The parallel plate electrode assembly, gas showerhead, gas/vapour delivery system and deposition chamber set-up (using a glass bell jar) were all designed and fabricated in-house. The set-up has been used to deposit thin films of polyaniline and polythiophene by plasma polymerisation. FTIR measurements confirm that polymerisation of the monomer vapours – aniline and thiophene – does occur in the deposited films. The refractive index and thickness of the deposited films have been measured by ellipsometry. Work is in progress to establish the optimum deposition parameters and relate them to the characteristics of the deposited films. Another deposition system, using a S.S. cross for the deposition chamber, is being set up also. In both the systems, RF generators (13.56 MHz) with matching networks are used for the application of RF power. Whereas the pumping systems in both systems use rotary pumps and diffusion pumps at present, it is planned to replace them with roots pumps and chemical combination pumps (for reactive vapours of aniline and thiophene which spoil the diffusion pump oil). Deposition of thin transparent conducting films of indium tin oxide [transmission about 80 % in visible region, sheet resistance about 50 ohms / square] by vacuum evaporation on 56 nos of glass substrates for OASLM fabrication was undertaken. Preliminary investigative work is being done on the deposition of multilayer thin film coatings for narrow bandpass filters for CWDM applications.

The work carried out during this period was focused on progressive steps towards the ultimate objective of fabricating prototype electrochromic windows of dimensions 300mm x 300mm. This mainly involved large area deposition of WO_3 and Prussian Blue (PB) : $Fe^{III}_4[Fe^{II}(CN)_6]_3$ films. As a result, there was a shift from spin coating and electrodeposition (carried out earlier on substrates of dimensions up to 100mm x 100mm) to dip coating. The synthesis of large amounts of the precursor material and optimization of various parameters were thus undertaken and WO_3 films of various dimensions were deposited. Special measures were devised to attain the desired properties for both WO_3 and PB films. A large number of prototype devices of various dimensions were fabricated using composite electrolyte (CPE) laminating WO_3 film as the primary

electrochromic electrodes and PB films as the active ion storing counter electrodes. The performance characteristics of the fabricated devices were examined. Successful operation of ECWs with following dimensions and configurations was demonstrated :

(1) Glass/SnO_2:F/WO_3/CPE/PB/SnO_2:F/ Glass(100mmx100mm)

(2) Glass/SnO_2:F/ CPE/PB/SnO_2:F/ Glass(230mm x 200mm)

Attempts to upscale ECWs to dimensions 300mm x 300 mm are in progress.

Nano-crystalline tin oxide powders were prepared by three different synthetic routes : (1) co-precipitation, (2) citrate process and (3) oxalate route. Calcined powders were characterized for their particle size using XRD. The mean crystallite size of tin oxide powder after calcination at 600°C was about 10-12 nm in the case of co- precipitation and citrate routes, whereas the oxalate route produced larger sized crystallite powder. Thick films were prepared by screen-printing techniques and tested for their gas sensitivity at various temperatures and concentrations. Using available components, a small facility for evaluating the sensitivity of the thick film gas sensors being developed as part of the DST project, GAP33332 at NPL. A small chamber with a provision for independent heater and temperature controller has been designed and fabricated. This has been used for testing the sensitivity up to 500°C. The use of removable contacts has ensured that the technological problems of contact fabrication and heater design can be separated from the tin oxide paste development steps. Three available MKS mass flow controllers have been connected to the chamber for testing the sensitivity to LPG and CNG. Gas flows with the hydrocarbon concentration down to 100 ppm have been achieved. Highly stable and mechanically strong thick porous silicon films have been obtained on textured silicon substrates. Porous silicon formed on textured substrates exhibits better mechanical strength, adherence to the substrate, negligible PL decay, non-fractured surface morphology and lower stress compared to porous silicon formed on polished silicon substrates at the same current density, time of anodization and method of drying. The improved properties are attributed to the formation of highly porous vertical layers separating macroscopic domains of nanoporous silicon.

Activities for the development of new conducting polymers, study of the conduction mechanism in conducting polymers and evaluation of films for photovoltaic application were continued.

Polypyrrole-heparin composites have been prepared by electrochemical polymerization technique. The mechanism of charge transport in the composite has been investigated. DC conductivity has been measured in the temperature range 13-300 K. In the very low temperature regime i.e. below 68 K, the conductivity of the composite saturates. This behaviour has been attributed to the tunneling mechanism. The tunneling contribution to the conductivity is dominant only at very low temperatures. Above 68 K, the variation of dc conductivity with temperature has been attributed to Mott's variable range hopping (VRH) mechanism (see Fig 4.5). Various Mott's parameters associated with mechanism of charge transport such as characteristic temperature (T_0), average hopping distance (R), average hopping energy (W) and density of states at the Fermi level ($N(E_F)$) have been evaluated and are ~ 6.26×10^5 K, 7.6 Å, 0.044 eV and $1.24 \times 10^{21} cm^{-3} eV^{-1}$ respectively. These parameters are in good agreement with the values reported earlier for other conjugated polymers.

Regio-random poly (3-octylthiophene) (Rdm-P3OT) has been synthesized oxidatively by chemical polymerization technique using ferric chloride ($FeCl_3$) as an oxidant in an inert atmosphere. The synthesis of Rdm-P3OT was confirmed by Fourier transform infrared (FT-IR) spectroscopy. Scanning electron microscopy (SEM) studies reveal gradual evolution of a partial crystalline mat type structure as dopant is washed out stepwise. This is attributed to the lamellar 3D-type partial crystalline growth in this polymer. The effect of doping on the surface morphology and conductivity of varying

dopant level of Rdm-P3OT films has been examined. Four regions of conduction are observed in J-V characteristics in P3OT thin films. The results of temperature and thickness dependence of J-V characteristics are being analyzed and measurement of other parameters are in progress. The synthesis and characterization of poly(3- hexyl thiophene) is also in progress.

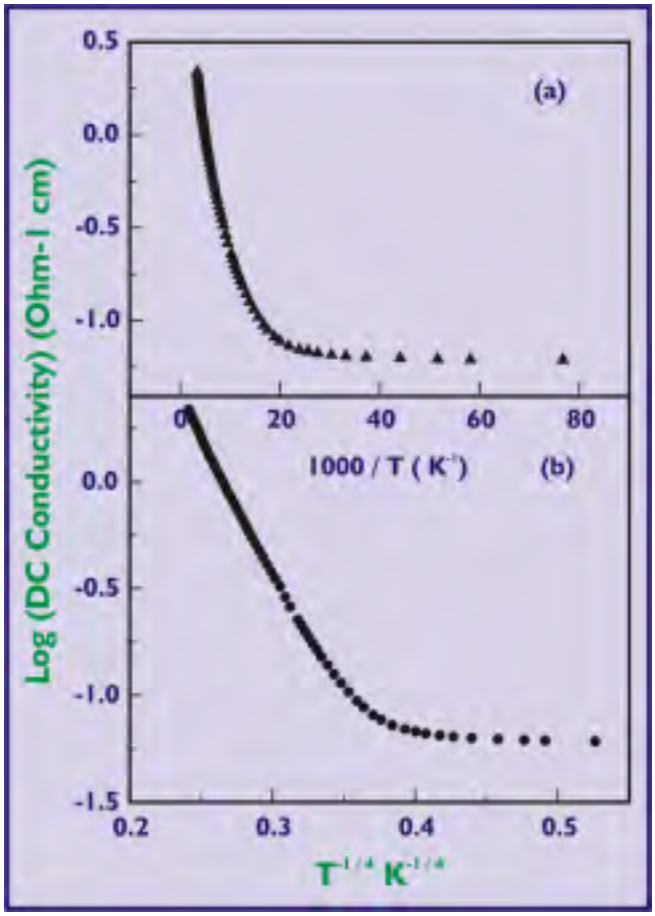

Fig. 4.5 : Plots of dc conductivity of polypyrrole-heparin composite as functions of (a) 1000/T and (b) $T^{-1/4}$

High Temperature Superconducting (HTS) Materials and Advanced Ceramics

The importance of HTS materials is well established from the statement of Chairman of Intermagnetics General Corporation, Prof. Carl H. Rosner: "High temperature superconductivity is Star Technology for the 21st century as lossless high field application seems possible at 77K".

The Bi-based $(Bi, Pb)_2 Sr_2 Ca_2Cu_2O_{10+x}$ (Bi-2223) HTS are today's first choice for high field and high current applications. Realizing this, our group has been focussing mainly on the (i) development of Bi-2223 bulk tube/rod high current leads of various sizes (length up to 300mm and diameter up to 30mm) and also to couple them. (ii) development of up to 50 meters long multifilamentary Ag-clad Bi-2223 tapes from wind and react method for high magnetic field inserts. Besides, this applied research work, basic studies to understand flux dynamics, flux pinning & mechanism of pairing etc. have also been done. During these studies, some significant results in national/ international scenario have been obtained. These are summarized below :

Applied Research Studies and Achievements

We have developed a low cost process (flame spray rather than expensive plasma spray) to achieve low current contact resistance as low as possible. We have reduced $R_c \sim 10^{-7}$ ohms at 77K ($\sim 10^{-8}$ ohms at 4.2K) by an order of magnitude (10^{-6}ohms) than the reported one. We have developed homogeneous 200mm long Bi-2223 bulk tubes (dia~30mm) with reproducible (>60%) critical current (I_c) >200A at 77K in self-field. Work is completed and ready to submit for a patent. These tubes are highly required in cryogen free magnetic systems. (Fig.4.6)

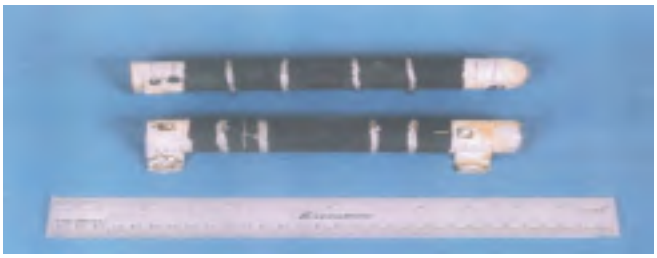

Fig. 4.6 : 200mm long Bi-2223 HTS tubes with low contact resistance contacts suitable for Ic >200A at 77K.

Another development of 300mm long Bi-2223 bulk tubes with small diameter of 10mm has also been made (Fig. 4.7). Work in optimization of processing parameters to enhance I_c at 77K, in self field and fracture strength is in progress (No reports in literature).

Fig. 4.7 : Bi-2223 HTS tubes of 300mm length and 10 mm diameter

Apart from these, preliminary studies on coupling of two bulk tubes have shown encouraging results. Work in optimization of joint with minimum superconducting loss and maximum fracture strength is in progress. (First in international scenario).

During these developments, a new cost-effective process has also been evolved for making of homogeneous Bi-2223 bulk rods of various size (length~10-15mm, dia.~3-9mm) which gave reproducible J_c values >4500A/cm^2 at 4.2K (Fig. 4.8), in self-field in 40–50hrs. shorter sintering duration than the conventional method (200hrs.). The present process involves initial sintering in tube shape rather than in rod shape as done conventionally.

Fig. 4.8 : Low loss superconducting joints made in Bi2223 HTS tubes with J_c >4500A/cm^2 at 4.2K.

Finally, applied work other than Bi-2223 bulk tube and rods for high current leads, 50meter long Ag-clad Bi-2223 multifilamentry tapes for high magnetic field inserts are under development. A three zone muffle furnace (constant zone length: 75cm & dia~10cm, temperature variations of $\pm$ 2°C) is under testing. This work will produce at least 50–100 meter long tape out of which at least 2 to 3 spools can be prepared. An estimated field is 0.3 – 0.4 T at 77K and 2 to 3 T at 4.2K at the center will be achieved.

The furnace & tape are still in experimental stage. The results of previous spools at 4.2K are encouraging.

Basic Research Studies

A new perspective has been suggested in explaining the origin of discrepancies in temperature dependent Non-Resonant Microwave Absorption (NRMA) signal amplitude behaviour in HTSC which involves the prominent role of Electromagnetic Coupling (EMC) not included by previous workers to explain NRMA in its totality.

In continuation of pining studies, to understand the role of magnetic impurity like Eu (0 – 0.12 Mole%) doping in Bi-2223 sintered pellets (30.5×12×3mm^3) on advancement in J_c, measurements under magnetic field (0 to 1T) have been made. Preliminary investigations at 77K have shown an enhancement and an oscillating behaviour of J_c with Eu concentrations under magnetic field. J_c measurements at field >1T will resolve this behaviour.

It has been accepted since 1980, that ESR studies revealing about CESR (conduction electron spin resonance) and spin wave resonance are highly important in realizing the interaction responsible for pair formation at E_f. The ESR studies of Eu doped HTSC Bi-2223 samples of different concentrations (0.0 – 0.12 Mole%) and MgB_2 are in progress and a well defined spectra showing the presence of CESR and spin waves at room temperature has suggested the enhancement of correlation effects at E_f. The low temperature studies are in progress to resolve the pairing interaction issue in HTSC.

Advanced Ceramic Materials and Devices

Development of Piezoelectric Ceramic Material possessing high dielectric permittivity along with high charge constant

Various compositions based on lead zirconate titanate Pb (Zr, Ti)O_3 doped with different mole percent of

lanthanum oxide La_2O_3 (0 to 10 mole %) were prepared close to morphotropic phase boundary by solid state mixed oxide route. The piezoelectric materials were developed and characterized for their dielectric and electromechanical parameters e.g., f_m, f_n, f_r, f_a, f_s, f_p, tan δ, K_p, s^E (Poisson's ratio), d_{33}, g_{33} and d_h. These studies resulted in the development of NPLZT-5H – a modified lead zirconate titanate material possessing high dielectric permittivity along with high charge constant ($d_{33} \sim 600 \times 10^{-3}$ C/N). This material offers the highest capacitance per unit volume and will find use in sensitive detector and receiver applications. The typical applications include passive sensors such as hydrophones, micro-control devices, buzzers, various acoustic sensors and other sensitive sensors and actuators.

Fabrication of Transducer Elements for Acoustic Emission (AE) sensor

The studies of vector impedance spectroscopy (VIS) of different dimensions of AE transducer elements using tailor-made piezoelectric materials possessing high piezoelectric sensitivity suitable for acoustic emission (AE) sensor applications were carried out by using computer controlled impedance analyser HP 4194A and Solartron 1260 FRA + Solartron 1296 dielectric interface. The suitable dimensions of transducer elements of 800 kHz frequency as well as the required ceramic phased material (Wear Plate) were prepared and acoustic emission sensors were designed -designated as NPL AE-80 (equivalent to R80 of Physical Acoustics Corporation)- and were fabricated employing stainless steel casing. This design and development work was carried out under a sponsored project "Development of Transducer Elements for Acoustic emission (AE) sensor".

Ionic conductors for solid fuel cells

Ionic conductors for solid oxide fuel cell have been investigated. It has been found that when CuO content was increased from 1 mol% to 33 mol % structure changes from two phase to three phase structure. Figure-4.9 shows three dimensional AFM topography of 33 mol% ZrO_2. It clearly shows three different phases. Nano crystalline tin oxide has been prepared with different aging conditions. Under TEM, we have obtained different particle size and distribution depending on aging time. Samples completely aged show a particle size of 30-55 nm(Fig. 4.10) whereas the intermediately aged sol gives rise to particle size in the range of 7-10 nm. (Fig. 4.11). ZST ceramics were prepared by solid state reaction from relatively pure oxides (>99%). Mixture is ball milled in an alumina jar with zirconia balls for 32 hrs in deionized water and then dried. It has been proved that Nickel enter in grain boundary sites.

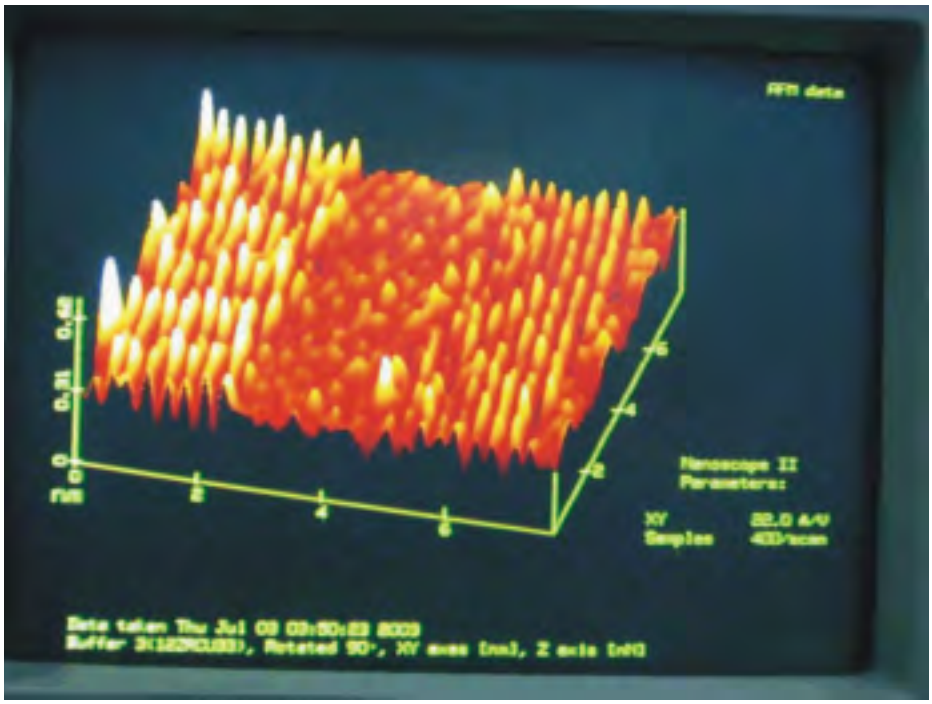

Fig. 4.9 : AFM topography of 33 mol% ZrO_2 showing three phase structure.

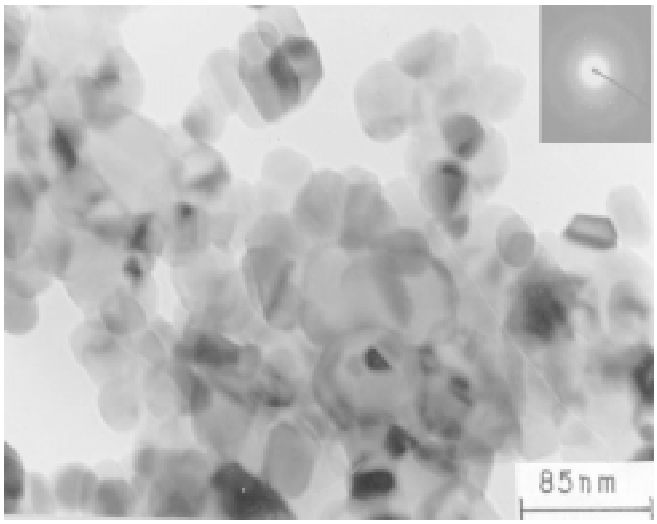

Fig. 4.10. TEM micrograph of SnO_2 powder processed after complete gelling.

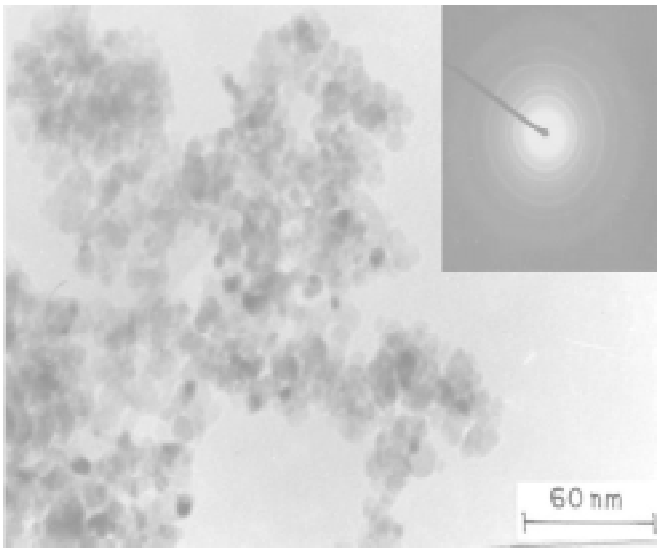

Fig. 4.11. TEM micrograph of SnO_2 powder processed at intermediate gelling

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पदार्थ अभिलक्षणन

MATERIALS CHARACTERIZATION

पदार्थ अभिलक्षणन

राष्ट्रीय भौतिक प्रयोगशाला का पदार्थ अभिलक्षण प्रभाग का कार्य पदार्थों की विशुद्धता, तत्वीय संयोजकता, लेश तत्वों का आंकलन, संरचनात्मक विश्लेषण, क्रिस्टलीकश्त प्रावस्थाओं की पहचान और दोषो के बारे में जानकारी प्राप्त करना है। प्रमाणित निर्देशक पदार्थो की योजना, संवधर्न और प्रचार अन्तः प्रयोगशाला सहायक प्रोग्राम के तहत यह इस विभाग का महत्वपूर्ण कार्य है। इस प्रभाग में कई उन्नत, परिष्कश्त, एकमात्र उपकरण उपलब्ध है, यह पदार्थ अभिलक्षण सुविधाएं एनपीएल के विभिन्न आर एण्ड डी अनुभागों और अन्य अनुसंधान संस्थानों व उद्योगों को प्रदान की जाती है। यह विभाग सीएसआईआर कस्टम टेलरड विशिष्ट पदार्थ (सीएमएम 022) और प्रमाणित निदेश्क पदार्थो का संवर्धन और प्रचार (सीएमएम 024) नेटवर्क परियोजनाओं में सक्रियता से कार्यरत हैं। इस कार्यकाल में निम्नलिखित अनुसंधान और अन्वेषण का कार्य किया है।

(i) सीपीसीबी एनपीएल सहायक प्रोग्राम के अन्तर्गत मानवीकृत कोहरा। धूमकोहरा का दिल्ली में प्रभाव पर ऐरोसोल के आकार का मापन और द्रव्यमान वितरण का अध्ययन एण्डरसन और क्वार्ज क्रिस्टल सूक्ष्मतुला द्वारा किया है तथा मार्ग प्रचार प्रसार परियोजना के तहत श्रेत्रीय कार्य के प्रचार पर इसरो जीबीपी प्रोजक्ट पर भी कार्य किया है।

(ii) मीथेन, कार्बनडाइआक्साइड और नाइट्रस आक्साइड जैसी ग्रीनहाउस गैसों का अन्वेषण पशुधन, धान की खेती और कशषि अवशेषो का खुला ज्वलन पर एमओईएफ द्वारा समर्थन प्राप्त भारतीय राष्ट्रीय संचारण (नेटकॉम) अनिश्चिता न्यूनीकरण परियोजना में इस संदर्भ पर अध्ययन किया। इस अनुसंधान में दस सहभागी संस्थानों के नेटवर्क ने प्रयोगशाला और क्षेत्रीय प्रयोगो पर गहन विश्लेषण किया और N_2O rFkk CH_4 गैसों का धान और गेहूँ की फसलो में उत्सर्जन और संबंधित तंत्रों पर राष्ट्रीय प्रचार किया गया।

(iii) यथा निर्मित और नाइट्रोजन संयोगी चतुष्फलकीय अक्रिस्टलीय कार्बन परतों का ई पी आर स्पेक्ट्रोस्कोपी द्वारा अध्ययन किया और प्राप्त परिणामों का सहसंबंध अन्तर आवेश परिमित चालकता (एस सी एल सी) एवम् यथार्थ निक्षेपण पैरामीटरो का निर्धारण भी किया है।

(iv) कोबालट फैराइट तरल लोह नैनो कणों का संशलेषण नाइट्रेट लवणों और सिट्रिक अम्ल द्वारा किया और इन्हें यूवी, एक्सआरडी, टीईएम, ईपीआर और माइक्रोवेव तकनीकों से अभिलक्षित किया। कार्बन नैनो नलिकाओं/तन्तुओं/ मिश्रिण मिश्रित तरल लोह, SnO_2, ZnO, ZrO_2 पाउडर जैसे विभिन्न एनपीएल अनुभागों और उद्योगों से प्राप्त उन्नत पदार्थो का अभिलक्षण एक्स आर डी, ई पी आर, एस इ एम, टी इ एम और इ डी ए एक्स द्वारा विश्लेषण किया है।

(v) इस कार्यकाल में 9 सी आर एमस का संवर्धन किया और इन्हें प्रतिभागी प्रयोगशालाओं में राउण्ड रॉबिन परीक्षण के लिए भेजा है। एक्स–किरण विवर्तनमापी के अंशांकन के लिए सिलिकन बी एन डी 1501 प्रतिदर्शी की अंतिम सीरिज भी तैयार है ।

(vi) विभिन्न सान्द्रता के क्षारीय हेलाइड मिश्रित और आयरन डोपड लिथियम बायोबेट क्रिस्टलों का सी जैड तकनीक से किया। उच्च विभेदी एक्स–किरण विवर्तन द्वारा KCl,NaCl,$S_{I-X}Ge_x$,Si, एपेटेक्सीय परतों और SiGe/Si विषमांगी द्विध्रुवी ट्रांजिस्टरों की संयोजकता, मोटाई और गहन सतहों का मापन भी किया।

vii प्लाज्मा ऑक्सीकश्त ळंछ तनु परतों का अध्ययन एस आई एम एस तकनीक द्वारा किया और गहन सतह मोड से आक्साइड परत की मोटाई और बलगतिकी का मापन किया।

(viii) एनपीएल में एक सेमिनार और परिचालन समिति का आयोजन किया। लगभग 27 शोध पत्रो का प्रकाशन प्रतिष्ठित जर्नलों में किया और 29.52 लाख रूपयों की बाह्य नकद राशि प्रयोजित परियोजनाओं परामर्श और परीक्षण व अंशाकन द्वारा अर्जित की।

MATERIALS CHARACTERIZATION

Materials Characterization Division of NPL is responsible for the characterization of the materials for ascertaining purity, elemental composition, estimation of trace impurities, structural analysis, identification of crystalline phases and information on crystal defects. Planning, preparation and dissemination of certified reference materials under an inter-laboratory collaborative programme is another important activity of the division. This Division is well equipped with many advance, sophisticated and unique facilities for the characterization of materials.

Material characterization facilities were provided to various R&D groups of NPL as well as to other research organizations/industries. This division is also actively engaged in the various CSIR network projects such as "Custom Tailored Special Materials" CMM(022) and Preparation & Dissemination of certified reference materials (CMM024). Some of the important R&D activities pursued during this period are:

(i) Aerosol size and mass distribution by Anderson and quartz crystal microbalance have been studied in relation to anthropogenic influence on fog/smog in Delhi under CPCB-NPL collaborative program, and also for road campaign project under ISRO-GBP field campaign studies.

(ii) Study of greenhouse gases viz CH_4, CO_2 and N_2O have been done in the sub-sectors e.g. livestock, rice cultivation and openburning of agricultural crop residues under agriculture sector for Indian National Communication (NATCOM) uncertainty reduction (UR) projects supported by MoEF. These studies involved extensive laboratory based and field experiments and included national campaign for N_2O & CH_4 in rice-wheat cropping system in a networked mode with ten participating institutions.

(iii) As grown and nitrogen incorporated tetrahedral amorphous carbon films were studied using EPR spectroscopy and the results were correlated with space charge limited conduction (SCLC) studies to optimize its deposition process parameters. EPR studies on ternary oxide glasses and conducting polymers were also carried out.

(iv) Cobalt ferrite nano particle ferrofluid using nitrate salts and citric acid was synthesized and characterized by UV, XRD, TEM, EPR and microwave measurements. A large variety of samples of advanced materials including carbon nanotubes/fibers/composites, ferrofluid composites, SnO_2, ZnO, ZrO_2 powders etc. received from various group of NPL and industries were characterized with XRD, EPR, SEM, TEM and EDAX analysis.

(v) During this period nine CRM's have been prepared and sent to different participating laboratories for round robin testing. Last batch of BND 1501 silicon material for the calibration of X-ray diffractometer was also prepared.

(vi) Mixed alkali halide and iron doped lithium niobate ($LiNbO_3$) single crystals with various concentrations were grown by CZ method. High resolution X-ray diffraction measurements were made on thin and alkali halide crystals like, KCl, NaCl, $Si_{1-x}Ge_x$/Si epitaxial layer and SiGe/Si hetero-bipolar transistor (HBT) to determine the composition, thickness and depth profile.

(vii) Study of plasma oxidation of GaN thin films was carried out by using SIMS and it was also employed in depth profile mode to measure the grown oxide thickness and growth kinetics.

(viii) One seminar and one steering committee meeting was organized at NPL. About twenty seven research papers were published in reputed journals and ECF of Rs.29.52 lakhs through sponsored projects, consultancy and testing & calibration was generated.

Analytical Chemistry

Material characterization for ascertaining purity, chemical composition and environmental species by chemical metrology have been done for various areas viz. chemicals, ecology & environment, health, metals, minerals, manufacturing sector including scientific and technological support. This caters the need of industries, government agencies and institutions for characterization of a large variety of materials viz. aluminium and other parameters in poly aluminium chloride samples used for treatment of water by DJB, and NPL developed indelible ink produced by Mysore Paints & Varnish Ltd., Mysore and used for the electoral process in India by election commission. The facilities utilized for trace metal analysis of materials are Flame Atomic Absorption spectrometer (FAAS), Graphite Furnace Atomic Absorption spectrometer (GFAAS), Spectrophotometer and Flame photometer. The Gas Chromatographic techniques have been utilized for evaluation of gaseous samples from different sources for Green House Gases (GHGs) under National Communication (NATCOM) projects, trace gas impurities in samples from security agencies, and pollutants viz. CO, NO-NO_2-NO_x, CO_2 using respective gas analysers. Suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM or PM-10) using high volume samplers were studied for their chemical composition. Aerosol size and mass distribution by Anderson and quartz crystal microbalance (QCM) have been studied in relation to anthropogenic influence on fog/ smog in Delhi under CPCB-NPL collaborative program, and also for road campaign project under ISRO-GBP field campaign studies.

National Communication of GHGs for UNFCCC

Various governments around the world, with a view to taking positive steps to combat climate change, adopted the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The mandate of the convention is to stabilize greenhouse gases (GHG) concentrations in the atmosphere at a level that would mitigate human induced interference with the climate system. It is stipulated that parties to the convention would protect the climate system according to their respective capabilities. India is a party to the UNFCCC and has initiated the preparation of Initial National Communication (NATCOM) to the UNFCCC through Ministry of Environment & Forests (MoEF) and which Global Environment Facility (GEF) has funded under its enabling activities programme through the United Nations Development Programme (UNDP), New Delhi. The current NATCOM process envisages comprehensive scientific and technical exercises for preparation of inventories of GHGs of anthropogenic origin for the base year 1994, reduction of uncertainties in these estimations and vulnerability assessment and adaptation due to climate change, besides other related information of India's initiatives which address the objectives of the convention.

The sources from which GHGs are being estimated are energy, industrial process, agriculture, land use change and forestry (LULUCF) and waste for the base year 1994. In order to be transparent and comparable, the Intergovernmental Panel on Climate Change (IPCC) 1996 guidelines for estimating national GHG inventories are being followed for all the sectors. Agriculture sector inventory for India under NATCOM activities covers the anthropogenic emission by sources and removal by sinks of greenhouse gases viz. Carbon dioxide (CO_2), methane (CH_4), and Nitrous oxide (N_2O). The sub-sectors involved in agriculture sector inventories are Rice Cultivation, Agricultural Soils, Livestock and Agricultural Residue Burning. National Physical Laboratory, New Delhi, is involved in the measurement of N_2O & CH_4 emission coefficients from managed manure systems, CH_4 from rice cultivation under different water regimes and organic amendments, and CO_2, CH_4, N_2O, NO_x and CO from burning of crop residue. NPL has been providing support as nodal agency for carrying out campaign mode observations in a coordinated and networked

mode with collaborating institutes and also standardization of measurements and instrument calibration. Network collaborating institutes for livestock related studies are National Dairy Research Institute (NDRI) Karnal, Haryana and Central Leather Research Institute (CLRI) Chennai in Tamil Nadu. For rice cultivation the collaborating institutes are Indian Agriculture Research Institute (IARI) New Delhi, Central Rice Research Institute (CRRI) Cuttack and Regional Research Laboratory (RRL) Bhubaneswar in Orissa, Anna University Chennai, RRL Trivandrum in Kerala, National Remote Sensing Agency (NRSA) Hyderabad in Andhra Pradesh, Assam Agriculture University (AAU) Jorhat in Assam, Central Fuel Research Institute (CFRI) Dhanbad, and Institute of Radio Physics & Electronics Kolkata in West Bengal.

CPCB-NPL Fog Studies

Under the CPCB & NPL collaborative project to understand anthropogenic influence on Fog, studies have been done for sampling the Suspended particulate matter (SPM) and respirable suspended particulate matter (RSPM or PM-10) using high volume samplers and analysed for their chemical composition. Aerosol size and mass distribution by Anderson and quartz crystal microbalance (QCM) have also been studied. A typical aerosol size and mass distribution with time during a diurnal sampling on 14-15th January 2004, by QCM is shown in figure-5.1.

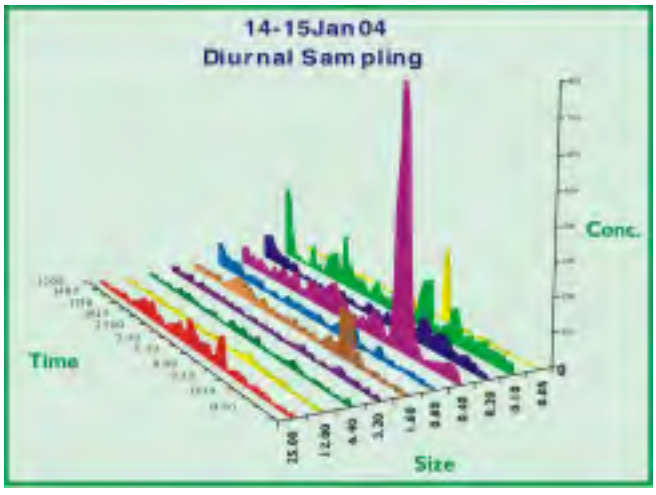

Fig. 5.1 : Aerosol size and mass distribution with time during a diurnal sampling on 14-15th January 2004, by QCM at NPL New Delhi

ISRO-GBP-Road Campaign

A nationwide road campaign on aerosols, radiation and trace gas measurements had been done during the period 31st Jan to 1st March 2004, by NPL in collaboration with Road Research Institute (CRRI) Mathura Road, New Delhi. It was funded by ISRO-GBP under Dept. of Space. Other participating institutions were PRL Ahmedabad, NRSA Hyderabad, VSSC Trivandrum, Indian Instt. of Science Bangalore, Andhra Univ., Visakhapatnam and IITM Pune. NPL had done above studies in Delhi-Hyderabad-Delhi corridor. These studies were first of its kind and have provided extensive database for understanding role of aerosols and trace gases for their radiative forcing over Indian region and would be very useful for climate modeling.

EPR Spectroscopy

Electron Paramagnetic Resonance (EPR) spectroscopy was used successfully for characterizing the paramagnetic centres/point defects/impurities present in different kinds of materials. Such centres/defects are usually produced in different fabrication/preparation processes and may play important role in controlling the properties of the material, therefore, such detailed investigations are generally beneficial for optimizing the process parameters or properties of the materials.

Tetrahedral amorphous carbon (ta-C) films are becoming of great interest because of their wide range of desirable properties such as high mechanical hardness, chemical inertness and tunable electrical and optical properties. These films are grown by different methods and their properties depend very much on process parameters. In collaboration with Plasma Processed Material Group, NPL, as grown and nitrogen incorporated ta-C films were characterized by EPR and results were correlated with space charge limited conduction (SCLC) studies to optimize its deposition process parameters to make these films suitable for electronic applications. Single line EPR signal due to the

presence of dangling bands of tetrahedral bonded carbon atoms was observed in all samples. Spin density (Ns) of these dangling bands in ta-C films with 5V substrate bias was found to be 6.7 x10^{19} cm^{-3} which decreased continuously to 4.6 x 10^{19} cm^{-3} with increase of substrate bias to 80V. Beyond this, the value of Ns increases to 5.8x10^{19} cm^{-3} with increase of substrate bias to 180V. It has been suggested that the local minimum in the values of Ns observed in ta-C films deposited at 80V substrate bias arise due to the ability of sp^2 sites to pair up. The trend observed in the values of Ns with change of substrate bias was found to be consistent with the trend of density of states $N(E_f)$ evaluated from SCLC measurements. In nitrogen incorporated ta-C films grown at low concentration of nitrogen (3.6 at %), value of spin density was first reduced as compared to as grown ta-C films due to the spin pair up between nitrogen extra electron and dangling bond electron of the carbon atoms. However on further increasing the value of nitrogen content, the value of Ns has been found to increase continuously with nitrogen content up to 15.6 at % where nitrogen acts as donor atom in these films.

Detailed EPR and other related measurements of aqueous based ferrofluid, composites of ferrofluid–conducting polymers and their films were made in collaboration with X-ray section and Electron Microscopy Section of the Division. Analysis and compilation of results obtained earlier were also completed. In aqueous based Fe_3O_4 ionic ferrofluid, a single broad EPR signal observed was assigned due to ferromagnetic resonance of single crystal magnetite particles well dispersed in the carrier fluid. At lower temperature viscosity of the carrier fluid increases which hinders the bulk rotation mechanism of ferrofluid. Moreover the initiation of process of freezing causes local expansion which may also cause randomness of spin orientation responsible for the observed broader line width. This state is known as spin glass or cluster glass state. In ferrofluid-PVA polymer films prepared under the influence of small magnetic field, no change in EPR parameters was obtained suggesting that external magnetic field was not sufficient to change the orientation of magnetic domains in these films and further work is required to explore this.

EPR study of microstructure of many ternary oxide glasses depending upon composition was made under collaborative project with Physics Department, M.D. University, Rohtak. In lithium borate glasses $xBi_2O_3(70-x)B_2O_3.30Li_2O_3$ [$0 \leq x \leq 20$] doped with V_2O_5 as paramagnetic probe it was observed that V^{4+} ions exist in octahedral coordination with a tetragonal compression. It has also been observed that octahedral symmetry around V^{4+} ions is improved and $3d_{xy}$ orbit of unpaired electron expands with increase in $Bi_2O_3 : B_2O_3$ ratio. In general electrical conductivity of these glasses were found to decrease with increase in Bi_2O_3 due to decrease in mobility and reduction in Li^+ ions available for conduction. Similarly alkali halide glasses having composition $2xMX\ (0.30-x)\ M_2O.0.70B_2O_3$ [M=Na or K; X = Cl, or Br; $0.01 \leq x \leq 0.10$] were also studied and many interesting results were obtained.

EPR study of conducting polymers has also been continued in collaboration with Conducting Polymer Group, NPL . In ferric chloride doped poly (3-octyl thiophene) and poly (3-methyl thiophene) samples, a broad EPR signal superimposed by a very weak and narrow line was obtained. Broad signal has been obtained due to Fe^{3+} ions and narrow signal has been assigned tentatively to polaron formation which may be responsible for charge conduction mechanism. Work is in progress to understand the behaviour of these charge carriers and the charge conduction mechanism. Apart from this, EPR measurements for large number of samples were made for other NPL groups for their research programmes.

X-Ray Analysis

Characterization of materials by X-ray diffraction and X-ray fluorescence method were carried out for 450 samples from various groups of NPL and outside institutions. These materials include carbon –carbon composites, WO_3, SnO_2 bulk and thin films, InSb, C-BN, Ba hexaferrite, TiO_2, B_4C composites, carbon nanotubes,

high Tc superconductors, SiC, ceramics like ZrO_2, ZrNi ZrCu, orthoferrites - $PrCaFeO_3$, MnO_3, luminescence materials like ZnS nano particles embedded in SiO_2, conducting polymers, industrial synthetic diamonds etc.

Sixteen samples of Macrolide Antibiotics drugs along with 2 parent drugs – Clarithromycin and Roxithromycin were studied by powder X-ray Diffraction method for College of Pharmacy Delhi, Government of India.

In the IRM activity under the project of planning , preparation and dissemination of certified reference materials, last batch of BND 1501 silicon material for the calibration of X-ray diffractometer was prepared. Work on the development of powder X-ray intensity standard is under progress. Primary work like procurement of α -Al_2O_3, reduction of desired particle size and X-ray diffraction measurement has been accomplished

Preparation and characterization of ferrofluids and their composites

Cobalt ferrite nanoparticles were synthesized by citrate precursor method using nitrate salts and citric acid in pH controlled reaction in aqueous solution. These nanoparticles were used for making ferrofluid. The structure of the particles was characterized by X-ray diffraction. The XRD pattern of the dried precursor shows amorphous in nature whereas the XRD pattern of annealed samples at 750^0 C for 4 hours shows crystalline phase of spinel structure of cobalt ferrite. The calculated particle sizes were approximately 15nm. We have utilized these particles for the synthesis of carbon nanotubes.

A water based magnetic fluid having Fe_3O_4 magnetic particles in the size range 2- 10 nm has also been prepared. The saturation magnetization Ms of the fluid was Ms~100 Gauss. The composites of this ferrofluid have been prepared with conducting polymer polyaniline (PANI). An aqueous solution of PVA was used as a host matrix. Different concentration of ferrofluid was added and the mixture was homogenized by ultra sonification and films were prepared on glass substrate using spinning technique under the influence of with and without magnetic field. Films were characterized by XRD, TEM/SEM, EPR and microwave measurements. The study reveals that the polymerization techniques of ferrofluid composite materials may have potential for EMI shielding. Relaxation behaviours at room temperature and liquid nitrogen temperatures, shape and size distribution of the composite and sample crystallinity have been investigated.

Electron Microscopy

Electron Microscopy is an important technique to characterize the materials at nano- and micro- scale. The two major equipments associated with this are scanning electron microscope (SEM) and transmission electron microscope (TEM). The SEM mainly concerns with the surface structure analysis of a given specimen and with the availability of energy dispersive spectrometer (EDS), the equipment enhances its capability for analyzing elements and compounds present in different areas of the specimen at micro-scale. In contrast the TEM is devoted for internal structure studies of the specimen at higher magnifications and in reciprocal space it characterizes the lattice structure of different phases constituting the material.

The group is involved in characterization of various types of materials including the metallic, semiconductors and amorphous using the SEM and TEM. Recently an exhaustive work is going on the studies based on nano-structured materials prepared by different routes available in the form of powders and thin films by different divisions in NPL and other academic institutes, laboratories and industries. Growth and characterization of various semiconducting thin films like InSb(Bi), SbTe(Bi) under doped conditions, standard gold resolution test specimens for electron microscopes and nano-materials is also a significant part of the group activity.

The present SEM is a PC controlled SEM model LEO 440 and fitted with turbo molecular pump for

producing clean vacuum. It has secondary & back scattered electron detectors, cathodoluminescence detector and specimen current monitor to investigate the microstructure of materials under different modes of operation. SEM has an attachment of energy dispersive spectrometer (EDS, Oxford Link ISIS 300) which uses Si(Li) detector to analyze elements from atomic no. 5 to 92 with a resolution of 133 eV. A heat & cold stage (model Gatan C1003) and a tensile stage (model Gatan Microtest 300) are also available as attachements with SEM. These stages are capable of examining the specimen at various heating temperatures (-185 to 400 °C) and at different load conditions (up to 300 N) under the electron beam so the in-situ microstructural changes can be studied.

Various groups in the laboratory working on the development of advanced materials for different applications have extensively used the SEM facility. About 400 samples were characterized with SEM and more than 50 samples were subjected to EDS analysis. Some of the materials characterized by SEM/EDS are CNT's with Ni & Co Catalyst, Ferrofluid Composites, ZnS powder, VGCF + pitch Composites, WO_3 film / ITO coated glass, Porous Si, SiC oxidized & Carboneous, Soda Glass, carbon fiber with polymer , ZnO, SnO_2 & CdS in Porous Alumina, Porous Alumina, La-Sr-Mn-O, Pb-Ca-Fe-O, Polystyrene & Pitch fibre, Porous Silicon, Polymer films, ZnO / Si, Fiber-Reinforced glass, Screen Printed Master patterns on Si, Conducting Polymer of thiophene family with different metal dopings, Ce-Ti film / Spin coated SnO_2 glass, X-ray generator filaments, Cubic Boron Nitride & Boron Carbide, Zirconia : Cu, Ni and Sn Composites with Varying % of Cu & Ni & Sn, Zn≈Te films on glass, Lanthnum Zirconate Titanate, Conducting Polymer (PANI) films with metal dopings, ZnO &TiO_2/ Nb Substrate, Amorphous carbon films/ Si Substrate H_2O treated & untreated Y-Ba-Cu-O, Bi223 Super Conductor, Porous Alumina with Ag, Pb & Gd dopings, Al_2O_3 : NaCl Sintered under different conditions.

The SEM/EDS facility has further extensively been used to help the industries located in and around Delhi for the characterization of their samples and giving them input in the form of test report to solve their problems associated with particle size analysis, surface microstructure, failure analysis, chemical composition of their products etc. More than 35 samples were analyzed and 20 test reports issued. The products analyzed were Steel, Zirconium Opacifier Powder , Broken Part of Striker Trunk Lid, Cut part of a tube, Broken Piece of metallic rod, Sulphur Sample in Powder, Drug Samples, Broken Compressor Shaft and gear shift rod. The companies include, M/s. Ranbaxy Chemical Manufacturing, M/s. Maruti Udyog Ltd, M/s. Sebros Enterprises, M/s. GKN Driveline (India) Ltd, M/s. Victora Tool Engineers, M/s. STI Sanoh India Ltd., M/s. United Metals and Plastics Pvt., M/s. Oriental Carbon and Chemicals Ltd, M/s. Jindal Strips Ltd, M/s. Orient Ceramics and Industries Ltd., M/s. Desiccant Rotors International, M/S. BRY-AIR (ASIA) Pvt. Ltd. The MoU with M/s Maruti Udyog for the characterization of their samples has been further extended for a period of one year.

The TEM (model JEOL JEM 200 CX) is operational and being used for microstructural analysis of variety of materials. The TEM facility is associated with modern techniques of sample preparation including the precision saw, variable speed grinder – polisher, ultrasonic disc cutter, dimple grinder, dual ion mill etc. The TEM, working at electron accelerating voltage of 200 kV is a central facility, being utilized actively by various groups in NPL and outside R&D organizations. There were about 60 samples characterized and analyzed using TEM facility including the other groups in NPL. The materials are carbon nanotubes, coconut whiskers, nano-structured thin films, ZnS, Carbon powder, ZnO, ZrO_2, SnO_2, Cobalt ferrites, Si nano-particles, Gold, BiSbTe and InSbBi. These materials are being prepared for possible applications in various fields such as gas sensors, electrochromic, electronic and nano-phosphors. Around 45 samples were analyzed for I.I.T. Delhi and other outside agencies. These materials were Nickel Oxide Nanoparticles, Molybdenum Oxide, Coating on TiO_2 Particles, La-Ba-Ca-Cu-O, Nd-Ba-Ca-Cu-O etc.

The group is actively involved in various research projects. Among these the development of nano-

phosphors sponsored by Department of Science and Technology and custom tailored materials under CSIR network scheme are the main. The materials prepared under these projects are being extensively characterized by SEM/EDS and TEM. Studies carried out on Pt and Pd nano-particles developed under custom tailored materials are quite significant and a US patent has been filed jointly by NPL and CSIO.

Indian Reference Materials

Certified Reference Materials are required for use in calibration of analytical equipments for example atomic absorption spectrometers, ICP emission spectrometers, ICP-mass spectrometers, UV-visible spectrometers, ion chromatographs, gas chromatographs, HPLC, X-ray diffractometers etc. to generate precise, accurate and reliable results and in validation of test methods for global acceptance of the products and test reports. It is a mandatory requirement of International Standards Organization (ISO) and World Trade Organization (WTO). To meet the demand of the CRMs, National Physical Laboratory, India initiated a multi-laboratory programme on planning, preparation and dissemination of Certified Reference Materials (CRMs) in the country. 30 reputed laboratories of the country are participating in this programme. These includes 20 CSIR laboratories and 10 laboratories from outside CSIR system namely Bhabha Atomic Research Centre, Mumbai; National Centre for Compositional Characterization of Materials, Hyderabad; Indian Agricultural Research Institute, New Delhi; National Remote Sensing Authorities, Ahmedabad; R&D Centre, National Thermal Power Corporation, NOIDA and R&D Centre, Indian Oil Corporation, Faridabad etc. The certified reference materials prepared under this programme had been named as Bharatiya Nirdeshak Dravyas (BNDs) or Indian Reference Materials. Certification of the property has been done by statistical computation of the data provided by these laboratories in accordance to ISO Guide 35. Some of the major users of CRMs developed under this programme are State Pollution Control Boards, Bureau of Indian Standards, National Thermal Power Corporation, Petroleum Refineries and accredited laboratories of private and public sectors. Demand of the CRMs is being increased tremendously with the growth of awareness of quality system in the country. For marketing and publicity of the BNDs prepared under this programme, published a new information brochure. Prof Suresh Chandra, Professor, Banaras Hindu University, Varanasi released it on January 20, 2004. These brochures have been distributed in several exhibitions, meetings, conferences etc. This programme had also been included in CSIR network programme on "Upgradation of SI Base Units, National Standards of Measurements & Apex Calibration Facilities and Creation of High Quality Network of Testing and Calibration Laboratories and Preparation & Dissemination of Certified Reference Materials (CMM 0024)".

Following CRMs have been prepared and sent to different participating laboratories for round robin testing during 2003-04:

2.1 New CRM of Mono-elemental solutions:

2.1.1 Cobalt in water nominal concentration 5 mg/L

2.1.2 Strontium in water nominal concentration 5 mg/L

2.1.3 Magnesium in water nominal concentration 5 mg/L

2.1.4 Barium in water nominal concentration 5 mg/L

2.2 Fourth Batch of earlier CRMs:

2.2.1 Lead in water nominal concentration 1 mg/L

2.2.2 Lead in water nominal concentration 2 mg/L

2.2.3 Cadmium in water nominal concentration 1 mg/L

2.3 Third Batch of earlier CRMs:

2.3.1 Chromium in water nominal concentration 1 mg/L

2.3.2 Chromium in water nominal concentration 2 mg/L

2.3.3 Arsenic in water nominal concentration 1 mg/L

Value of the concentration of element will be certified after statistical computation of values reported by the participating laboratories.

Crystal Growth & Characterization

Work on growth of mixed alkali halide single crystals by CZ technique in an indigenous crystal growth system was continued during this period. Solid solutions of potassium chloride and potassium bromide in various molar proportions were prepared and bulk single crystals were obtained. The following compositions of KCl and KBr single crystals were prepared; (i) KCl (60%) + KBr (40%) (ii) KCl (40%) + KBr (60%). Number of experiments were performed to optimize the growth parameters for growing BGO single crystals by Low Thermal Gradient CZ technique using Automatic Weight Control process.

Effect of annealing on the structural perfection of iron doped lithium niobate ($LiNbO_3$) single crystals grown by Czochralski (CZ) method has been studied by high-resolution X-ray diffractometry (XRD), topography (XRT) and FTIR measurements. Diffraction curves and section topographs revealed that the boundaries observed in as-grown specimens were annealed out at elevated temperatures. FTIR spectra of as grown specimens shows that these crystals contain OH^- and CO_3^{-2} defects. After annealing the defect concentration was considerably reduced which is also responsible for improved perfection.

Porous silicon (PS) layers formed by anodization on polished and textured substrates of (100)Si at different current densities for a fixed anodization time of 30 min. have been characterized by high resolution X-ray diffraction (HRXRD) and photo luminous (PL) techniques. These studies indicate that the structural, mechanical and optical properties of thick PS formed on textured Si are superior to those formed on polished Si substrates.

Using high-resolution X-ray diffractometry, germanium content x, relaxation R and thickness of the $Si_{1-x}Ge_x/Si$ epitaxial layers and Ge depth profile in advanced SiGe/Si hetero-bipolar transistor (HBT) structures have been determined. For pseudomorphic or fully strained epitaxial layers, germanium content and thickness of the layers were accurately determined by simulating the high resolution rocking curves with the in-house developed software computer programme using semi-kinematical theory. In case of partially relaxed layers due to misfit dislocations, the values of x and R were determined by determining the perpendicular lattice constant $a_{\perp}$, and in plane lattice constant $a_{||}$ by recording rocking curves for a pair of symmetric and asymmetric lattice planes.

High resolution X-ray diffraction experiments were conducted on thin ($mt << 1$)and imperfect alkali halide single crystals like KCl and NaCl. A forward X-ray diffracted beam along with the normal X-ray diffracted beam were observed. These two beams were earlier observed only for thick ($\mu t \geq 10$) and nearly perfect crystals. This proves the universal nature of the observation made earlier. The X-ray topographs for KCl & NaCl crystals showing both normal and forward diffracted beams are shown in Fig. 5.2 below.

Fig. 5.2 : High resolution X-ray topographs of : (a) normal diffracted beam of KCl, (b) forward diffracted beam of KCl, (c) normal diffracted beam of NaCl and (d) forward diffracted beam of KCl

Secondary Ion Mass Spectrometry

Measurements and analysis of the intensity and mass (and energy) of the ions , atomic or molecular, that desorbs from the solid surface due to primary ion bombardment forms the basis of what is known as Secondary Ion Mass Spectrometry (SIMS). This is distinguished from the other surface analytical techniques by its extreme sensitivity in detecting impurities even in parts per million (PPM) or below level and its ability to detect all elements including Helium & Hydrogen. It can be used in static mode (for minimum damage), dynamically (for

determination of concentration profiles) and surface chemical imaging. Secondary electron and ion images of the solid surface can also be generated for exact location of analysis. The important aspect of SIMS for chemical analysis is that many of desorbed ions may be molecular in nature and may reflect the composition of bombardment surface. Using low primary ions doses, it has been possible to detect them without significant fragmentation.

Study on plasma oxidation of GaN thin film

Growth of good quality oxide on GaN is required for the fabrication of metal oxide-semiconductor devices because a grown native oxide on the semiconductor is the most preferred one for achieving low interface state density and lower leakage current in the devices. Amongst the different techniques used for oxidation of GaN, direct plasma oxidation of GaN has not been explored in detail yet. n-GaN layer of 1μm thickness was grown on sapphire substrate by metalorganic vapour deposition (MOCVD). Samples were oxidized in an oxygen plasma at a pressure of 1.0 Torr with 12 sccm oxygen flow. The oxidation time was varied between 5 min. to 30 min.

Secondary ion mass spectrometry (SIMS) was employed in depth profile mode to measure the grown oxide thickness and the growth kinetics. In the present case Ga^+ ions were used from a liquid metal ion gun at a primary beam energy of 25keV having beam current of 4 nA and negative secondary ions were detected to enhance the signal of Ga-O related species. An area of 150μ m X 150μm was scanned during depth profiling and 10% electronic window gating was used to avoid any crater edge effect. The average sputtering rate was 0.15 nm/sec and very high depth resolution $\Delta z \sim$ 2.0 nm could be achieved by optimizing the above parameters. The actual depth scales were calibrated using a Alpha Step 500 profilometer by measuring the exact crater depths.

The survey scan spectra of the as grown sample show peaks related to Ga, GaN and other impurities like H, C, O, Na & Al which are on the top surface only. Trace of GaO is also detected which decreases very quickly after initial sputtering. The oxygen plasma treated GaN epilayer is then investigated in the –ve SIMS depth profile mode monitoring only the GaO species while species like Ga_2O could also be detected in the survey spectra. Fig.5.3 shows the depth profile of all the four samples, i.e. 5, 15, 20, and 30 minutes oxygen plasma treated samples. All the samples show the growth of an oxide film on GaN of thickness starting from 4.2 nm for 5 min. to 10.3 nm for the 30 min. O-plasma treatment. The thickness versus plasma treatment time is shown in Fig.5.4 which shows a linear growth at the initial stage up to almost 20 min. plasma treatment. After that the growth rate saturates, suggesting that the oxide layer formed of the top of the GaN epilayer acts as a barrier for further diffusion of oxygen species into GaN, which is quite expected in the plasma process in the absence of any external bias. The occupation of available bonding sites for oxygen on the GaN surface provides a kinetics barrier to further oxidation of the GaN bulk.

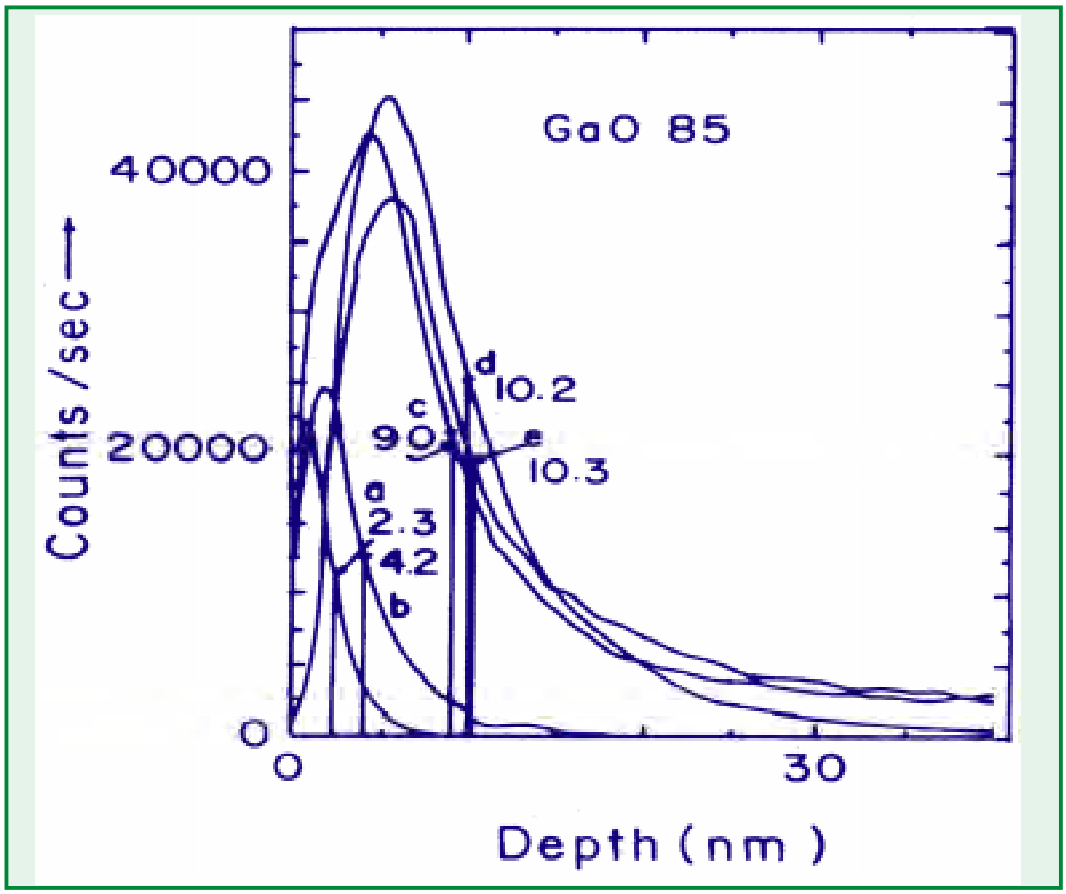

Fig. 5.3 : SIMS depth profile of oxide layer (GaO) grown on GaN with different plasma oxidation time (a) 0 min.,(b) 5min., (c) 15 min., (d) 20 min., (e)30 min.

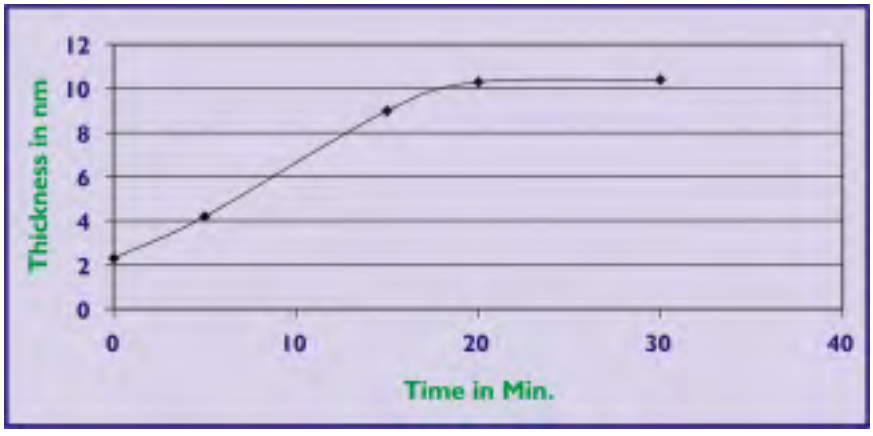

Fig. 5.4 : Gallium oxide thickness vs. O_2-plasma treatment time showing saturation after 20min.

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रेडियो तथा वायुमण्डलीय विज्ञान
RADIO AND ATOMOSPHERIC SCIENCES

रेडियो तथा वायुमण्डलीय विज्ञान

रेडियो और वायुमण्डलीय प्रभाग ने सीएसआईआर की तीन नेटवर्क परियोजनाओं में कार्य प्रारम्भ किया। यह तीन राष्ट्रीय वातरिक्ष प्रयोगशाला (एन ए एल) द्वारा "उच्च कोटि के विज्ञान और तकनीकों के विकास" परिवर्धन राष्ट्रीय पर्यावरण अभियंत्रिकी अनुसंधान संस्थान (एन ई ई आर आई या नीरी) द्वारा संचालित "प्रदूषण मानीटरन, न्यूनीकरण व युक्तियों" और राष्ट्रीय समुद्र विज्ञान संस्थान (एन आई ओ) द्वारा "मानवीकरण क्षोभ प्रक्रिया का समुद्री वायुमण्डलीय प्रभाव" भारत और इसके निकटवर्ती क्षेत्रों पर व्यापक परिवर्तन के सन्दर्भ पर परियोजनाएं आधारित हैं।

व्यापक परिवर्तन अध्ययन के अन्तर्गत, पारगामी राष्ट्रों में प्रचार किया। इसमें सहारन गर्त का हालने वायुमण्डल पर प्रभाव, एस पी एम स्तरों की तुलना, जैव पदार्थ ज्वलन से यू वी बी किरणों की तीव्रता पर प्रभाव, बश्हत–नगरों में उत्सर्जको के प्रभाव पर कार्य किया। इस अध्ययन में दिल्ली के सामान्य वायुमण्डल में किये हैं जिनमें दोनों सैद्वांतिक और नियमित मानीटरन प्रयोग सम्मिलित हैं।

अंटार्कटिका अध्ययन के अन्तर्गत ओजोन छिद्र, किरणन बजट, CO, CO_2 और CH_4 में परिवर्तन, कालम जल मात्रा, कुल ओजोन मात्रा और अवरोही वायु इत्यादि विषयों पर विश्लेषण किया। 23 नवम्बर 2003 के सूर्य ग्रहण के दौरान अंटार्कटिका स्थित मैतरी केन्द्र से वायुमण्डलीय अध्ययन किये गये। आर डब्ल्यू सी (प्रादेशिक चेतावनी केन्द्र) वैबसाइट आरम्भ की गई जिसके द्वारा उपभोक्ताओं को उत्पादों और सेवाओं के बारे में जानकारी दी गई। सहसंबंधित रेडियो बीकन रिसीवर प्रयोग (सी आर ए बी इ एक्स) क्रियात्मक क्रिया और कुल इलेक्ट्रान संख्या मापन के लिए आवश्यक साफॅटवेयर का विकास भी किया है। चुंबकीय तूफान पर आधारित अध्ययन में स्रॉस–सी 2 (एस आर ओ ओ एस–सी 2) और ए ई–सीरीज के उपग्रहों से प्राप्त आंकडों के उपयोग द्वारा महत्वपूर्ण परिणाम मिले हैं। आयनमण्डलीय प्रतिरूपण प्रयास के तहत असंगत प्रकीर्ण राडार ऑकडें, डिजिटल आयन अनुनादी प्रयोग टी इ सी निचली तह की टी ई सी, इलेक्ट्रान तापमान मापन के लिए एच एम एफ 2 और आई आर आई माडलों का प्रयोग किया है। इस तुलनात्मक विशलेषण में आई आर आई माडल में संशोधन के लिए उचित सुझाव भी दिये हैं। कोलकत्ता में, एक्स–बैंड राडार द्वारा राडार परावर्तकता का मापन किया और भारत दूर–संचार प्राधिकरण (टी आर ए आई) को स्लेयूलर स्पेक्ट्रम की कार्यक्षमता बढाने के लिए परामर्श दिये। पी सी आधारित उपकरणों के विकास के लिए शक्तिशाली कल्पित उपकरण प्लेटफार्म पर कार्य आरम्भ कर दिया है। हाल ही में आई आई जी के साथ वायुमण्डलीय विद्युत क्षेत्र में परियोजना शुरू की है। बॉल ऐन्टीना के लिए इलैक्ट्रानिक्स और संवेदकों के डिजाइन और निर्माण का कार्य प्रगति पर है। ध्वानिक वायु प्रोफाइलर के निष्पादन का परीक्षण सफलतापूर्वक पूर्ण किया। एन पी एल में क्रियात्मक पी सी पर आधारित उपकरण जैसा संयंत्र को तैयार किया है कोहरे में वायुमण्डलीय तापमान और आर्द्रता मापन के लिए तथा इसे हरियाणा के भामबेवा में लगाया गया है। ओजोन अंशांकन विश्लेषण के लिए ओजोन मानक सुविधा पर कार्य आरम्भ कर दिया है।

RADIO AND ATOMOSPHERIC SCIENCES

Radio and Atomospheric Sciences (RASD) has started new major activities in three CSIR network projects. These three project are National Aerospace Laboratory (NAL) led project "High Science & Technology Development for National Aerospace Programme", National Environment Engineering Research Institute (NEERI) led project "Pollution Monitoring Mitigation & Devices" and National Institute of Oceanography (NIO) led project " Impact of anthropogenic perturbances on oceanographic-atmospheric processes in and around India in context of global change".

Under global change studies, cross country campaigns were conducted. The studies were conducted on the effect of Saharan dust on Hanle atmosphere, comparison of SPM levels, effect of biomass burning on UV-B intensities, effect of emissions from mega-cities. The studies were also conducted on the ambient atmosphere in Delhi which included both theoretical and regular experimental monitoring. In Antarctic studies, the studies pertained to ozone hole, radiation budget, variations of CO, CO_2, CH_4, column water content, total ozone content and katabatic winds. The effects of a solar eclipse in November 2003 was also studied on Maitri atmosphere in Antarctica.

The website for RWC (Regional Warning Centre) was launched giving the details of products and services for users. Coordinated Radio Beacon Experiment (CRABEX) receiver was made operational and the necessary software to derive Total Electron Content (TEC) values was developed. In magnetic storm studies, data from SROSS-C2 and AE- series of satellites was used and some very interesting results were obtained. In the ionospheric modeling effort, Incoherent scatter radar data and digital ionosonde was used to compare TEC, Bottomside TEC, electron temperature and hmF2 with IRI model. On the basis of this comparison suitable modifications have been suggested for IRI model. Radar reflectivity measurements were carried out over Kolkata using X-band radar. Advice was rendered to the Telecommunication Regularity Authority of India (TRAI) on various options in increasing the spectrum efficiency in cellular communication.

A very powerful new activity for PC based instrument development has been started using a very powerful Virtual instrumentation platform. In the recently initiated project in the area of atmospheric electricity in collaboration with IIG, design and development of the electronics and sensors for fabrication of 'ball antenna' is under progress. The performance of Acoustic Wind Profiler was tested successfully. A PC based system, similar to the one operational at NPL, was developed for automatic measurement of atmospheric temperature and humidity for fog studies and installed at Bhambewa in Haryana. Work has started for setting up the ozone standard facility to calibrate ozone analysers.

New Major Initiatives

RASD participation in three CSIR Network Projects with its sister laboratories is approved. In the NAL led project 'High Science & Technology Development for National Aerospace Programme' RASD will contribute by setting up digital ionosonde station, identical to the one operational at NPL, at Bhopal and a network of GPS receivers. Using these RASD will generate improved reference ionospheric parameters over the Indian region enabling better position fixing exercises for aerospace applications. In the second network project led by NEERI, namely 'Pollution Monitoring Mitigation & Devices' RASD is contributing to three activities. The first one in which Polymer and Soft Materials activity of the Engineering Material Division is also participating, polymeric thin film sensors based compact and inexpensive devices will be developed for detection of toxic gases in ambient air, such as ozone, CO, NOx, SOx, HCl etc. for commercial applications at a later time. While polymeric thin film sensor development and standardization will be the responsibility of the Polymer Group, the digitization of the sensor output, associated electronics and device packaging will be carried out by RASD. As the second activity by RASD under this network project, the Division will be conducting a series of scientific investigations relating to trends of concentrations of a large number of minor constitutents including atmospheric pollutants, greenhouse gases, surface ozone & precursor gases in the lower atmosphere using a High Resolution Open Path FTIR to be acquired from the project funds. The third contribution under the network project will be setting up a laboratory facility to create smog under controlled conditions to study its relationship with various atmospheric control parameters including precursor gases from various polluting sources in a city like Delhi. The third network project to which RASD is contributing is in the area of "Impact of anthropogenic perturbances on oceanographic-atmospheric processes in and around India in the context of global change" and is led by NIO. The project addresses understanding of air-sea interaction and its effect on the processes in the mixed-ocean-layer. RASD will be contributing by providing long term measurements of greenhouse gases, aerosols and radiations and analyse them for short/long term trends, particularly the flow pattern of pollutants across land-ocean boundary.

Atmospheric Environment and Global Change

NPL's activity is focused on certain important issues including greenhouse gas emissions, urban and regional atmospheric pollution, regional increases in tropospheric ozone, decrease in stratospheric ozone particularly ozone hole over Antarctica, dry & wet deposition etc. Monitoring of greenhouse and other trace gases from NPL and various other locations including Antarctica is an important part of this.

Cross-Country Monitoring:

Cross-country monitoring at four stations, namely, Henle/Leh, Darjeeling, located at mountain heights in the north-west and north-east regions of India, Sundarbans in the Indo-Gangetic planes and Port-Blair at a remote marine loacation was continued with the purpose to investigate the purported four channel horizontal transport of aerosols, surface ozone etc, across the Indian region. Map showing these locations is given in Fig. 6.1. Participation of the India Institute of Astrophysics and J&K University, Leh, the Central Road Research Institute, New Delhi, and the Kolkata University, Bose Institute and Jadavpur University, Kolkata, was sought in these measurements.

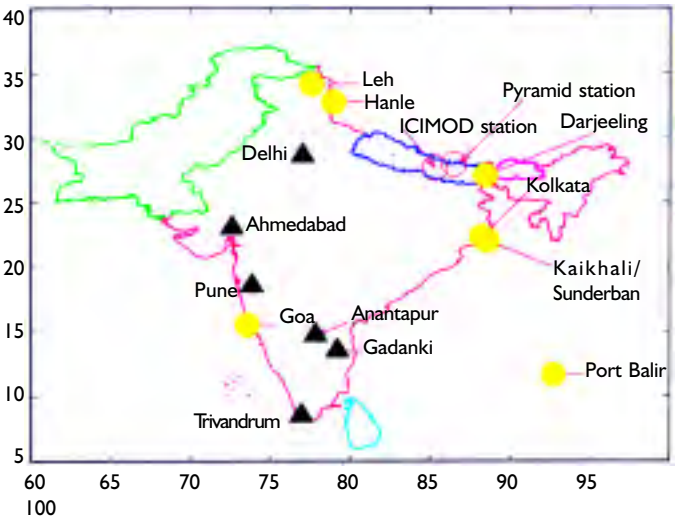

Fig. 6.1 : Map showing locations of cross country monitoring

Influence of Saharan dust on Hanle atmosphere

An analysis of the optical observations made using microtop sun-photometer and pytannometer from Hanle and Leh sites situated at the heights of 4.5 and 3.4 km above msl during July 4-18 2003 and the contemporal TOMS satellite data was done. The aerosol optical depths (AOD) at two wavelengths 380 and 500 nm had a value of 0.172 ± 0.035 and 0.095 ± 0.018 at Hanle and 0.275 ± 0.045 and 0.177 ± 0.050 at Leh, respectively. The irradiance measurements were compared with the model calculations done using the tropospheric ultraviolet visible radiation model (TUV). Initially the observed values of irradiance showed slightly lesser than the model values. But an adjustment of AOD within its error limits (one sigma) gave a good agreement called best fit here (Fig. 6.2). The value of AOD, particularly at Hanle (4517 masl), which is a virgin hilly desert free from anthropogenic activity, was found to be unexpectedly high for this altitude. To explain this the back trajectories ending at Hanle at different altitudes and for varying time durations were plotted. Fig. 6.3 shows three such back trajectories ending at Hanle at 0600 UTC at 4.5, 5.0 and 6.0 km above ground level on July 14, 2003. The trajectories indicate the flow of air mass during the observation was from the Saharan and sub-Saharan regions and would therefore carry fine dust particles in the high altitude regions of the atmosphere at Hanle thus giving rise to high AOD values.

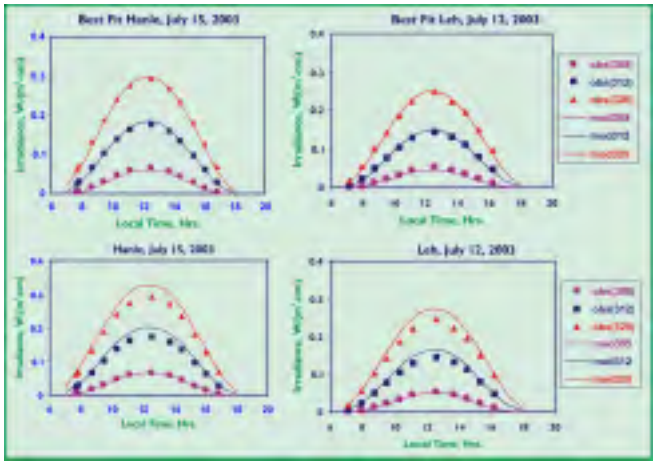

Fig. 6.2 : Variation of measured irradiance at high altitude of Leh and Hanle and their comparison with TUV model

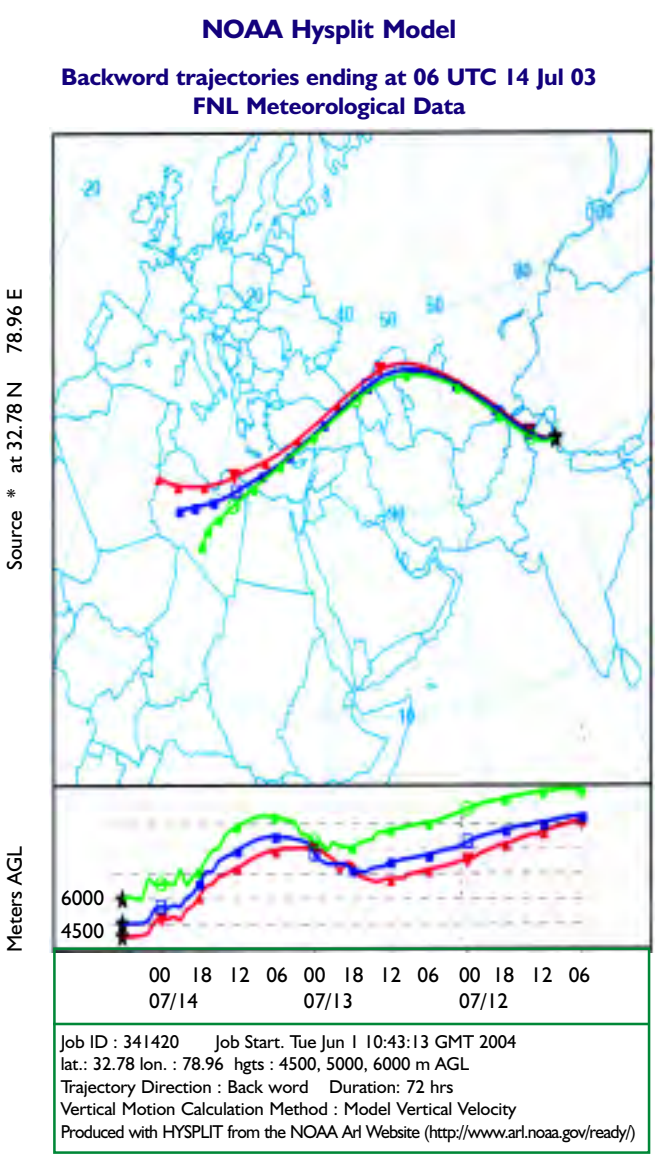

Fig. 6.3 : Back trajectories showing transport of air mass from Sahara region to Hanle

Comparison of SPM levels

SPM levels at all these sites were compared and it was found that the SPM level at Port Blair is low (Fig. 6.4). The analysis with other data obtained at these four places shows couple of interesting features: (a) Large biomass burning can be correlated to high concentration of CO concentration at Sunderban., (b)Very low ozone in presence of high CO and NOx at Port Blair and (c) Role of Humidity and cloud over Ozone Formation at Darjeeling and Hanle.

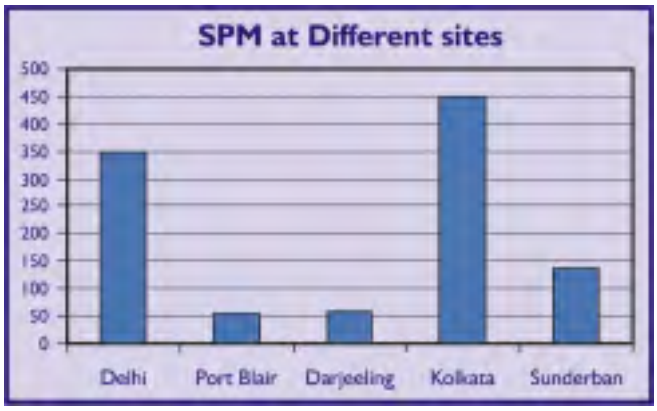

Fig. 6.4 : SPM levels at different sites

Other results from Leh/Hanle

Aerosol size distribution in the range 0.3μm to 20 μm was monitored using a 15 channel Grimm aerosol – dust monitor. Column ozone and water vapour were also monitored at Henle and Leh. The effect of the intensity of solar radiation which was found to be three times higher at Henle compared to Delhi at 305 nm range, is easily noticed in the heavily wrinkled faces of the local inhabitants, particularly those working in open fields. The water vapour at Helne was roughly one tenth compared to Delhi.

Near zero surface ozone at Port Blair - a photo-chemical box model result

The campaign at Port Blair measuring surface ozone, CO, NO_x, CO_2, Aerosol concentration and its size, UV radiation at Port Blair was conducted during March 16-26, 2002. Near zero surface ozone concentration on different time scales was observed several times, particularly midnight. (Fig. 6.5). NOx ($NO + NO_2$) was very high (~40 ppbv) during low ozone concentration periods. CO was very high at 300-600 ppbv during the period. Sources of this high pollution are not clear although 7-days isentropics back trajectory analysis suggest that air mass came from the eastern side of the Indian subcontinent (Fig. 6.6). A Photochemical Box Model which includes chemistry module for non-methane hydrocarbon was used to understand the role of high NOx and CO concentrations on low ozone concentration. For the purpose of modeling NOx emissions from the maximum industrial emission values from various source categories in kg(N)/yr per 1x1 grid cell were used. The overall maximum grid cell was 1.7934e+08, which pertained to the category "Transport : Road". Presuming NOx emissions at Port Blair of the order of 1.24×10^7 Tg,, representative of the Okalahoma City, USA the model predicted low ozone concentration while the value of CO was kept large as actually measured (Fig. 6.7).

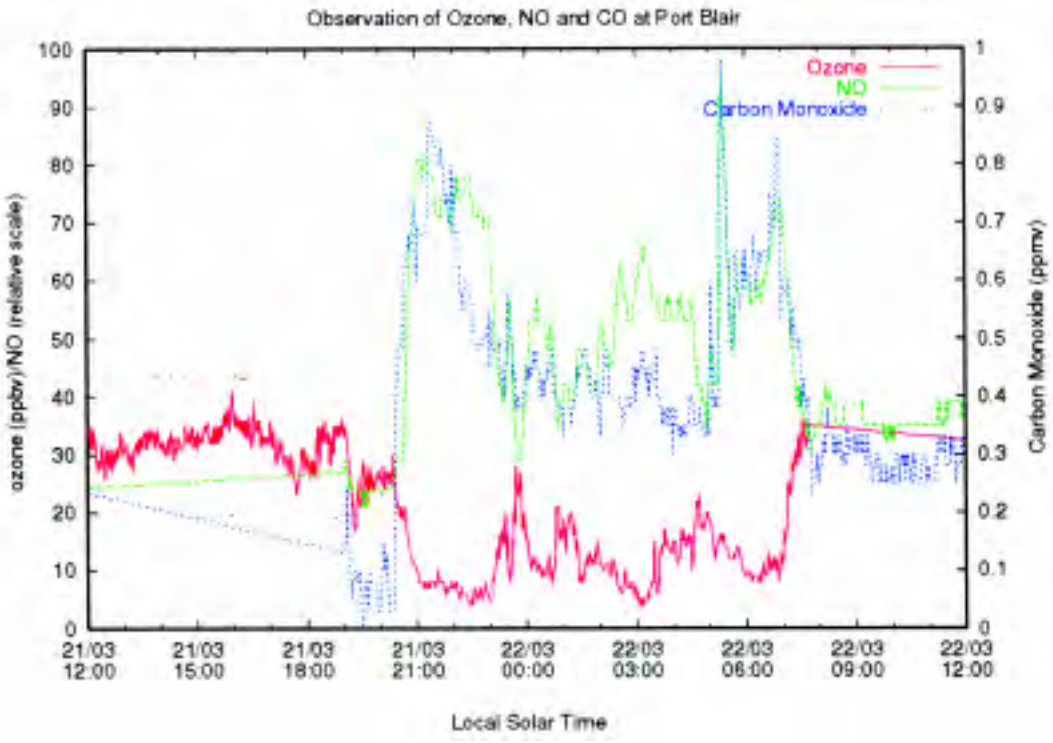

Fig. 6.5 : Observations of Ozone, NO and CO at Port Blair

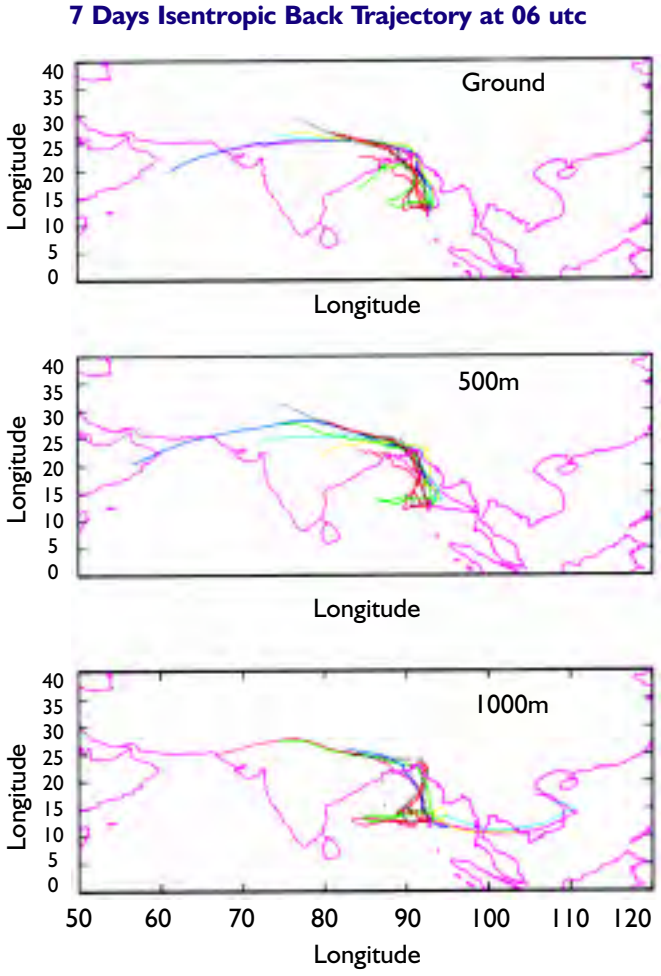

Fig. 6.6 : 7-days isentropics back trajectory at 06 UTC at different heights

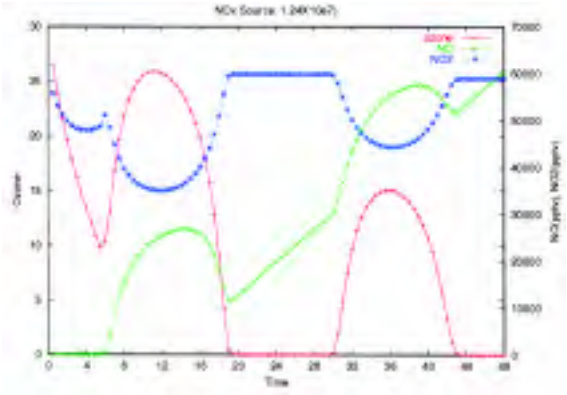

Fig. 6.7 : Model calculations of Ozone, CO and NO values

Effect of aerosols from Biomass burning on UV-B intensities

Biomass burning campaign was conducted in the Mizoram state of North-East India in 2002. The UV-B intensities and aerosol optical depth were measured, during control days and during biomass burning period, using Erythemal Probe and Microtop Sunphotometer respectively. Both UV-B intensities

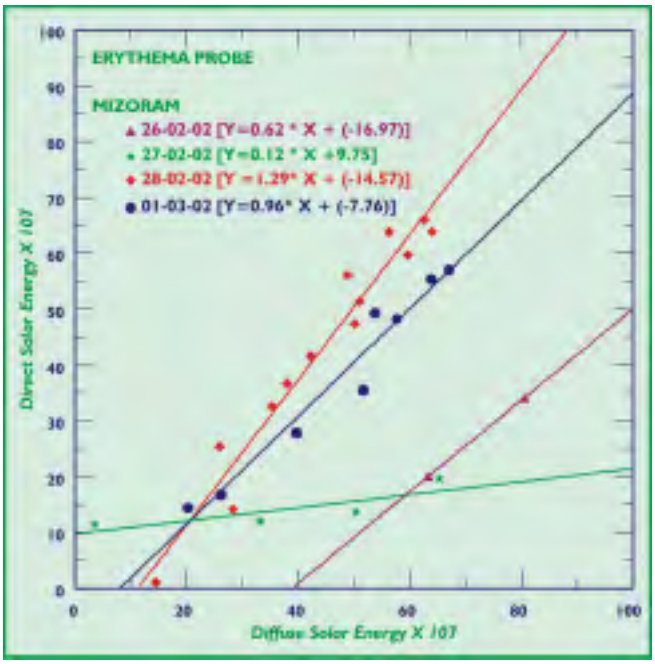

Fig. 6.8 : Correlation of direct and diffuse UV-B radiation measured by Erythemal probe on different days in Mizoram forest including biomass burning day 27-2-2002

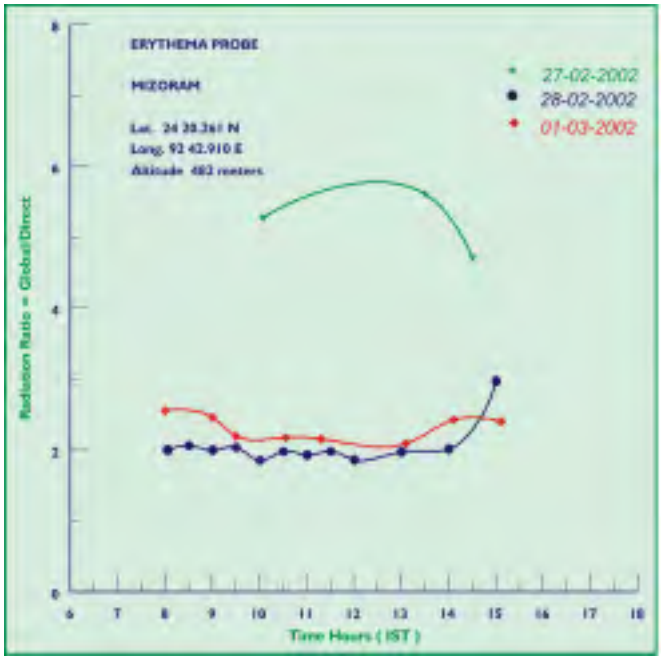

Fig. 6.9 : Variation of Global/Direct ratio on different days in Mizoram forest including biomass burning day 27-02-2002

and aerosol optical depth were found to be affected due to biomass burning episode. A correlation between the increase in diffuse UV-B intensities relative to the direct UV-B intensities (Fig.6.8) during biomass burning period shows the effect of aerosols on UV-B intensities. The similar effect is seen in diurnal variation of global/direct ratio of UV-B intensities as shown in (Fig. 6.9).

Emissions From Mega-Cities and Related Studies

Emissions from Delhi and Kolkata

Cities in Asia are increasingly vulnerable to environmental degradation and ecological disasters due to population growth, expansion of industrial activities and rapid urbanization. Thus urban managers and policy makers in this region are in need of the tools to evaluate the effectiveness of various measures in quantitative terms when formulating regional action plans for prevention of the global warming. In response to this practical needs for developing policy evaluation tool, this activity aims to study the dynamics of industrial transformation taking place in Asian cities and analyze its environmental implications with special regards to energy consumption and GHG emissions by developing GHG budget data of seven mega-cities in Asia and the future scenarios of GHG emissions. This will help in identifying the drivers that are responsible for global change. The study covers the sectors and activities for which cities can manage to implement effective countermeasures by adopting locally operational policy instruments.

In this program Delhi and Kolkata are covered as the two representative Indian mega-cities. Activity data related to demographic profiles, socio-economic parameters, vehicle population, consumption of energy & agriculture products, generation of waste for the cities of Delhi and Kolkata have been collected and inventories of greenhouse gases and short-lived gases for both direct and embodied emissions from different sectors have been developed including the future scenarios of emissions. The results show that Delhi and Kolkata had 2.4% of the total population of India in 1990 which was responsible for about 5% of total CO_2 emitted from India. In 1995, the share of these two cities population had gone up to 2.7% and the share in total CO_2 emission also increased to 5.2%. Thus it indicates that the steps to mitigate CO_2 emission within mega-city will have significant impact on national emissions.

Mega-city – suburban corridor campaigns

To understand the transport of pollutants from mega-city to its suburban surroundings extending upto mesoscale often covering several ecosystems, two corridor campaigns were conducted, one from Delhi to Chandigarh in collaboration with CRRI, New Delhi and the second from Kolkata to Sunderban in collaboration with the Jadavpur University and the West Bengal Pollution Control Board. First of the planned three pilot studies in the Delhi-Chandigarh-Delhi corridor study was carried out during June 22 – 24, 2003 and included measurements of atmospheric trace gases and particulate matter. The Delhi-Chandigarh highway (NH-1) is a 200-km long north-south stretch connecting the capital city of Delhi to the well-planned city of Chandigarh. Along this highway, a variety of ecosystems are present ranging from urban, villages, agriculture fields, lakes, forests and industrial townships. During this pilot study, efforts were made to make measurements in and around some of these ecosystems. The preliminary indicative values of different parameters observed are tabulated below.

RASD also participated in the ISRO organized National Road Campaign for study of aerosol levels contributed by traffic on national highways. RASD conducted observations using Micro-tops, UV radiometers and Sodar for one month period during February-March 2004 on way from Delhi to Hyderabad and back. While at Hyderabad, all the participating institutions took part in a mega inter-comparison campaign of various instruments used by them.

Table 6.1: Preliminary indicative values of different parameters

Delhi-Chandigarh Corridor [NH-1; 22-24 June 2003]													
Piao Maniary (Kundli Border)													
	SO_2	CO	O_3	NO	NO_2	NO_x	THC	CH_4	NMHC	PM_{10}	$PM_{2.5}$	PM_1	$PM_{2.5}/PM_{10}$ Ratio
	ppbv	ppmv	ppbv	ppbv	ppbv	ppbv	ppmv	ppmv	ppmv	ug/m^3	ug/m^3	ug/m^3	
AV	2.0	0.4	29.3	1.9	30.4	32.9	0.63	0.55	0.07	238.0	146.9	50.6	0.62
SD			4.3	0.42	6.03	6.2	0.07	0.04	0.03	99.5	70.4	2.9	
Karna Lake, Karnal													
AV	2.80	0.20	33.1	1.2	27.8	30.2	5.75	5.05	0.70	246.2	163.1	57.5	0.66
SD			4.2	0.6	10.8	9.8	0.19	0.07	0.22	88.7	62.3	13.4	
IMTECH, Chandigarh													
AV	0.17	0.71	11.9	2.0	17	19.1	3.5	3.3	0.14	101.2	54.2	34.3	0.54
SD			9.9	4.3	9.1	13.0	3.2	3	0.13	48.4	20.4	13.4	
Seonthi, Kurukshetra													
AV	0.03	0.12	34.6	1.4	14.7	16.4	6.1	5.9	0.1	141.4	85.7	42.9	0.61
SD			10.3	0.8	4.7	5.3	2.3	2.1		47.2	22.4	2.0	

Table 6.2: Results of the Gas Chromatographic (GC) analysis of collected grab samples:

Date	Place	Time of sample collection	CH_4 (ppmv)	CO_2 (ppmv)	N_2O (ppbv)
22.6.03	Piao Maniary	1 PM	2.4	485	370
22.6.03	Karna Lake, Karnal	7.30 PM	2.6	484	410
23.6.03	IMTECH, Chandigarh	8 PM	2.3	515	360
24.6.03	Seonthi, Kurukshetra	4 PM	3.7	440	360

Antarctica Studies

NPL has been participating in the Indian Antarctic expeditions for more than 15 years for conducting research on the Antarctic atmosphere. The phenomena of ozone hole, radiation budget, Katabatic winds etc have drawn special attention. Accordingly several experiments have been conducted. The highlights of this year include the following:

Carbon dioxide

Atmospheric carbon dioxide was measured by gas chromatography with flame ionization detection. The monthly averaged variation of atmospheric CO_2 measured at Maitri during Feb 2002 – Jan 2004 is depicted in Fig. 6.10. The gaps in data are due to the inability to conduct measurements on account of Antarctica blizzards. The carbon dioxide was found to vary in the range around 360 to 377 ppm. The average

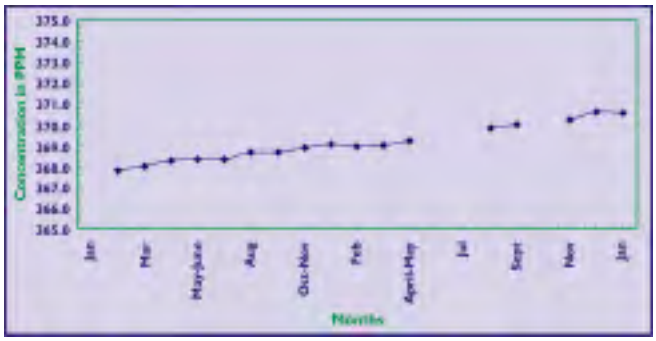

Fig. 6.10 : Monthly averaged CO_2 from January 2002-January 2004 at Maitri, Antarctica.

concentration measured was was 368.32 ppm and 369.51 ppm during 2000 and 2003, respectively which is comparable to the current global average. No seasonal variation of CO_2 has been observed at Maitri. The CO_2 measurements using the GC are very consistent and variations if any are due to met parameters particularly wind.

Column Water vapour

Total Water Vapour Column has been measured at Maitri using microtop sun-photometer during 16th, 21st, 22nd and 23rd Indian Scientific Expeditions to Antarctic. The annual averaged water vapour was found out to be 0.24 cm in 1997, 0.42 cm in 2002 and 0.45 cm in 2003. Monthly average Column water vapour concentration observed at Maitri during 1997, 2002, 2003 and 2004 is depicted in Fig. 6.11. Maximum monthly averaged water vapour values occurred in the month of January in all study years, namely, 1997, 2002, 2003 and 2004. In comparison to 1997 the column water vapour was higher by 48.8% in 2002, 57.7% in

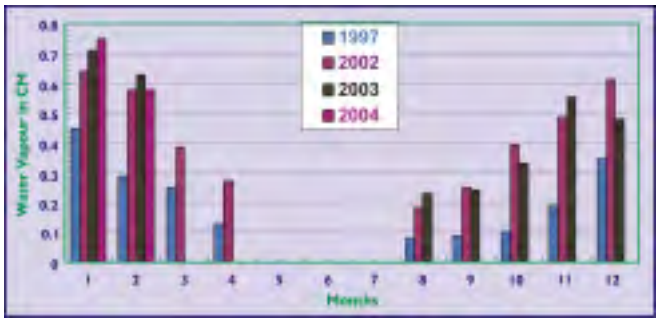

Fig. 6.11 : Monthly average column water vapour concentration at Maitri during 1997, 2002, 2003 and 2004

2003 and 66.6% in 2004. This was possibly due to higher surface temperatures in these years, in particular the months of January.

Methane

Methane is the most abundant hydrocarbon in the atmosphere. Its tropospheric chemistry affects hydroxyl (OH) radical and CO concentration. In stratosphere, the oxidation of methane by OH radical is a major source of water vapour, and its reaction with chlorine atom terminates the chlorine- catalyzed destruction of ozone. The daily average atmospheric methane measured at Maitri from February 2003 to February 2004 is depicted in Fig. 6.12. The day-to-day variation of surface CH_4

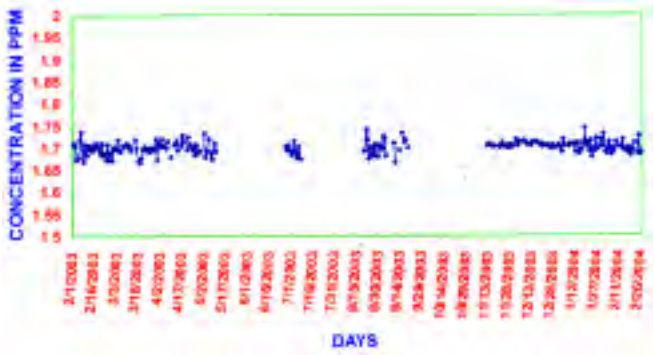

Fig. 6.12 : Daily averaged CH_4 at Maitri Antarctica from February 2003 to February 2004

concentration was vary small in this period. The daily averaged surface methane concentration varied between 1.64 to 1.73 ppm and the total period average was 1.70 ppm. No seasonal variation of methane was observed. Values are pretty consistent. Variations if any are attributable to met parameters changes particularly winds. From other studies it is known that air arriving at Maitri is well mixed, having traveled over the Southern Ocean, and is far away from spatial and seasonal variations in source strength characteristic of land areas. The values of CH_4 observed at Maitri are comparable to present global CH_4 values.

Carbon monoxide

During the 22nd Indian Scientific Antarctica expedition a new system was deployed at Maitri to monitor CO

on round the clock basis. The variability in CO concentration has been observed, with hourly mean mixing ratios ranging from 30 ppb to 65 ppb. Diurnal changes in CO concentrations were systematically observed showing higher CO during daytime. The daytime increase of carbon-monoxide is attributed to the photolysis of formaldehyde in the Antarctic atmosphere which is released from snow during sunlit hours. Formaldehyde is rapidly destroyed by sunlight to produce H_2O and CO.

The daily mean concentration of CO was found to vary between 30 ppb to 60 ppb during January to April 2004 and is shown in Fig. 6.13. Sometimes, values

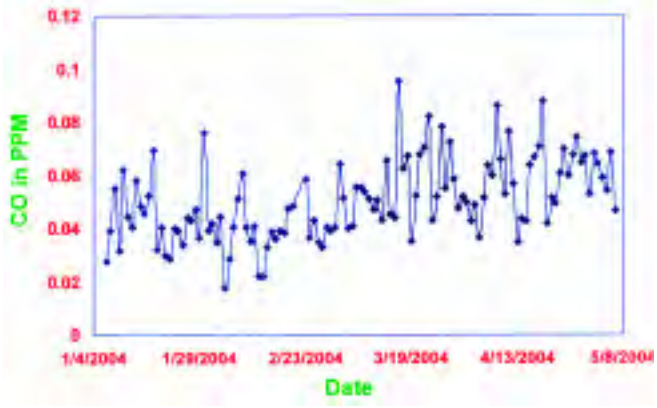

Fig. 6.13 : Daily averaged CO at Maitri Antarctica from January 2004 to April 2004

as high as 150 ppb were observed, which could be due to the 'station effect' whenever prevalent wind direction changed from station to experimental site. The monthly mean concentration was derived to be 0.044 ppm, 0.038 ppm, 0.056 ppm and 0.058 ppm in January, February, March and April 2004, respectively.

Total Column Ozone

The column ozone measurements were carried out during 1997 and again during 2002-2004 at Maitri Antarctica on all clear days. Integrated column Ozone observations during 1997, and 2002, 2003 at Maitri show ozone concentration up to 320 DU in the months of January-February as shown if Fig. 614. The minimum value of column ozone during spring

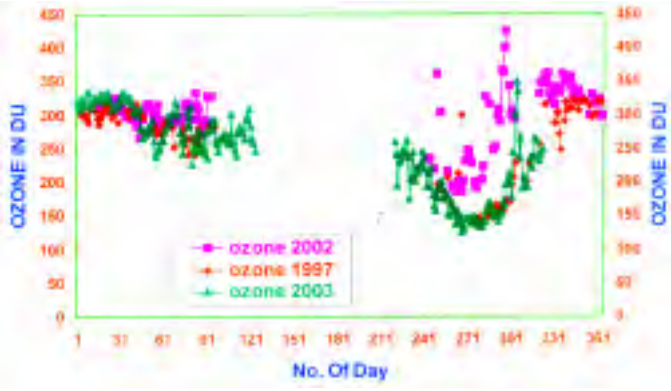

Fig. 6.14 : Column Ozone at Maitri, Antarctica during, 1997, 2002 and 2003

of 1997 observed was about 135 DU in the first week of October while during spring of 2002 the minimum value of column ozone was found to be 185 DU and 126 DU in the year 2003. Thus it was found that the ozone hole during Antarctica spring of 2002 was not as pronounced as in 1997 and 2003. Also it was of shorter duration during 2002 as compared 1997 and 2003. The above figure shows the daily averaged total column ozone over the Maitri, Antarctica from Jan 2003- Dec 2003. Ozone hole started appearing in the month of August and disappeared in the late November. High ozone values up to 351 DU were observed in the month of November 2003 during the recovery period of ozone hole. These measurements were also compared with those obtained by satellite data and are in good agreement. There are indications of recovery of ozone hole from NPL and other observations during 2002. However, to confirm this observations from Maitri have to be continued.

Measuring the effect of solar eclipse on Maitri atmosphere

Appearance of a total solar eclipse on November 23, 2003 seen in the Antarctic region provided a rare and a unique opportunity to check its affects on ambient environment over the Maitri station. The maximum of eclipse at Maitri was at 23:17:20.0 hour GMT. The totality was for 79 seconds and partial eclipse phase lasted one hour 37 minutes. Luckily

sky was also clear enabling optical observations. The solar radiation at all the wavelengths started to drop very sharply during the eclipse. The water vapour dropped from 0.11 cm to 0.04 cm while the aerosol optical depth at 1020 nm increased from 0.017 to 0.135 during the eclipse. A sudden increase of solar radiation was observed just before the totality at all the five wavelengths. The anomalous behaviour of solar radiation observations is being analyzed. The column ozone and UV radiation at 305, 312, 320 nm could not be estimated due to instrument limitation and due to high solar zenith angle, around 88° during eclipse.

Modelling katabatic winds

Antarctica is known to be the windiest continent in the world. This is basically due to the fact that Antarctica is domed shaped. Therefore, steep inversion air mass resting on the inclined planes is pulled down by the gravity. As this air-mass moves from the interior of the continent towards the periphery, it picks up momentum, resulting in the formation of katabatic winds. These winds are one of the most celebrated features of Antarctica, and have attracted attention of each country to model the characteristics. Keeping this in view efforts were made for modelling katabatic winds over the Schirmacher region, east Antarctica.

Thermal convection over Schirmacher Oasis & its role in dispersal of microorganisms

The Indian Antarctic station, Maitri ($70^0$45'57" S, $11^0$44'09"E) is situated over the Schirmacher oasis of Princess Astrid Coast, east Antarctica. It is a small hilly oasis (area 35 km^2), which exhibits a congenial place for microorganisms (algae, lichen, mosses, midge, mites, tardigrades) found in the harsh polar region(Gajananda, 2002). The study of these microorganisms is essential to understand their life cycle, growth and the survival mechanisms. During the winter season, a thick sheet of ice, burying all life forms, covers Schirmacher region. However, during local summer, life blooms, and under thermal convection conditions, measured by an acoustic sounder, microorganisms disperse as part of their survival strategy.

Studies of the Ambient Environment at Delhi

Prediction of total ozone over Delhi using neural network modeling

Ozone trend analysis has been a significant concern since the discovery of Antartic ozone hole. Neural network has been extensively used to solve many complex problems in the field of meteorology for cloud classification and visibility prediction, artificial intelligence of speech and visual recognition etc. As part of a study at NPL the neural network modeling technique was used for the first time for predicting total ozone over Delhi. It is well known that total ozone exhibit natural variations like seasonal, quasi-biennial (QBO) and 11-year solar cycle variation. A neural network was developed to include various periodicities like 6-, 4- and 3- month, annual, biennial, 11- and 22- years solar cycles as input variables and total ozone as the output variable. The network was then trained using monthly mean total ozone Dobson data for the period of 1990-2001 over Delhi. The results are shown in Fig. 6.15.

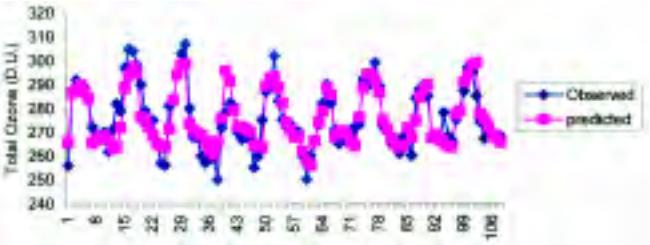

Fig. 6.15 : Observed and predicted monthly mean total ozone over Delhi using neural network

The results obtained from the trained network were compared with that of a time series regression model discussed below. The trained network was used for future prediction of total ozone. A time series regression model considered for this purpose is

$$O_3(t) = a + bt + g.\ \text{Harmonics} + \text{noise}$$

where $O_3(t)$, $t=1,2,\ldots,T$ denotes the time series of monthly average total ozone, t denoting the time in

month, a the intercept, b the trend coefficient and g the collection of terms involving the amplitude and phase of 6-, 4- and 3- month, annual, biennial, 11 and 22 years cycles. The results obtained from the time series regression model were compared with that of the trained neural network and are comparable as shown in Fig. 6.15.

Thus, the feasibility to apply the neural network technique for the prediction of total ozone and other atmospheric minor constituents has been established.

Long term monitoring of surface ozone

Using data from the round the clock monitoring of surface ozone using Dasibi analyzer continuing since 1997 at NPL the monthly average values for the total period were derived (Fig. 6.16). They show highest ozone during 2002 since 1997. This can possibly be attributed to very low water vapour during 2002 on

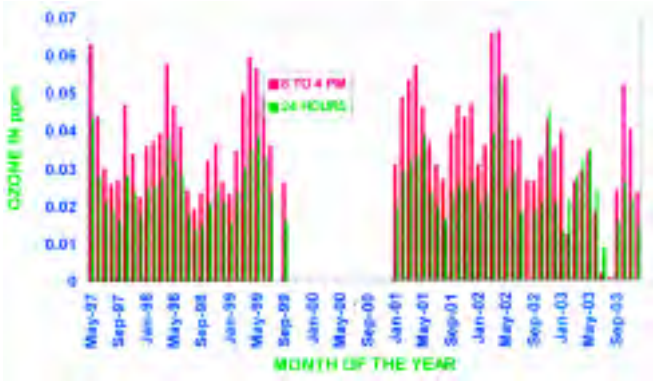

Fig. 6.16 : Monthly average surface ozone for 24 hours & 8 am to 4 pm at NPL, New Delhi during 1997-2003

account of droughts. Number of occurrences of hourly averaged ambient concentration of ozone crossing the WHO prescribed safe level of 80 ppb were found to be 83, 39, 113, 158, 112 and 111, respectively in the years 1997 to 2003. The nighttime increases of surface ozone have been observed several times under stable boundary layer conditions in nights and also during thunderstorms as shown in Fig. 6.17 and Fig . 618. The high surface ozone at night in winter months could possibly be attributed to strong temperature inversion after sunset, which triggers the formation of wind maximum slightly above the inversion layer. This

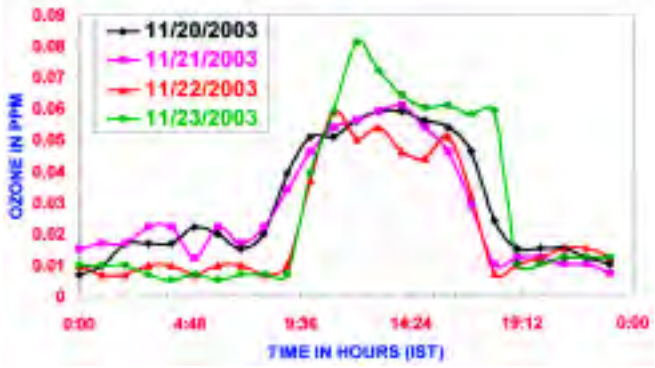

Fig. 6.17 : Diurnal variation of surface ozone with night time high values during winter

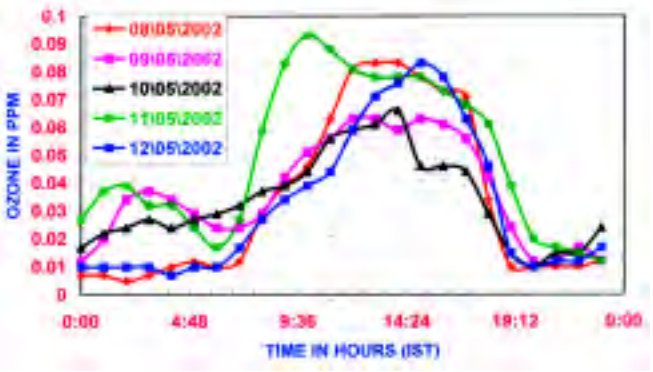

Fig. 6.18 : Diurnal cariation of surface ozone with night time high values during thunder storms

meteorological phenomenon is referred to as the low-level jet. This jet produces mechanical turbulence that can bring the ozone rich air from aloft to the ground. During thunderstorm the movements of updraft and downdraft can transport the ozone rich air from upper troposphere to surface.

In addition to surface ozone, monitoring of NOx, CO and meteorological parameters including temperature, humidity, solar radiation, wind speed and wind direction has also been started at the same site on a continuing basis lately to help in interpreting surface ozone variations. The Differential Absorption Lidar (DIAL) facility that was built indigenously is also being used from time to time to monitor surface ozone, water vapour, ethylene and ammonia.

Round the clock aerosol/dust monitoring

On line regular measurements of PM 1 / PM2.5 / PM10 at NPL were continued. The monthly average mass

concentration of PM 2.5 at NPL, New Delhi ranged from 60 $\mu g/m^3$ to 475 $\mu g/m^3$ from October 2002 to November 2003 is shown in Fig. 6.19. The concentration varied

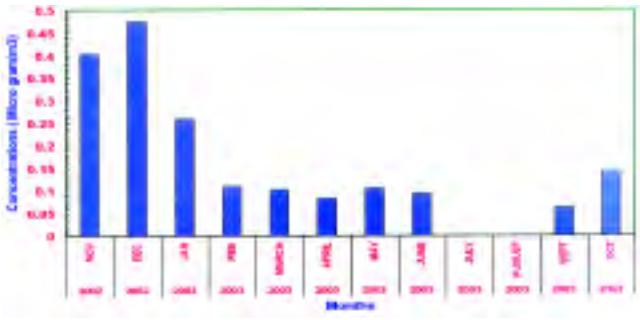

Fig. 6.19 : Monthly average of PM 2.5 concentrations from Nov. 02 to Oct. 03 over NPL, New Delhi

significantly with season and time of the day and was found highest during winter months as expected in the presence of shallower mixing height during colder months.

During clear day the particulate matter exhibit minimum level of 50 $\mu g/m^3$ or less during mid day and increasing to 200 – 300 $\mu g/m^3$ in the evening and night. The daytime minimum value can result if injection of additional aerosols during daytime is accompanied by significant raising of boundary layer height. The increasing concentration towards evening and nighttime on the other hand can result from appearance of inversion.

The fine particles with aerodynamic diameter < 2.5 mm (PM 2.5) was found to increase to an exceptionally high value of 800 $\mu g/m^3$ around 2200 hrs on the Diwali night. The normal concentration of particles as observed during pre Diwali days was around 200-300 $\mu g/m^3$. The persistence of high concentrations after Diwali for few days is attributable to injection of organic compounds and soot particles into the atmosphere from extensive burning of crackers. Organics and soot particles reduce the rate of evaporations of aqueous aerosols and thus haze persists longer.

The infrared absorption monitoring system developed and designed at NPL was used to record online the onset and dispersal of fog events in winter.

Impact of Climate Change on Human Health

The likely health concerns of India in the climate change scenario, with special focus on malaria has been under investigation in NPL since last three years. Malaria is one of the major vector borne health hazards of the country today and has become endemic in some of the regions of India. Increase in malaria incidences and deaths are attributed to resistance of mosquitoes to pesticides and those of the parasites to anti-malarial drugs. Though socio economic parameters as well as climate influence malaria vector growth and transmission, however, the present study is limited to understanding the relationship between climate and malaria trends in India and its likely future scenario in the climate change regime. Preliminary analysis indicates that temperature has a greater influence on malaria incidence as compared to precipitation. The transmission windows of malaria in the present climate have been classified as Class I, Class II and Class III in terms of threshold temperatures and number of days in which relative humidity ranges between 60% to 80% - a condition appropriate for high malaria incidences. In the climate change regime, transmission windows of malaria in India are likely to spread at higher latitudes and altitudes and duration of the transmission windows may widen in northern and western states and shorten in the southern states. The Government of India, through its planning process, has put in place, major initiatives like the National Anti Malaria Programme, to control malaria in the country. Additional surveillance through an integrated environment management approach will strengthen the adaptive capacity of the population vulnerable to malaria in the climate change scenario. This study is now being expended to integrate climate change with the other major factor driving malaria i.e. the socio economic trends, land use changes etc. This will be helpful in getting the indication about the extent to which the malarial boundary may shift in future and also help identify the vulnerable pockets and therefore appropriate adaptation strategies.

Radio Communications and Space Physics

RWC website launched

The Regional Warning Centre at NPL, RWC-India, has launched its own website in Jan. 2004, (http://www.npl-cgc.ernet.in/atul/cgc/rwc/INTRUDUCTION4_Buln.htm) that gives details of Product and Services for users. The website is also hooked up globally as part of International Space Environment Services (ISES) chain (http://www.ises.org/). In addition to the usual services like daily URSIGRAM, Solar Alerts, Monthly Geophysical Bulletin, Point-to-Point and Area Prediction of Ionospheric parameters useful for HF Communication applications etc. some new products are also introduced recently, such as,

1. Estimation Radar Tracking Errors over the Indian zone for defence applications.

2. Initial phase of development of Ionospheric Electron Content (IEC) Model for Indian zone is completed. Using the model contour map of monthly median IEC values over the Indian zone is provided in the website for the current months for navigational and other applications which is changed every month. An example is IEC shown in fig. 6.20.

3. Solar cycle Prediction and Sun Spot predictions six months in advance is one of the important service which RWC is providing to the users continuously updated every month.

TEC from CRABEX Receiver

This division is participating in the national Coordinated RAdio Beacon EXperiment (CRABEX). As part of this a CRABEX receiver has been made operational at NPL and data is being recorded from some radio beacon satellite transits over Delhi for deriving the Total Electron Content (TEC). Necessary software has been developed and is being used for deriving TEC from the received signals. Fig. 6.21 at prepage shows the

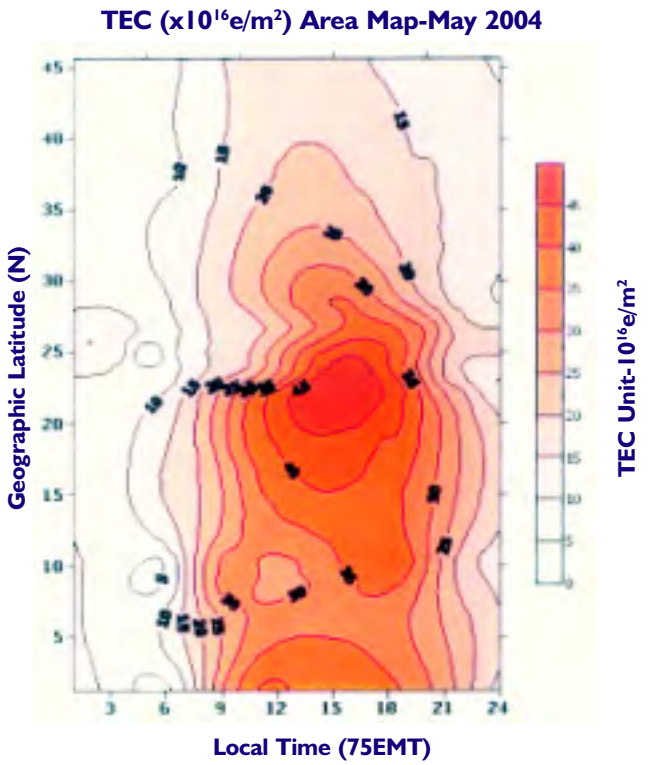

Fig. 6.20 : Controur map of IEC for Indian zone for the month of may 2004 obtained from NPL TEC Model.

variation of TEC (upto the satellite height of 1000 Km) as derived from these observations. In this figure Red line shows the Slant TEC while Green one shows the Vertical TEC values.

Magnetic Storms Studies

With a recent renewal of interest of effects of solar weather events on low and equatorial ionosphere,

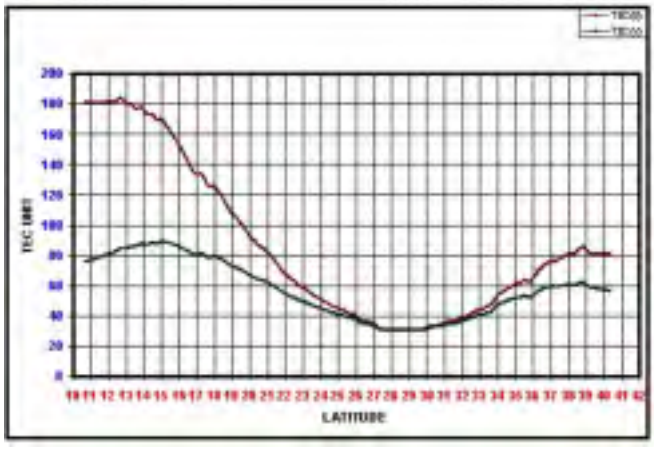

Fig. 6.21 : Latitudinal Variation of TEC using CRABEX receiver

SROSS-C2 data has been studied in conjunction with major magnetic storm events. This study is very promising and the following observations are recorded.

- Effects of geomagnetic storms are basically due to direct penetration of the magnetospheric electric fields to low latitudes.
- Meridional neutral winds coupled with changing (intensity) eastward electric field causing redistribution of latitudinal ionzation distribution.
- Clear evidence of seasonal changes in meridional neutral winds affecting latitudinal ionization distribution in opposite fashion.
- SROSS-C2 data offers a great chance to model these winds coupled with electric field and to establish whether they are magnetic storm driven or otherwise.

Studies of magnetic storms using AE series of data revealed some very interesting results for a magnetic storm during low solar activity period at mid-latitude. Normally it is expected that O+ decreases after the peak density at around 350 to 400 km. But for this storm it was observed that though O+ shows a decrease with altitude upto about 950 km, it increase with altitude upto about 1100 km., that is a result which normally one does not expect. However H+ behaves in a manner that is expected. This behaviour could probably be attributed to influx coming from topside.

Contribution towards updating IRI model for the Indian region

High resolution electron density profiles measured with the Arecibo incoherent Scatter radar are used to derive the Total Electron Content (TEC) and slab thickness during the period 1989-90 (solar maximum). The diurnal and seasonal variations of TEC and slab thickness are examined and these observations are then used to assess the predictability of latest available International Reference Ionosphere (IRI-2001) model. Also in order to examine the solar control, we have compared these observations with those obtained earlier by us during solar minimum period (1974-77). Discrepancies between the IRI and the observed median values exceed 40 % during nighttime for winter and equinox, while during daytime, they are less than 20 % for all the seasons. The TEC peak content increases by a factor of around 4 from solar minimum to solar maximum.

Occasional temperature enhancements around midnight has been observed by analyzing about three years of incoherent scatter measurements of Arecibo radar. Definitive seasonal effects have been noticed with a very pronounced maximum during summer and a feeble maximum during winter. These effects have also been examined in relation to simultaneously measured vertical drift.

Using Digital ionosonde measurements at New Delhi, the diurnal and seasonal variations of the hourly Bottomside Total Electron Content (BTEC) are derived from January 2001 to August 2002 during a high a solar activity period. Comparative studies of these observations are then made with those obtained from the IRI-2001 model. The IRI model with a new option, provides a better agreement with the observations especially during summer and equinox for daytime conditions. However, during winter, the IRI predicted values of BTEC using old option are found to be closer to the observations than obtained using new option.

Using Arecibo incoherent scatter radar measurements, we have correlated the nighttime electron temperature with N-S drifts and concluded that temperature variations are related with reversal of ion drift velocity from North to South.

Seasonal and solar activity variations of hmF2 (the real height corresponding to peak electron density of the F2-region) are examined in the equatorial and low low latitude sectors over India. The hmF2 values are generated by the NPL prediction model for different stations and are then compared with those obtained from the IRI-2001 model. Both the NPL and IRI predicted exhibit in general a similar increasing trend with

solar activity. However, there exists a few disagreements between the two at stations lying within and outside anomaly crest. The deviation of NPL prediction model with respect to IRI model values remains within 20 % in general.

Rain drop size distribution from radar reflectivity measurements

Rain drop size distribution (RDSD) is useful for estimation of attenuation of electromagnetic waves above 10 GHz due to rain. The results on RDSD at different rain intensities in the range 50-150 mm/hr have been deduced from radar reflectivity measurements. Radar reflectivity measurements were carried out over Kolkata by using an X-band radar belonging to the India Meteorological Department and operating at ~9.4 GHz. The equation obtained for RDSD is of general type and it would satisfy RDSD for the other rain rates also, if the radar reflectivity is calibrated properly with various rain rate. The unique feature of this distribution has its direct application of radar reflectivity data and rain rate for RDSD.

Mobile Communications

In the area of mobile communications the effect of antenna tilting on mobile and fixed communications has been investigated. The path loss exponents deduced over the northern India have been utilized to deduce the path length differences and other associated parameters for untilted and tilted positions. In the case of mobile systems as the tilting angle increased cell radius decreased. These studies can be of great help in optimizing tilting angles and cell radius. Also COST 231 Walfish-Ikegami and COST 231 Hata models have been utilized to deduce the path loss at cell boundary as a function of base station antenna height for tilting angles ranging from 3^0 to 10^0 at a frequency of 1800 MHz. This concept effectively reduces the interference between different cells and also reduces multipath fading. Downward tilting decreases the probability of occurrence of unacceptable inter symbol interference due to multipath propagation by diminishing the power level of echoes with long delay times. Delay time in turn determines the delay spread which further decides the transmissible bit rate.

Based on experimental results conducted in western India on mobile train measurements in UHF band path loss exponents have been deduced from different base stations and the observed losses were compared with various theoretical models. These studies will be useful for designing future mobile communciation systems in this region. In collaboration with Idea cellular limited. extensive mobile communication experiments were conducted in dense urban, medium urban, sub-urban regions of Delhi at a frequency of 1800 MHz.

Advice was rendered to the Telecommunication Regularity Authority of India (TRAI) on various options in increasing the spectrum efficiency in cellular communication

Instrumentation and Facility Development Activities

Virtual Instruments development for atmospheric research applications

A very important new activity for PC based instrument development has been started using a very powerful Virtual Instrument platform known as LabVIEW from National Instruments (NI), USA. Together with NI-DAQ PCI plug and play hardware, very powerful user defined instruments can be built capable of data capture, analysis and display of data in any user defined form acquired from real world sensors. Several such useful experimental cofigurations for atmospheric studies have been realized by this Division. Some of these are briefly described with appropriate diagrams.

In Fig. 6.22 the signal strength and Doppler height profile obtained from an acoustic wind profiler consisting of a phased array system is shown. The data from the phased array sound sensors has been captured using LabVIEW in combination with a high speed dynamic signal analyser card (NI 4472) which consists of 8 independent ADC channels capable of simultaneous analog-to-digital conversion at 24-bit resolution at a maximum of 100.2 kHz sampling.

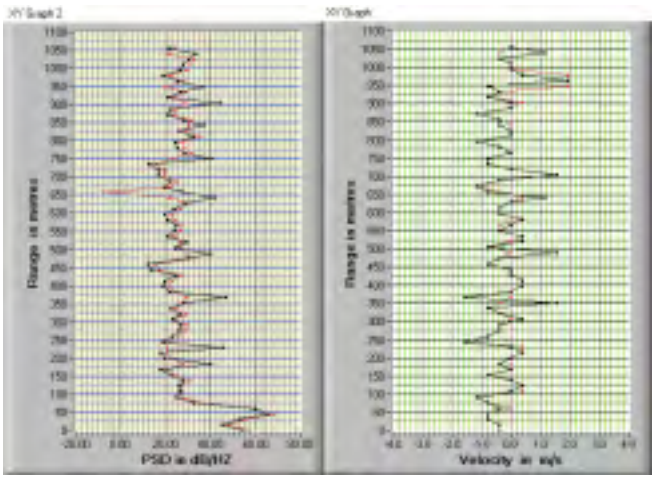

Fig. 6.22 : Display of the signal strength and doppler height profile obtained from online processing of acoustic phased array Doppler Radar

Fig. 6.23 shows the plot of real-time quadrature components of Delhi A.I.R. FM (102.6 MHz) base-band signal which is used in the feasibility studies for the development of a Bi-static radar scheme using commercial FM signals of opportunity. Again, this is realised using NI high speed DAQ card with LabVIEW. The base-band signal has a bandwidth of 250 kHz and hence needs to be sampled at least at 500kHz rate.

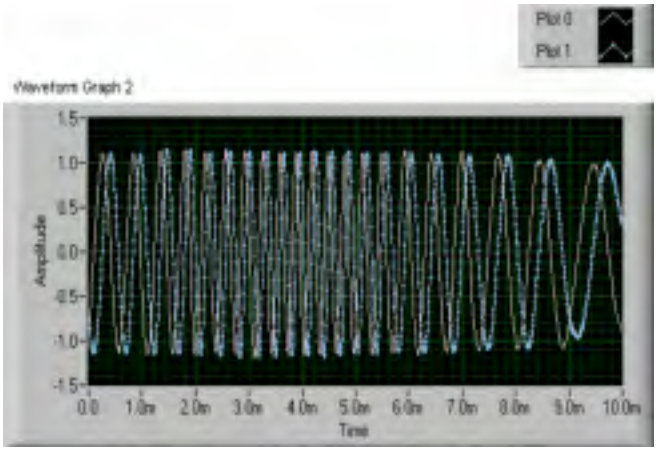

Fig. 6.23 : Plot of real-time quadrature components of Delhi A.I.R. FM (At 102.6 MHz) baseband-signal

In Fig. 6.24 a plot of autocorrelation function (ACF) of the FM base-band signal is depicted. Due to pseudo-noise nature of the base band signal the ACF resembles that of a typical noise source with a very sharply falling value for the function within about a lag. This is a very useful parameter which decides the radar range ambiguity. Sharp fall of ACF is desirable as it denotes that the range resolution within one lag is of the order of 300m.

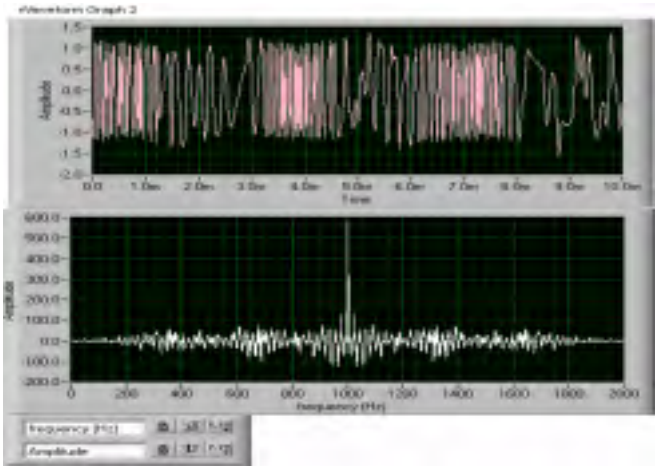

Fig. 6.24 : Plot of autocorrelation function of a typical FM baseband signal which is shown in the top panel

The plot of Schumann resonance line (at 21 Hz) is shown in Fig. 6.25. This has been captured in real time using relevant sensors and an electrometer amplifier. Here again data is captured using a NI-DAQ card and LabVIEW.

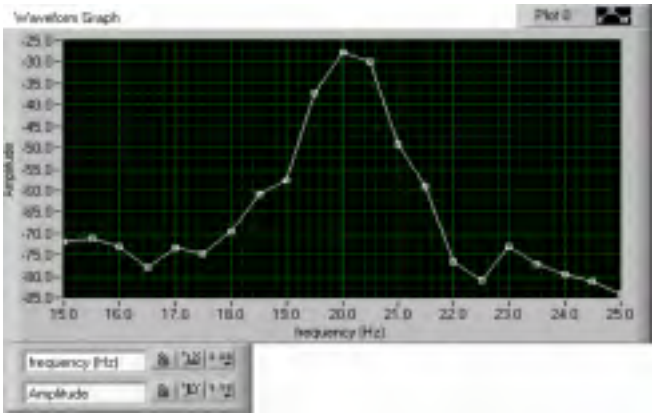

Fig. 6.25 : Plot of Schumann resonance line at 21 Hz. captured in real-time

Sensors for atmospheric electricity

The recently initiated project in the area of atmospheric electricity in collaboration with IIG involves the design,

development and fabrication of electrometers that can measure below pico-ampere level currents from high impedance sources for the study of Maxwell Current Density and very high impedance AC voltmeter to measure signals of a few milli-volt in the frequency range 5 Hz to 35 Hz in the presence of full scale 50Hz noise for Schumann Resonances studies. Design and fabrication of ball antenna sensors is being carried out under this project. Design and development of the electronics and sensors for fabrication of 'ball antenna' is under progress.

Doppler Sodar development

Vertical profiler for monitoring outside Delhi

Two P C Based systems were designed and developed for automatic measurement atmospheric temperature and humidity vertical profiles for fog studies. One of these has been installed atop a 35 feet tower erected by RASD outside the Bhambewa town in Haryana 100 km in the north-west of Delhi. Another identical system was mounted at NPL for comparing temperature and humidity profiles on foggy days. The outside site selected is an unpolluted rural site in the upwind direction from Delhi.

Ozone standard

Work was initiated for setting up in the course of the next year an ozone standard facility for calibrating ozone analysers.

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अतिचालकता तथा निम्नतापिकी

SUPERCONDUCTIVITY AND CRYOGENICS

अतिचालकता तथा निम्नतापिकी

आजकल हमारा कार्य अतिचालक चुंबको और अतिचालक नैनो पदार्थों से संबंधित विषयों के मूल अनुसंधान पर केन्द्रित है। उच्च क्षेत्रीय चुंबकीय तंत्रों के निर्माण व संचालन के अतिरिक्त हमारी अभिरूचि मुख्यतः क्यूपरेटस्, रूथनेटस और मैगनीशियम डाईबोराइड व मैगनाइट्स आदि विभिन्न अतिचालक पदार्थो के संवर्धन और नवीन प्रयोगात्मक परिणामों के प्रकाशन पर आधारित है।

प्रयोगशाला में निर्मित 11 टेस्ला 150 मि. मी. छिद्र व्यास के अतिचालक चुंबकीय तंत्र की क्रियाविधि प्रदर्शित की गई और अब बडे छिद्र वाली 256 मि.मी. व्यास की 6 टेस्ला वाली चुंबकीय कुंडली परीक्षण के लिए तैयार है। तकनीकी महत्व की MgB_2 तनु परतों के किरणन से पूर्व और पश्चात चुंबकन अध्ययन द्वारा इनके पिन प्रभाव पर प्रकाश डाला $Y_{I-X}\ Pr_xBa_2Cu_3O_{7-\delta}$ और $RuSr_2(Gd_{0.7}Ce_{0.3})\ 2Cu_2O_{10-\delta}$ अतिचालकों की अतिचालकता और चुंबकन के सहसंबंध के विषय पर भी अन्वेषण किया। $Y_{1-X}Ca_XBa_2Cu_3O_{6.3}$ और $Y_{0.6}Pr_{0.4}Ba_{2-X}Sr_XCu_3O_7$ अतिचालकों में विद्युत रोधन से धातु संक्रमण तथा अतिचालकता प्रेरक का उध्ययन किया। डह प्रतिस्थापित Cu-1234 न्यून क्षेत्रीय चुंबकीय प्रवृति मापन द्वारा Jc का विषपदैशिक घटक के प्रभाव पर अध्ययन किया। ABO_3 तरह के सी एम आर पेरावोस्काइट (pervoskite) पदार्थो में A (La/Ca का Pr/Sr से) और B (Mn का Fe से स्थानीय (site) प्रतिस्थापन द्वारा एम–आई संक्रमण के विषय पर अन्वेषण किया। Ca का Y-123 यौगिक की रेणु परिसीमा में प्रतिस्थापन द्वारा अन्वेषण का लक्ष्य इस पदार्थ में दुर्बल बन्ध समस्या के विषय में पता लगाना है। Gd डोपड Bi(Pb)SrCaCuO-2223 में द्रव प्रावस्था का अभिरूपण और इसका J_c मान पर प्रभाव का भी अध्ययन किया। TiO_2 ZnO और कार्बन के नैनो व मीसो स्केल पदार्थो का संवर्धन विभिन्न ज्यामितीय आकशति और रूपों में किया। नैनो तारों के तत्रों की प्रतिरोधकता और इनकी तार चौड़ाई, ताप और उर्जा पर र्निभरता का सैद्रधांतिक परिकलन किया।

SUPERCONDUCTIVITY AND CRYOGENICS

Our current activities are centered around superconducting magnets and basic research in supercounductivity including nano materials. Besides the construction and operation of high field magnet systems, we have been particularly interested in publications based on synthesis and new experimental findings in varying superconducting materials like cuprates, ruthenates and MgB_2, and manganites.

Functioning of an in-house developex 11 Tesla (50 mm bore diameter) superconducting magnet system was demonstrated and a large bore (256 mm dia.) 6 tesla magnet coil was ready for testing. Study of magnetization in MgB_2 thin films before and after irradiation shed light on the nature of pinning in these technically promissing materials. The correlation of superconductivity and magnetism was investigated in $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ and $RuSr_2(Gd_{0.7}Ce_{0.3})2Cu_2O_{10-\delta}$ superconductors. Insulator to metal transition and induction of superconductivity in $Y_{1-x}Ca_xBa_2Cu_3O_{6.3}$ and $Y_{0.6}Pr_{0.4}Ba_{2-x}Sr_xCu_3O_7$ was studied. The effect of Zn and Fe substitution, in Er-123, on superconducting order parameter fluctuations was investigated. Low field susceptibility measurements on Mg substituted Cu-1234 were performed to study the Jc in the light of its anisotropy factor. The effect of A (La/Ca by Pr/Sr) and B (Mn by Fe) site substitution on the M-I Transition in the ABO3 type CMR perovskite materials has been investigated. The effect of Ca substitution on the grain boundaries in Y-123 system was studied with an eye on addressing the weak-link problems of these materials. The liquid phase formation during the synthesis of Gd-doped Bi(Pb)SrCaCuO-2223 and its effect on the Jc values in this system was studied. Nano- and meso- scale materials of TiO_2, ZnO and carbon were synthesized in different geometrical shapes and forms. The resistivety of nanowire systems and its dependence on the wire width, temperature and Fermi energy was theoretically calculated.

Superconductivity Studies

Basic Studies on High Temperature Superconductors

Magnetization studies were conducted on MgB_2 superconducting thin films in a temperature range 4.2–40 K and magnetic field range 0–6 T. Thin films prepared by both pulsed laser deposition (PLD) and electron beam evaporation (EBE) methods were investigated. In addition, both films were studied before and after heavy ion irradiation by 200 MeV Ag ions with a dose of 10^{11} ions cm^{-2}. Variation of sweep rates during the measurement of the magnetization loop reveals the presence of flux creep in both films. The PLD film, after irradiation, shows a severe degradation of T_c, critical current densities (J_c) in low fields and irreversibility line ($B^*(T)$). In contrast, the EBE film shows a slight enhancement in T_c, and nearly no change in $J_c(B)$ and the position of irreversibility line after irradiation. For both pristine films, the obtained volume pinning forces F_p versus reduced field $b = B/B^*$ shows a good scaling for T≤10 *K*, which matches well with the theoretical curve based on the flux line shear (FLS) pinning model. These and other results can be interpreted in terms of grain boundaries in MgB_2 films acting as FLS channels.

The structure, normal state electrical transport and superconducting critical temperatures (T_c) of $Y_{1-x}Pr_xBaSrCu_3O_{7-\delta}$ (i.e., Y(Pr)-1113) and $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ (i.e., Y(Pr)-123) systems, with $0.0 \le x \le 1.0$ and $6.93 \le 7\text{-}\delta \le 6.95$, have been investigated. Residual resistivity (ρ_o) and resistivity slope $(d\rho/dT)_{cc}$) corresponding to the linear ρ -T region are determined from the normal state resistivity measurements. It is found that an increase in ρ_o and $(d\rho/dT)_{cc}$ correlates with a decrease and enhancement of $T_c(x)$, respectively. Interestingly, in both the systems, the destruction of superconductivity seems to occur at the same value of x where $(d\rho/dT)_{cc}$ tends to zero. The observed correlations suggest a possible mechanism of superconductivity in these systems.

According to a long-term common sense superconductivity and magnetic long-range order do not mutually exist within a single (thermodynamical) phase. Nevertheless, coexistence of high-T_c superconductivity and magnetism was reported for a rutheno-cuprate of the Ru-1222 type, *i.e.* $RuSr_2(Gd_{0.7}Ce_{0.3})_2Cu_2O_{10-\delta}$ and more recently for $RuSr_2GdCu_2O_{8-\delta}$. These reports have renewed the interest in the possible coexistence of superconductivity and magnetism. We in NPL synthesized Ru-1222 compound and varied its T_c with suitable heat treatments (Fig. 7.1) The magnetization measurements (Fig. 7.2) are done in TIFR in collaboration with Prof. S.K.

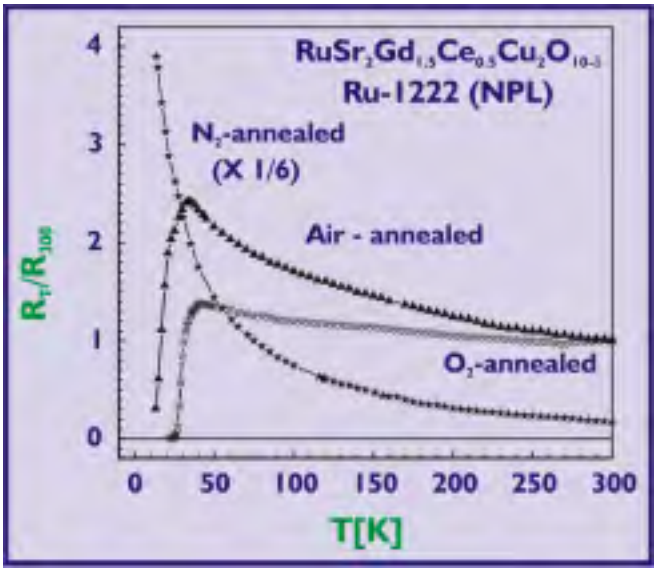

Fig. 7.1 : Normalized resistance (R_T/R_{300}) for variously synthesized Ru-1222 samples.

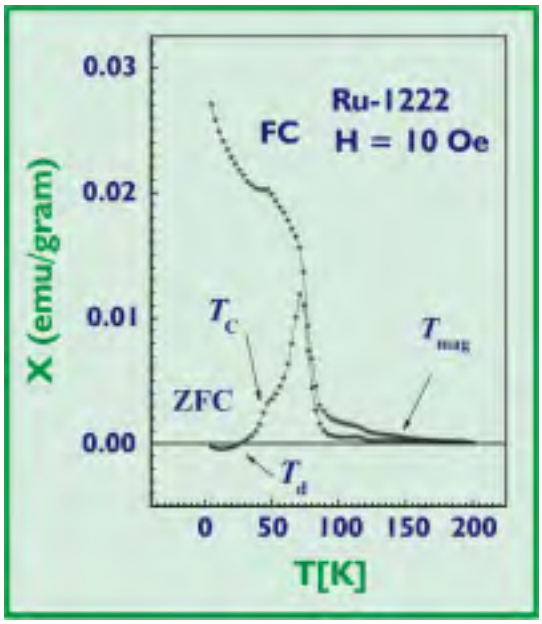

Fig. 7.2 : DC magnetic susceptibility versus temperature plots for Ru-1222 compound.

Malik. Worth mentioning is the fact that synthesis of Ru-1222 or Ru-1212 ferromagnetic superconductor is very difficult. One has to avoid formation of strongly magnetic $SrRuO_3$ phase in the matrix. Moreover many times the compound results in non-superconducting behavior.

Insulator to metal transition and subsequently the induction of superconductivity is observed in $Y_{1-x}Ca_xBa_2Cu_3O_{6.30}$ (Fig. 7.3) and $Y_{0.4}Pr_{0.6}Ba_{2-x}Sr_xCu_3O_7$ (Fig. 7.4) systems with increase in x. While the Y^{3+} site Ca^{2+} substitution directly dopes the mobile p-type carriers to bring in superconductivity, in later the Ba site Sr substitution de-localizes the carriers by decreasing the Pr-4f hybridization with O-2p in otherwise non-conducting Cu-O_2 planes of Pr-123. Both results have far reaching consequences in terms of completing the HTSC phase diagram and resolving the issue of non-superconducting $PrBa_2Cu_3O_7$ system.

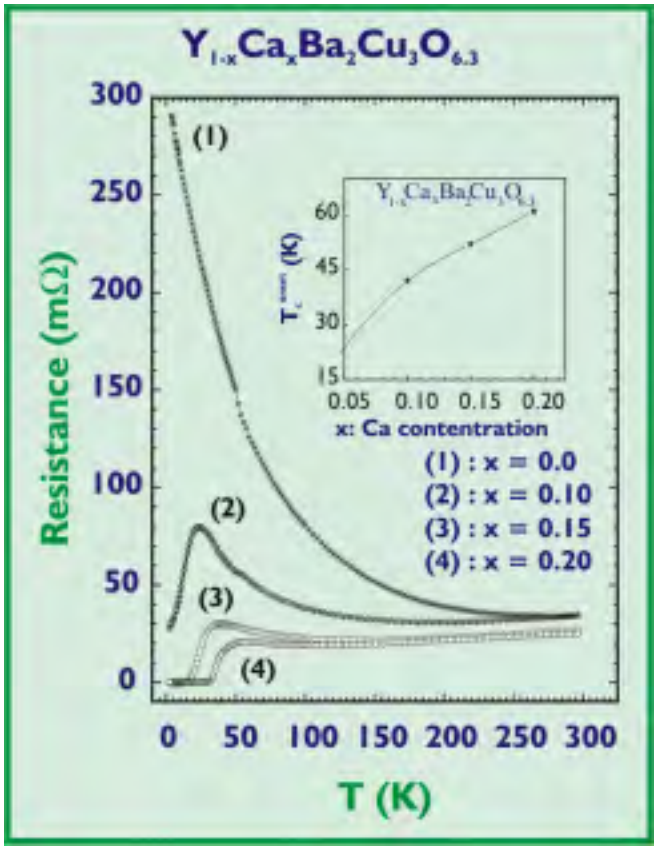

Fig. 7.3 : Resistance versus temperature plots for $Y_{1-x}Ca_xBa_2Cu_3O_{6.3}$ samples, the inset shows the Tc versus x plot for the same.

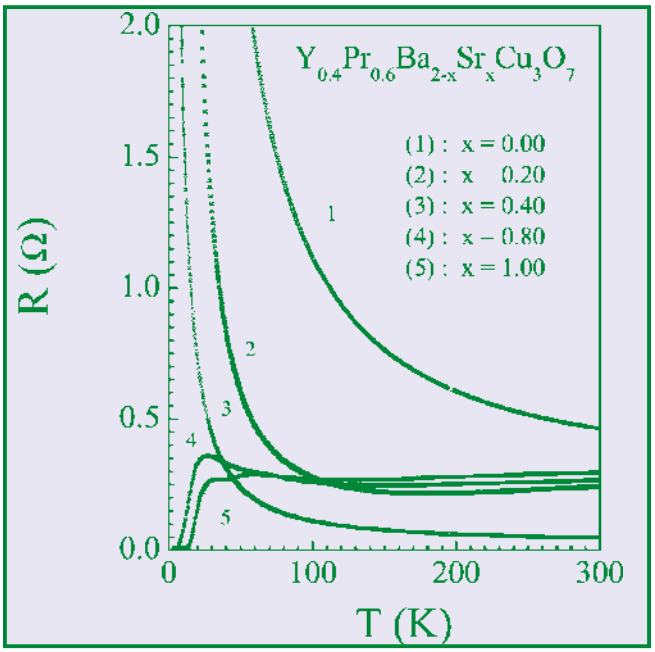

Fig. 7.4 : Resistance versus temperature plots for $Y_{0.4}Pr_{0.6}Ba_{2-x}Sr_xCu_3O_7$ compounds.

Zn concentration variation effects on superconducting order parameter fluctuations are compared in $ErBa_2Cu_{3-x}Zn_xO_{7-\delta}$ polycrystalline bulk samples for x=0.0, 0.03, 0.05, 0.12, and 0.18; perhaps as a first ever study. The SCOPF in pure and Zn doped samples are 3D. Zn seems to cause suppression of 2D fluctuations. SCOPF dimensionality shows independence from carrier concentration variation due to Zn in the planes and also suggests strong coupling between two nearest CuO_2 planes in the unit cells in pure and Zn doped samples. Fluctuations remain almost invariant to Zn doping vis-à-vis the pure sample.

The effects of predominantly chain-site dopant, Fe, concentration variation on superconducting order parameter fluctuations (SCOPF) in $ErBa_2Cu_{3-x}Fe_xO_{7-\delta}$ polycrystalline bulk samples are presented and compared. A large reduction in OPD near the dynamic critical region is seen, suggesting an anomalous crossover and indicating a much slower suppression of superconductivity. Near to T_c the SCOPF behaviour suggests Cu-O network coupling deterioration. It is also observed that the SCOPF are invariant to Fe low concentrations and with Fe concentration increase these

show marked dimensionality variation and increased oxygen content dependence. Higher Fe concentration is seen to promote a dimensionality reversal.

Analysis of the low field (upto 800 A/m) AC susceptibility ($\chi = \chi' + i\,\chi''$) measurements of $CuBa_2(Ca_{1-x}Mg_x)_3Cu_4O_{12-Y}$ (Cu-1234) (x =0, 0.1 & 0.2) high temperature superconductors with low anisotropy factor, have been carried out for the first time to examine the intergranular critical current density J_c. The observed increase in the Jc in Cu-1234 system with Mg substitution has been investigated in the light of the crystal structure and the superconducting anisotropy factor ($\gamma=\xi_{ab}/\xi_c$) of the system.

Effect of ex-situ (ramanant) pressure (10-40kbar) and internal pressure (through) substitutions of Fe at Mn sites) on the conductions mechanism in $Pr_{2/3}\,Ca_{1/3}\,MnO_3$ colossal magneto-resistive (CMR material has been examined. $Pr_{2/3}\,Ca_{1/3}\,MnO_3$ is normally insulating at low temperatures which however, shows a plateau around 115k in ρ-T behaviour on the application of applied pressure of 10 kbar, which are definite signatures of a metal to insulator transition. Interestingly, similar indications are revealed through substitutions of Mn^{+3} Fe^{+3} at 113K. An attempt has been made to understand such transitions in $Pr_{2/3}\,Ca_{1/3}\,MnO_3$ and $Pr_{2/3}Ca_{1/3}FeO_3$ in terms of the competition in Double - Exchange and super -exchange processes in the Mn-O-Mn networks.

M-I transition temperature T_{MI} of the CMR perovskite materials depends on the tolerence factor t and the associated crystal lattice distortion. We have studied the effect of A (La/Ca by Pr/Sr) sites and B (Mn by Fe) sites substitutions on the tolerance factor which in turn is thought to affect the lattice distortion. Such a situation is studied through the ensuing changes in T_{MI} via the competition between double exchange and super-exchange processes involved. Further work on field depentdent magnetic transitions is in progress.

In order to circumvent weak and often insulating nature of grain-boundaries in $Y_1Ba_2Cu_3O_7$ (Y-123), which do not allow the material to carry theoretical value of de-pairing super-current density, an effect of calcium doping (0, 5,10,15 and 20 % in place of Y) in Y-123 has been studied. With an increase of Ca, as the resistivity measurementnt technique yields, the superconducting temperature, T_C decreases from 93 K (0% Ca), 86 K (5 % Ca) to 82 K (15% Ca). Microstructural studies with SEM reveal that with the increase in calcium addition, porosity is reduced and the grain- to-grain contact is improved and more elongated but randomly oriented grains have been observed. More and more spiral growth structures have been noticed. It seems that calcium aids in the formation of such structures and improves contact areas. STM studies, if made, will help in delineating the real role of Calcium in reducing weak link problem, as it will establish a map of conductivity from the boundary to the interior of the grain.

The spectral function for electrons in the normal state of a bilayer cuprate is calculated by employing a slave fermion approach. The electron correlations in the CuO_2 layers in these cuprates are described by a *t-J* model, and the electronic coupling between the two CuO_2 layers within the same unit cell is introduced via a hopping matrix element ($t_\perp$) and an exchange interaction ($J_\perp$). The spectral function is calculated for different values of the hole concentration, temperature and anisotropy at various values of the momentum (k_x,k_y). It is found that the bilayer coupling ($t_\perp$) significantly affects the behaviour of the spectral function. The spectral function around the momentum value (π, 0) for a coupled bilayer cuprate shows a peak much sharper than that for a system of uncoupled layers. Our calculation also suggests a splititing of electronic states of the bilayer cuprates along the (π, 0) direction for the heavily overdoped regime. Calculations of the imaginary part of the self-energy $\sum^{1"}(\kappa,\omega)$ for a bilayer system have also been presented. It is found that $\sum^{1"}(\kappa,\omega)$ depends strongly on the momentum and shows a ω^{α} dependence on energy with $1.2 < \alpha < 1.5$ for values of the parameters *t* and *J* considered in the present calculations.

Polycrystalline (Ba, Sr)TiO_3 (BST) thin films being prepared by the sol–gel technique using titanium isopropoxide and 2-ethyl hexanoate precursors for barium and strontium were provided by IIT (Delhi). The

films were porous and adsorb water vapour when exposed to a humid environment. Atomic force microscopy (AFM) done in NPL showed that grain size decreases from 67 to 38 nm with the increase of pH from 7.4 to 9.5, while surface roughness decreases from 0.81 to 0.74 nm. It has been found that sensitivity, linearity and response time of the humidity sensor utilizing these films can be improved by tailoring the process parameters such as pH and molarity of the precursor solution.

Critical Current Studies

In the programme on critical current studies of high Tc superconductors for the investigation of pinning centres in f-level doped YBaCaCuO and Bi(Pb)SrCaCuO series, structural characterization and superconductivity studies were carried out. A correlation of the critical current densities (Jc) observed in Gd-doped samples of Bi(Pb)SrCaCuO with the microstructures of these samples revealed some unusual features of the Gd-doped specimens. The most striking of these is the enhancement of critical current density. Micro-structural (SEM) examination of these samples has shown that the presence of the additional element modifies the formation process of the superconducting Bi-2223 phase in which the formation of a liquid phase gets suppressed. This liquid phase is otherwise considered essential for both; the formation of the 2223 phase in sufficient quantities , as well as for enhancing the critical current density Jc. High values of Jc of such un-doped sample (where the growth of the superconducting phase is assisted by a liquid phase formation) is believed to be a consequence of improved connectivity of the superconducting grains and yet our results show higher Jc values in samples where the formation of liquid phase is suppressed. Microscopic reasons for the above behaviour and the role of the dopant are being investigated.

Studies on Nanomaterials

Using a tight-binding approach for the electronic structure, deformation potential approach for the electron-phonon interaction, and the Kubo formula for the conductivity, an expression has been obtained for the resistivity of nanowire systems. The resulting expression involves (1) vertex corrections approximated by the sum of ladder diagrams, and (2) a self-energy approximated by the one-phonon processes. The dependence of the resistivity on the wire width, temperature and Fermi energy has been investigated by performing numerical calculations in terms of typical values of different parameters. It has been found that the resistivity increases with decreasing wire width. It has been further found that the resistivity increases with the temperature such that the resistivity slope increases with decreasing wire width. The temperature dependence shows a superlinear behaviour for wires of width $<\sim$20 nm. For wires of larger widths a linear behaviour has been found. The resistivity is found to increase slowly with the Fermi energy. The relevance of the calculated results has been discussed in light of the existing experimental studies.

Two important oxide materials - TiO_2 and ZnO – with innumerable uses ranging from conversion of solar energy to generating powerful and room temperature ultra-voilet nano-laser in the nano- and meso scale forms have been synthesized, the details of which is given below.

TiO_2 nano-tubes (50 nm and more) and tapes (width from several nm to hundreds of nm) and length several microns, from a TiO_2 powder coating on Nb-Ta substrate (superconductor) in NaOH aqueous solution at 60-100 ^{0}C, using hydrothermal technique have been produced. For the first time, we have observed many Y- and T-junctions / joints and pea-pod like structures. Kinks and joint- breakings have also been occasionally observed. The mechanism of formation of tubes has been attributed to the curling of tapes.

ZnO nanomaterial on Nb-Ta, quartz, stainless steel, and polymer substrates, by evaporation and co-condensation method, in the presence of argon, water vapour and zinc vapours generated at 750 ^{0}C in a wide variety of geometrical shapes in nano- and meso size single crystals and through self assembly of nanocrystals, ranging from 100 nm to 1500 nm has been synthesized

and it includes cages / shells, polyhedrons and their stackings, tapes and transmission-pole-like structures. Still smaller size structures are also formed. Among many configurations, we have observed, for the first time, polyhedron nuts (either closed / open) and nano-boxes. Nucleation and growth of these various geometrical shapes and sizes is attributed to a combination of many factors like structural and chemical meta-stability of (0001) face of hexagonal ZnO wurtzite and its elongation in [0001] direction, preferential dissolution of (0001), Ostwald ripening and high concentration of zinc vapour

Under organic materials, we have successfully synthesized CNTS and carbon "onions", from the vapours of graphite rod by heating and quenching technique, as confirmed by TEM. We have made a first observation of carbon "onions," produced by this simple method, which otherwise have been produced in electric arc synthesis method by others.

Cryogenic Plants & Facilities

A new liquid nitrogen plant, Model STIRLIN-4, (procured from M/s Stirling Cryogenics, Netherlands) of 45 litres/ hour capacity has been installed. The facility of transferring liquid nitrogen from this plant to the existing 6000 litres storage vessel has also been commissioned. With this new facility the availability of liquid nitrogen to the various R & D groups at NPL is assured. A total of 2700 litres of liquid helium has been procured from different outside agencies for the various R & D activities of the laboratory.

Cryo-Techniques

Superconducting Magnet Technology

- Operation of an 11 Tesla (50 mm bore dia.) Superconducting (SC) magnet system has been successfully demonstrated to scientists of IGCAR, Kalpakkam. The SC magnet and a project document giving complete details of magnets and its operation, has been handed over to IGCAR. Another magnet, a large bore (255mm) 6 Tesla SC magnet coil, which has been developed in collaboration with Institute of Plasma Research, Gandhinagar, was provided with end current terminals and has been handed over to IPR for impregnation and testing.
- Another 11 Tesla superconducting magnet (Nb-Ti coil fabrication) is under progress. Work has been initiated to setup facility for the transport properties measurements at low temperatures and under high magnetic field. Various components of Variable Temperature Inserts for the 3.5 Tesla, 7 Tesla and 11 Tesla SC magnets have been designed and fabricated.

❑❑❑❑❑

सहायक सेवाएं
SUPPORT SERVICES

Library and Technical Information Services

NPL Library has been providing library and information support to scientists for R & D pursuits. Over the years it has developed a rich collection of scholarly books and journals for the purpose specifically in the field of physics and related sciences. During the year 2003-04, it continued to update its collection and subscribed 117 scholarly journals (100 foreign journals + 16 Indian journals), added 76 S&T books, 41 Hindi books, 104 standard specifications and 219 bound volumes of journals. It continued to perform its house keeping functions by using Library Management package developed in-house. Besides, It continued to provide library services such as circulation, inter-library loan, reference, and literature search to the scientists at NPL

The library offers Science Direct service under the e-journal consortium project of the CSIR. It facilitates online access to 1700 full-text e-journals published by Elsevier Science as well as to their archives going back to 1995. This service was first made operational in NPL on 31 July 2002. During the year the scientists downloaded 4007 articles by using this service.

The library offers web access to ERL/INSPEC database over the NPL intranet. The INSPEC database covers scientific literature in physics, electronics, and computers science dating back to 1969. The library continued to maintain and update this service during the year.

The library has a KSK Library site on the NPL intranet providing latest information on its activities such as additions to its collection, current subscription, new issues received during the week, links to electronic journals, electronic libraries, publishing houses, library catalogue, and papers published by NPL scientists. The library continued to update this site during the year.

The library also maintains NPL website (www.nplindia.org) on the Internet. It is providing latest information on NPL activities such as its roles, thrust areas of research, facilities, services and achievements. The library continued to update this site.

Publication and Documentation

This unit is responsible for compiling, editing, printing, and distribution of Annual Reports and other documents describing laboratory activities. This unit also compiles information on NPL achievements during the year and submitting it to the CSIR as the NPL input for the CSIR annual report.

Planning, Monitoring and Evaluation Group

Contract R & D projects such as sponsored projects, collaborative projects and grant-in-aid projects are undertaken by the laboratory. The complete database of these projects is maintained by this group. Further, major laboratory projects and other laboratory projects funded by CSIR and NPL are monitored by this group. It keeps a watch on allocation and expenditure, purchase indents and staff employed under various R & D Projects. This group handles matters relating to Research Council & Management Council. Management of intellectual properties rights is a sub-set of this group.

Industrial Liaison Group

This group handles two major areas, viz. marketing of technology and consultancy projects. This group handles all matters connected with business development, pricing of technology, and acts as a laboratory interface with entrepreneurs. Maintenance of database of various industrial consultancy projects will be done by this group. Further, distribution of royalty, premia, honorarium and moneys from consultancy services is also a part of this activity.

Human Resource Management Group

This group arranges training programmes for the benefit of NPL staff and also organizes NPL sponsored training courses for the benefit of industries in various areas of

core competency. It also supports organization of symposia, conferences, etc. at NPL. It also attends to various public relations activities and follows up various MoUs with educational institutions in respect of doctoral, post graduate and summer training on reciprocal basis. It processes induction of JRFs. SRFs, Research Associates for NPL programmes. The group also pursues other schemes of CSIR on EMR and HRD activities. List of training programmes and other events organized by the group is given in the respective appendices.

International Science and Technology Affairs Group

International visits play an important part of scientific R & D. Processing of applications of the laboratory scientists pertaining to international visits, bilateral exchange programmes, sabbatical study period and deputations abroad are handled by this group. It also arranges important lectures and invited talks. Arranging training programmes for international candidates is also the job of this group.

Technical Support Services Group

Responsibility of general maintenance of technical infrastructure like electricity, pumping, air conditioning, telephones, fax, photography service, auditorium, maintenance of campus and colony etc. lies with this section. Works pertaining to civil engineering of the laboratory and the NPL colony come under the purview of this group.

Central Workshop

NPL Central Workshop undertakes design, development and maintenance of work related to scientific equipment of the laboratory and assists industry by accepting outside assignments on payment. It is equipped with general purpose machines. CNC machines and has precision measurement facilities. CNC machines aided by computerized parts such as die cavities, moulds and punches. Glass Technology Unit undertakes jobs relating to the design, development, fabrication of scientific apparatus and equipments.

Central Computer Facility

NPL-LAN, Intranet and IT Infrastructure: As a part of the NPL-LAN expansion programme, infrastructure for additional 200 nodes was installed. The NPL Intranet site was completely redesigned and expanded. Facility for online registration of computer/printer for inclusion in AMC, and filing of computer/printer fault complaints for service under AMC was developed and implemented. WebCal was implemented to provide users a web browser based facility with advanced calendaring features. Private and public calendars are both supported. A Web Mail server was configured using Open Webmail and implemented with online filters for viruses. A draft requirements document for a comprehensive Management Information System was prepared.

The software required for developing above applications were open source. This has saved significant amounts of money as well as ensured that future upgradation would be easy and timely.

Physics of pattern formation in melting snow and vapour deposited atomic layers: Work done earlier to construct and study, theoretically and by computer simulations, a two-dimensional model of a layer of snow melting on the ground so as to form ordered patterns of snow and water was extended to include formation of similar patterns in a sub-monolayer of lead atoms on a lead-copper alloy substrate. The highlight of the work was that the same physical mechanism was able to explain the pattern formation in the two cases which ***differ in length scale by seven orders of magnitude.*** This finding opens up various possibilities of the application of this work in areas from nanoscience to pancakes of ice forming in the arctic ocean. The work has been done in collaboration with Jawaharlal Nehru University, New Delhi.

Evolution and Auto Catalytic Sets: Studies on interacting species in adaptive systems forming complex networks of the interdependent species and the application of Auto Catalytic Sets to such systems was expanded.

- The very fast and efficient algorithm to solve the coupled differential equations numerically developed earlier was used to study the question of stability of such networks as a function of total size of the network. There is a school of thought which says that more complexity (larger size network) leads to its destabilization.
- The population dynamics of species with their interactions represented by a sparse directed graph was studied. At each time step, once the populations stabilize, the least populated species is considered extinct and replaced by a new species with interactions with the same average number of randomly chosen species as that of the total system. With this "mutation" rule , the stability of the network was examined.
- The interesting result of the study was that ***diversity leads to stabilization***. As the number of species increases in the system, the number of mass extinctions in the system becomes exponentially small. This result is significant in understanding how complex molecules evolved in the prebiotic stage of our evolution and the system stabilized.

This work has been done in collaboration with Delhi University.

Rajbhasha Unit

As in the previous years, this unit arranged various training programmes and organized events for encouraging the use of Hindi in all official proceedings as well as in writing research paper publications in Hindi for the benefit of the society. It also rendered help to the scientists in the Hindi transcription of their papers, articles, reports etc As per Government of India directives the unit arranges selection of NPL employees who contribute the most to the propagation of Hindi in office work. Cash awards are given to the winners in various categories. A detailed report of the unit is given in Hindi in the following pages.

राजभाषा कार्यान्वयन

प्रशासनिक कार्यशालाएं

राष्ट्रीय भौतिक प्रयोगशाला में 21–22 मई, 2003 को दो दिवसीय प्रशासनिक कार्यशाला का आयोजन किया गया जिसमें लगभग 50 अधिकारियों ने सक्रिय रूप से भाग लिया। सर्वप्रथम कार्यकारी निदेशक, एन पी एल, श्री एस. सी. गर्ग ने कार्यशाला का उद्घाटन किया और इस कार्यशाला के मुख्य अतिथि डा. सूरज भान सिंह ने अध्यक्षीय भाषण प्रस्तुत किया। अंत में डा. नीरज खरे द्वारा धन्यवाद प्रस्ताव के साथ उद्घाटन कार्यक्रम का समापन किया गया। डा. सूरज भान सिंह ने 'कार्यशाला में कामकाजी हिन्दी' के बारे में जानकारी दी। कार्यशाला में मुख्य रूप से भण्डारण व्यवस्था, आचार संहिता, चिकित्सा सम्बन्धी नियमों, छुट्टी के नियमों तथा पेंशन सम्बन्धी नियमों पर जानकारी दी गयी। व्याख्याताओं में प्रयोगशाला के श्री बृजेश शर्मा, श्री आर पी शर्मा, श्री एस सी त्यागी तथा श्री बी एस राजपूत सम्मिलित थे। कार्यक्रम के अंत में निदेशक महोदय ने प्रतिभागियों को प्रमाण पत्र प्रदान किए।

कार्यशाला के विषय में जानकारी देते हुए डा. गोपाल भाटिया

इसी श्रृंखला के अंतर्गत प्रयोगशाला में 16–17 जून, 2003 को एक और दो दिवसीय प्रशासनिक कार्यशाला का आयोजन किया गया जिसमें लगभग 90 अधिकारियों ने भाग लिया। विभाग के विभागाध्यक्ष, श्री एस सी गर्ग, एन पी एल ने उद्घाटन भाषण दिया। अध्यक्षीय भाषण श्री कृष्ण कुमार ग्रोवर, पूर्व सचिव संसदीय राजभाषा समिति द्वारा प्रस्तुत किया गया। सत्र के आरंभ में श्री कृष्ण कुमार ग्रोवर ने 'राजभाषा हिन्दी : नियम और स्वरूप' विषय पर व्याख्यान दिया। कार्यशाला में सामान्य प्रशासन, क्रय प्रक्रिया, आचार संहिता, चिकित्सा सम्बन्धी नियमों, भण्डारण व्यवस्था तथा छुट्टियों के नियमों पर जानकारी दी गयी। वक्ताओं में प्रयोगशाला के श्री बी एस राजपूत, श्री बृजेश शर्मा, श्री आर पी शर्मा, श्री एस सी त्यागी सम्मिलित थे। कार्यशाला के अंत में निदेशक महोदय ने प्रतिभागियों को प्रमाण पत्र प्रदान किए।

हिन्दी पखवाड़ा, सितम्बर, 2003

प्रयोगशाला में दिनांक 1.9.2003 से 16.9.2003 तक हिन्दी पखवाड़ा मनाया गया जिसके अन्तर्गत विभिन्न कार्यक्रमों का आयोजन किया गया जिनका संक्षिप्त विवरण निम्नांकित है :–

1. निबंध प्रतियोगिता
2. काव्य पाठ प्रतियोगिता
3. डिक्टेशन प्रतियोगिता
4. टिप्पण/आलेखन प्रतियोगिता

दिनांक 16.9.2003 को पूर्वाह्न 11.00 बजे प्रयोगशाला के ऑडिटोरियम में हिन्दी पखवाड़ा समापन समारोह का आयोजन किया गया। सर्वप्रथम श्री एस.सी. गर्ग, ने प्रयोगशाला में हो रहे हिन्दी के प्रगामी प्रयोग की प्रशंसा की तथा प्रयोगशाला के सदस्यों से अनुरोध किया कि वे अपने दैनिक कार्यों के साथ–साथ वैज्ञानिक कार्यों में भी हिन्दी को और अधिक अपनाएँ।

निदेशक, एन पी एल द्वारा मुख्य अभिभाषण एवं संदेश प्रस्तुत किया गया जिसमें निदेशक महोदय ने पुरस्कृत कर्मचारियों को बधाई दी तथा राजभाषा हिन्दी के कार्यान्वयन को बढ़ावा देने के लिए प्रेरित व प्रोत्साहित किया।

काव्य पाठ प्रतियोगिता के प्रथम व द्वितीय विजेताओं द्वारा अपनी–अपनी कविताएं सुनाई गयी तथा उसके बाद निदेशक, एन पी एल ने सभी विजेताओं को पुरस्कार प्रदान किए।

कार्यक्रम का समापन डा. नीरज खरे के धन्यवाद प्रस्ताव के साथ हुआ। उपर्युक्त प्रतियोगिताओं में कुल 45 प्रतिभागी थे। काव्य पाठ प्रतियोगिता के लिए आमन्त्रित किए गए निर्णायक मण्डल में सुप्रसिद्ध पत्रकार व हास्य कवि सम्मिलित थे जिन्होंने निर्णायक की भूमिका के साथ–साथ अपनी हास्य रस की कविताओं/गीतों से सभी श्रोताओं का मनोरंजन किया व हिन्दी भाषा तथा इसमें कार्य करने की गरिमा के विषय में बताया।

डा. नीरज खरे धन्यवाद प्रस्ताव देते हुए

राष्ट्रीय कार्यशाला

प्रयोगशाला में 20–21 जनवरी, 2004 को मापिकी एवं निम्नताप भौतिकी विषय पर वैज्ञानिक एवं तकनीकी शब्दावली आयोग के सहयोग से दो दिवसीय राष्ट्रीय कार्यशाला का आयोजन किया गया। राष्ट्रीय भौतिक प्रयोगशाला में हिन्दी माध्यम से राष्ट्रीय स्तर पर आयोजित की जाने वाली विज्ञान की यह चौथी कार्यशाला थी। इससे पहले भौतिकी मापों के मानक, पदार्थ विज्ञान, रेडियो एवं पर्यावरणीय विज्ञान पर राष्ट्रीय कार्यशालाएं आयोजित की गयी थी।

आज के युग में मापिकी के महत्व को देखते हुए यह अनिवार्य हो गया है कि इसे अपनी राजभाषा हिन्दी में अभिव्यक्ति देकर जनमानस तक पहुंचाया जाए। वास्तव में यह कार्यशाला विज्ञान की अन्य सभी कार्यशालाओं के समान ही थी जिसमें वैज्ञानिकों ने अपने–अपने विषयों पर प्रस्तुतीकरण किया और एक मंच पर एकत्रित होकर अपने ज्ञान का आदान–प्रदान किया और सभी संभावनाओं को उजागर किया।

इस कार्यशाला में 54 वक्ताओं ने अपने पेपर प्रस्तुत किए जिसमें 12 आमंत्रित वार्त्ताएं तथा 42 मौखिक प्रस्तुतीकरण सम्मिलित थे। कार्यशाला में राष्ट्रीय भौतिक प्रयोगशाला के अतिरिक्त देश की 11 अन्य प्रयोगशालाओं/संस्थानों से प्रतिभागियों ने उत्साहपूर्वक भाग लिया जिसमें रूड़की, देहरादून, लखनऊ, सीतामढ़ी, अमृतसर, वाराणसी, पटना, रायपुर आदि सम्मिलित थे।

माप के मानक, गुणवत्ता नियंत्रण, मापन की अनुमार्गणीयता, मापन में अनिश्चितता, राष्ट्रीय प्रत्यायन, एम आर ए तथा निम्न ताप मापन एवं भौतिकी कार्यशाला के मुख्य विषय थे।

इस कार्यशाला का उद्घाटन प्रयोगशाला के सभागार में दिनांक 20 जनवरी, 2004 को किया गया जिसमें प्रतिभागियों के अतिरिक्त लगभग 400 स्टॉफ सदस्य उपस्थित थे।

डा. विक्रम कुमार, निदेशक, एन पी एल, उद्घाटन भाषण देते हुए

कार्यशाला का उद्घाटन निदेशक, एन.पी.एल. ने किया। अपने उद्घाटन भाषण में निदेशक महोदय ने कहा कि ज्ञान विज्ञान से जुड़े वैज्ञानिक राजभाषा हिन्दी में अपने अनुसंधान कार्यों का उजागर कर अपना अमूल्य योगदान आम जनता तक सम्प्रेषित कर सकते हैं। उन्होंने कार्यशाला के सफल आयोजन की कामना की।

कार्यशाला की पृष्ठभूमि के विषय में डा. (श्रीमती) एस. शर्मा, वरिष्ठ हिन्दी अधिकारी ने संक्षिप्त जानकारी दी। उन्होंने बताया कि मापिकी एवं निम्न ताप भौतिकी पर यह चौथी कार्यशाला है इससे पहले मापन व्यवस्था एवं गुणवत्ता प्रबंधन, पदार्थों के संश्लेषण, अभिलक्षणन एवं अनुप्रयोग तथा रेडियों एवं वायुमण्डलीय विज्ञान नामक विषयों पर राष्ट्रीय कार्यशालाएं आयोजित की जा चुकी है। इन सभी कार्यशालाओं में देश के विभिन्न राज्यों से प्रतिभागियों ने उत्साहपूर्वक भाग लिया और एक मंच पर एकत्रित होकर अपने विचारों का आदान प्रदान किया तथा पूर्णतः वैज्ञानिक पेपर प्रस्तुत कर राजभाषा हिन्दी भाषा को गौरवान्वित किया।

बनारस हिन्दू विश्व विद्यालय के प्रो. सुरेश चन्द्र ने मुख्य अतिथि के रूप में इस कार्यशाला के उद्घाटन अवसर पर प्रतिभागियों व उपस्थित सभी सदस्यों को सम्बोधित करते हुए कहा कि एन.पी.एल. में जिस गति से प्रशासन के साथ–साथ वैज्ञानिक क्षेत्र में हिन्दी का प्रयोग हो रहा है वह वास्तव में उल्लेखनीय है। हिन्दी भाषा में पूर्णतः वैज्ञानिक विषयों पर बोलना अथवा लिखना कठिन अवश्य है किन्तु असम्भव नहीं और यह यहां के वैज्ञानिकों ने स्वयं तो किया ही है, दूसरी प्रयोगशाला/संस्थाओं के वैज्ञानिकों को भी हिन्दी में लिखने के लिए प्रेरित व प्रोत्साहित किया है। यह वास्तव में बहुत बड़ी उपलब्धि है।

प्रो.ए.आर. वर्मा ने अपने अध्यक्षीय भाषण में हिन्दी के महत्त्व, इसकी गरिमा व उपयोगिता के बारे में बताकर इसमें कार्य करने के लिए सभी को प्रोत्साहित किया।

डा. अशोक कुमार ने मुख्य अभिभाषण में कहा कि हिन्दी विज्ञान लेखकों को जहां पहले उपेक्षित समझा जाता था अब वह बात नहीं है इस प्रकार की कार्यशालाओं/संगोष्ठियों के आयोजन से अब उनके वैज्ञानिक कार्यों को आम जनता तक पहुंचाकर और अधिक उजागर किया जा सकता है।

अंत में डा. पी. सी. कोठारी ने धन्यवाद प्रस्ताव के साथ उद्घाटन समारोह का समापन किया।

डा. पी.सी. कोठारी धन्यवाद ज्ञापन प्रस्तुत करते हुए

इस कार्यशाला में कुल 7 सत्र थे जिसमें 54 वक्ताओं ने अपने वैज्ञानिक प्रपत्र पूर्णतः हिन्दी में प्रस्तुत किए। इसमें 12 आमन्त्रित वार्ताएं तथा 42 मौखिक प्रस्तुतिकरण सम्मिलित थे। कार्यशाला में राष्ट्रीय भौतिक प्रयोगशाला के अतिरिक्त देश के 11 अन्य संस्थानों से प्रतिभागियों ने भाग लिया। दिल्ली के अतिरिक्त रूड़की, देहरादून, लखनऊ, वाराणसी, अमृतसर, रायपुर (छत्तीसगढ़), पटना, सीतामढ़ी एवं ईटानगर सम्मिलित हैं।

यह कार्यशाला वैज्ञानिक तथा तकनीकी शब्दावली आयोग (सी.एस.टी.टी.) के सहयोग से आयोजित की गयी थी। सी.एस.टी.टी. के अतिरिक्त एन.ए.बी.एल., सी.एस.आई.आर. ने जो आर्थिक योगदान दिया वह वास्तव में इस कार्यशाला के सपने को साकार करने में सराहनीय रहा।

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संलग्न

APPENDICES

APPENDIX - 1
PUBLICATIONS

Papers published in journals

1. Agarwal Seema, Samanta S.B. and Sharma G.L., Influence of pH on structural and electrical properties of sol-gel derived (Ba-Sr)TiO_3 thin films under humid conditions *Thin Solid Films* 448, 502-508 (2004).

2. Aggarwal R. K., Bhatia G., Raman V., Saha M. & Mishra A., A study of partial carbonisation for the development of pitch based carbon fibres, *Carbon Science,* 5, 23-26 (2004).

3. Agrawal A. K., Lal Krishan, Saxena R.K., Bhatnagar Abha & Ganju Sunita, Programme on preparation and dissemination of certified reference materials in India, *MAPAN- J. Metrology Soc. of India*, 18, Supplementary Issue, 291-298 (2003).

4. Agrawal A.K.. Saxena R.K, Bhatnagar Abha, Ganju Sunita & Lal Krishan, Role of certified reference materials in ensuring quality of drinking water, MAPAN-*J. Metrology Soc. of India*, 18,17-24(2003).

5. Ahmad Shahzada, Ahmad Sharif and Agnihotry S.A., Composite polymeric electrolytes based on PMMA- $LiCF_3SO_3$-SiO_2, *Ionics*, 56, 439-443 (2003).

6. Amit Pratap & Govind, normal state fermi surface of cuprates: effect of bilayer cuprate superconductors, *Physica C* : Superconductivity 391, 61-66 (2003).

7. Anand Suman & Kandpal H.C. An experimental study of anomalous behaviour of spectra near phase singularity, *Optics Communications*., 232, 69-75 (2004).

8. Anand Suman & Kandpal H.C., Experimental study of spectral anomalies in Fraunhofer diffraction pattern, *J. Opt. A: Pure and Applied Optics*. 6, 177-179 (2004).

9. Awana V.P.S., Gupta Anurag, Kishan H., Takayama-Muromachi E., Watanabe T., Karppinen M., Yamauchi H., Malik S.K., Yelon W.B., Ganesan V., and Narlikar A.V, Superconductivity with transition temperature up to 80K for $TbSr_2Cu_{2.7}Mo_{0.3}O_{7+\delta,}$ *Solid State Communications* 129, 117-121 (2003).

10. Badrinath K.V.S., Madhavi Latha K., Kiran Chand T.R., Gupta Prabhat K., Ghosh A.B., Jain S.L., Gera B.S., Risal Singh, Sarkar A.K., Nahar Singh, Koul S., Kohli R., Shambhu Nath, Ojha V.K. & Gurbir Singh, Characterisation of aerosols from biomass burning- a case study from Mizoram (North East), India. *Chemosphere*, 54, 167-175 (2004).

11. Bandyopadhyay A.K., et. al. Results of the APMP Pressure key comparison in gas media and gauge mode from 0.4 to 4.0 MPa, *Metrologia* 40, Technical Supplement 07002 (2003).

12. Bandyopadhyay A.K., D. Varandani, Nita Dilawar, Raman Studies of $In_{0.53}Ga_{0.47}As$/InP multi quantum wells, *Thin Solid Films*, 444(1-2), 221(2003).

13. Banerjee, P.K. & Sengupta, A, Doppler technique for detection of victims buried under earthquake rubble, *Indian J. of Pure & Applied Physics*, 41, 970-974, (2003).

14. Batra Rajan, Sharma Amit L., Pandey Manoj K., Saini K. K., & Malhotra B. D., An experimental set-up for the study of electromechanical properties of conducting polymer films, *Current Applied Physics*, 3 (2003).

15. Bhatia G., Raman V., Aggarwal R. K., Sengupta P. R., Mishra A. & Saha M., Development of carbon fibres from pitches modified with polymers, *J. Mat. Sci.,* 39, 1297-1303 (2004).

16. Bhuyan P.K., Chemua M., Subrahmanyam P. & Garg S.C., Ion temperature measured by the SROSS

C2 over Indian equatorial and low latitudes, *J. Atmos. & Solar Terr. Phys*., 66, 301-312, (2004).

17. Bose D.N. & Bandyopadhyay A.K., Semiconductor materials characterization by Raman spectroscopy, *Indian Journal of Physics* 77B, 139-143 (2003).

18. Bose D.N., S.Pal, S.K.Ray and B.R.Chakraborty, Novel gate dielectrics for nanoscale semiconductor devices *Indian Journal of Physics*, 78A (1), 35-39, (2004).

19. Chakraborty B.R., Characterization of interfaces in nanoscale semiconductor devices by optimizing depth resolution in SIMS depth profiling *Appl. Surf. Sc* 221(1-4) 143-154, (2004).

20. Chakravarty B.C., Nanostructured semiconductor devices, *Quanta*, 1, 20-24 (2003).

21. Chatterjee S., Shanker Virendra and Harish Chander, Thermo luminescence of Tb doped Gd_2O_2S Phosphor, *Materials Chemistry and Physics*, 80, 719 (2003).

22. Chaubey Asha, Pande K. K. & Malhotra B. D., Application of polyaniline/sol-gel derived tetraethylorthosilicate films to amperomteric biosensor, *Analytical Sciences*, 19, 1-5 (2003).

23. Chaudhary K. P., Mangal M. L. & Singhal R.P., A simple approach of ring gauge measurement and comparative study using different schemes of measurements, MAPAN- *J. Metrology Soc. of India*, 19(1-2), 2004.

24. Dabas R.S. & . Kersley L., Radio tomographic imaging as an aid to modeling of ionospheric electron density, *Radio Science*, 38, 1035- 1054 (2003).

25. Dabas R.S. & Kersley L., Study of mid-latitude night time enhancement in f region electron density using tomographic images over UK, *Annls. Geophys*.21, 2323-2328, (2003).

26. Dabas R.S., Lakha Singh, Subramanyam P., Lakshmi D.R., Chopra P., & Garg S.C., The evolution and dynamics of equatorial plasma bubbles: relationships to ExB drift, post-sunset total content enhancements and equatorial electrojet strength, *Radio Science,* 38,1075-85. (2003).

27. Das Gupta A., Ray S., Paul A., Banerjee P. & Bose A., Errors in position-fixing by GPS in an environment of strong equatorial scintillations in the Indian zone, *Radio Science (USA), 39,1 (2004)*.

28. Das M.L. & Lal T., Corrosion study of material used for fabricating mass standards, MAPAN- *J. Metrology Soc. of India,* 18, Supplementary Issue 115 (2003).

29. Deepa M., Agnihotry S.A., Gupta D. and Chandra R., Ion pairing effects and ion-solvent-polymer interactions in $LiN(CF_3SO_2)_2$ – PC- PMMA, *Electrochimica Acta,* 49, 373-383 (2004).

30. Dhakate S. R. & Bahl O. P., Effect of carbon fibre surface functional groups on mechanical properties of carbon-carbon composites with HTT, *Carbon*, 41, 1193-1203 (2003).

31. Dhawan S. K., Singh N. & Rodrigues D., Electromagnetic shielding behaviour of conducting polyaniline composites, *Journal of Science & Technology of Advanced Materials*, 4, 105-113 (2003).

32. Dilawar Nita, D. Varandani, Bandyopadhyay A. K. & Gupta A. C., Characterization of a pneumatic differential pressure standards, *Metrologia*, 40, 1-10, 2003.

33. Diva, D. Kabiraj,.Chakraborty B.R, .Shivaprasad S.M, & Avasthi D.K. , RBS and SIMS investigation of V/Si mixing induced by swift heavy ions *Nucl. Ins. & Methods in Physics Research, B* 222, 169-174 (2004).

34. Dwivedi A.K. & Mahajan K.K., Plasma distribution at Venus and ionospheric magnetic fields:

implication for Mars, *Geophy. Res., Lett.* , 30, 2284, (2003).

35. Felner I., Awana V.P.S. and Takayama-Muromachi E., Magnetization study of $RuSr_2Y_{1.5}Ce_{0.5}Cu_2O_{10}$, *Phys.Rev. B*. 68, 094508-12 (2003).

36. Gadi Ranu, Kulshrestha U.C., Sarkar A.K., Parashar D.C. &. Mitra A.P, Emission of SO_2 and NOx from biofuels in India., *Tellus*, 55 B. pp 787-795, (2003).

37. Gajananda Kh, Kaushik Anubha & Dutta H.N., Thermal convection over east Antarctica: potential microorganism dispersal, *International J. Aerobiologia* 20**,** 21-34. (2004).

38. Garg, R.N., Kalra, N., Harit, R.C. and Sharma, S.K. Flyash incorporation effect on soil environment of texturally variant soils. *Asia Pacific J. Environ. and Development*. 10 (2), 59-63 (2003).

39. Godet C., Sushil Kumar and Chu V., Three dimensional field-enhanced electrical transport mechanism in amorphous carbon films, *Phil. Mag.,* 83, 3351 (2003).

40. Golia Santosh, Arora M., Sharma R. K. and Rastogi A C., Electrochemically deposited bismuth telluride thin films, *Current Applied Physics*, 3 (2–3), 195-197 (2003).

41. Golia Santosh, Structural and optical properties of electrochemically deposited bismuth alloyed cadmium telluride thin films, *Proc. Society for the advancement of electrochemical science and technology*, 38, 82 (2003).

42. Govind and Joshi S.K. Effect of out-of-plane interactions on normal state spectral properties of bilayer cuprate, *Physica C: Superconductivity* 398, 13-19 (2003).

43. Govind, Lal Ratan and Joshi S.K, Spectral behaviour of the electronic states of bilayer cuprate systems using a slave fermion approach, *Phys. Rev. B* 69, 094522-094530 (2004).

44. Gupta Alka , Mehrotra Ranjana, Varma S. P., Joshi R. M. & Chauhan V.S., Infrared spectroscopic studies on a dehydrophenylalanine acid containing model peptide: Boc– Ala- $(\Delta Phe)_4$ – NHMe, MAPAN- *J. Metrology Soc. of India*, 18, 63-66 (2003).

45. Gupta Anil K., Light weight high strength material development at NPL using novel processing techniques, *Trans. Indian Inst. Met.*, 56(6), 549-558, (2003).

46. Gupta Anurag, Narayan H., Astill D., Kanjilal D., Ferdeghini C., Paranthaman M., and Narlikar A.V. Study of magnetization and pinning mechanisms in MgB_2 thin film superconductors: effect of heavy ion radiation, *Superconductor Science Technology.* 16**,** 951-955 (2003).

47. Gupta Anurag, Sedky A. and Narlikar A.V., Suppression of superconductivity and normal state electrical transport in $Y_{1-x}Pr_xBaSrCu_3O_{7-\delta}$ and $Y_{1-x}Pr_xBa_2Cu_3O_{7-\delta}$ systems, *Physica Status Solidi*(*B*) 241, 895-901 (2004).

48. Gupta Kedar, K.K., Srivastava G.P. & Kataria N.D.,CAD analysis of HTS microstrip patch antenas using spectral domain method, *Electromagnetics, 23, 595-605, (2003)*.

49. Hanjura A.K., SenGupta A. et al, Results of Diff. STFS-via INSAT, *IETE Tech. Review, 20, 6, 493-505 (2003)*.

50. Haranath D., Shanker Virendra, Harish Chander and Sharma Pooja, Tuning of emission colours in strontium aluminate long persisting phosphor, *J. Phys. D: Applied Physics*, 36, 2244-8 (2003).

51. Hari Kishan, Jokhan Ram, Bhikham Singh, J.P. Singh and Deepti Chadha, Vapour Pressure calculations based on the International Temperature Scale (ITS 90) used in the computation of Relative Humidity MAPAN- *Journal of Metrology in India*,18, Supplementary Issue, 35-42, (2003).

52. Heifetz A, Agarwal Ashish et al, Super efficient absorption filter for quantum memory using atomic ensembles in a vapour, *Optics Communication*. 232, 289 (2004).

53. Jain Kamlesh, Bowers Walt & Schmidt James W, A primary dead weight tester for pressure 0.5-1.0 MPa in Gage Mode, *J. Res. NIST,* 108(2): 135-145. (2003) .

54. Jain Kiran, Sharma R. K., Kohli Sandeep, Sood K. N. and Rastogi A. C., Electrochemical deposition and characterization of cadmium indium telluride thin films for photovoltaic application, *Current Applied Physics*, 3 (2-3), 251-256 (2003).

55. Jain Kiran, Singh P.K. and Lakshmikumar S T, Investigation on porous silicon CdTe system, *Indian Journal of Physics*, 78, 261 (2004).

56. Jain Kiran, Vipin Kumar, Rashmi, Sood K N and Lakshmikumar S T,, Preparation of Sb doped SnO_2 transparent conducting coating by dip coating technique; *Indian J. of Physics,* 78A (2) 215 – 219 (2004).

57. Jain S. C. & Tanwar V. K., Photo-responsive self-assembled monolayer /photopolymer film for optical information storage using liquid crystals, *IEE Proc.-Circuits Devices Syst.,* 150, 556-558, (2003).

58. Jain S.L., Arya B.C. & Arun Kumar, Measurements of liquid water content and trace species in the atmosphere using differential absorption lidar, *Proc. SPIE* 4893(18),. 121-131 (2003).

59. Jain S.L., Arya B.C. & Ghude Sachin D., Measurement of Green House Gases at Maitri Antarctica, *Asian J. Phys.,* 12, 103-107 (2003).

60. Jaiswal S.K**.,** Gupta S.R., Sridhar L. and Singh D Evaluation of uncertainty of measurement in calibration of electrostatic voltmeter – A case study. *Journal of Scientific & Industrial Research*, 62 (12), 1176-1180 (2003).

61. Joshi G. P., Saxena N. S., Dixit V. & Misra S. C. K., Band gap determination of chemically doped polyaniline materials from reflectance measurement, *Indian Journal of Pure & Applied Physics*, 41, 462-465 (2003).

62. Joshi G. P., Saxena N. S., Sharma T. P., Verma S. & Misra S. C. K., Transport properties of chemically doped polyaniline materials, *Journal of Physics and Chemistry of Solids,* 64, 2391-2396 (2003).

63. Kalra N., Jain, M.C, Joshi, H.C., Choudhary, R., Kumar, S., Pathak, H., Sharma, S.K., Kumar V., Kumar, R., Harit, R.C., Khan, S.A. and Hussain, M.Z. Soil properties and crop productivity as influenced by flyash incorporation in soil. *Environment Monitoring & Assessment*. 87(1), 93-109 (2003).

64. Kandpal H.C. & Anand Suman Determination of correlation properties of moving diffuser by spectral analyses of the scattered light emerging from two pinholes, *J. Mod. Opt*., 51, 669-676 (2004).

65. Karar N., Singh F., Mehta B.R., Structure of Photoluminescence Studies on ZnS:Mn Nanoparticles, *J. Appl. Phy.*, 95, 656 (2003).

66. Karfa Mrityunjay, Kumar Mukesh, Kumar Vijay & Sanjid Arif , Simple device , technique-cum-software for measurement of refractive index of liquid medium using "00" grade slip-gauge concept, *Indian Journal of Pure & Applied Physics*, 41, 310-313, (2003).

67. Kaur S., Thakur A. K., Bawa S. S. & Biradar A.M., Behaviour of goldstone and soft mode at Tc in ferroelectric liquid crystals, *Physica B*, 344, 133-139 (2004).

68. Kedar Ashutosh, Kataria N. D. & Gupta K.K., Full-wave modelling of non-linear power dependence of high-Tc superconducting microstrip resonators, *Electronic Letter, 39 (23), 1660-1661, (2003)*.

69. Khare, Neeraj, Moharil, U. P., Singh, B. S. & Gupta, A. K. Study of low field magnetoresistance in $La_{0.67}A_{0.33}MnO_3$ [A= La, Ba, Sr] screen printed films. *Indian J. Pure and Applied Physics* 42, 62 (2004).

70. Khare Neeraj, Moharil U.P., Singh B. S. & Gupta A.K. Low field magnetoresistance and conduction noise in $La_{0.67}Ba_{0.33}MnO_3$ film. Science Letters 26, 214 (2003).

71. Khare Neeraj, Singh D.P., Singh H.K., Gupta A.K, Siwach, P.K. & Srivastava O.N. Preparation and study of silver added $La_{0.67}Ba_{0.33}MnO_3$ film. *Journal of Physics and Chemistry of Solids* 65, 867 (2004).

72. Khasa S. K., V. P. Seth, P. S. Gahlot, A. Agarwal, R. M. Krishna & S. K. Gupta, Electron paramagnetic resonance, optical transmission spectra and dc conductivity studies of vanadyl doped alkali halide borate glasses *Physica B*, 334 , 347-358, 2003.

73. Krishna Prasad V,. Ben Stinner, Deb Stinner, John Cardina, Richard Moore, Prabhat.K. Gupta, Harao Tsuruta, Kiyoto Tanabe, K.V.S. Badarinath and Casey Hoy. Trends in food production and nitrous oxide emissions from the agriculture sector India: Environmental implications. *Regional Environmental Change*, Vol. 3 (No. 4), 154-161(2003).

74. Krishna Prasad V. K. Madhavi Latha, T.R. Kiran Chand, Prabhat K. Gupta, A.B. Ghosh, S.L. Jain, B.S. Gera, Risal Singh, A.K. Sarkar, Nahar Singh, R.S. Parmar, S. Koul, R. Kohli, Shambhu Nath, V.K. Ojha and Gurbir Singh.Characterization of aerosols from biomass burning – a case study from Mizoram (North East), India. *Chemosphere*, 54 (2), 167-175 (2004).

75. Kulshrestha M. J, Kulshrestha Umesh C., Parashar D. C. & Vairamani M., Estimation of Sulphate contribution by dry deposition of SO_2 on the dust particle in India, *Atmospheric Environment*. 37, 3057-3067 (2003).

76. Kumar Lokendra, Dhawan S. K., Kamalasanan M. N., Chandra Subhas, Bright orange organic light emitting diodes fabricated using benzene-naphthalene co-polymer, *Thin Solid Films,* 441, 243-247 (2003).

77. Kumar Lokendra, Dhawan S. K., Kumar Mahesh, Kamalasanan M. N. & Chandra Subhas, Yellow-green organic light emitting diodes based on poly (p-phenylene vinylene)/CdS hetrojunction thin films, *Indian Journal of Pure & Applied Physics*, 41, 641-645 (2003).

78. Lakshmikumar S. T. and Singh P. K., Stabilization of porous silicon surface by low temperature photoassisted reaction with acetylene, *Current Applied Physics*, 3(2-3), 185-189 (2003).

79. Lal K, Srivastava A.K., S.Singh & Ram Kishore, Effect of process conditions on microstructural development during thermal evaporation of AlSb thin films *Journal of Material Science Letters,* 22 515-518, (2003).

80. Lal Ratan, Effect of electron-phonon interaction on the resistivity of metallic nanowires *Phys. Rev. B* 68, 115417-115426 (2003).

81. Lal Tripurari, Das M.L. & Goutam Mandal, present status of mass measurement at NPL India and its metrological equivalence in regional and global metrology network, *MAPAN- Journal of Metrology Society of India*, 19(1-2), (2004).

82. Lal Tripurari, Kumar Harish, Singhal R.P., Saxena A.K., Rao S.U.M., Interalaboratory proficiency testing in mass measurements - 2001/02, *MAPAN, Journal of Metrology Society of India*, 18 (2), 103-114 (2003).

83. Lal Tripurari, Present status of national prototype kilogram of India, *MAPAN- Journal of Metrology Society of India*, 18 (4) 235-242, (2003).

84. Lamba S. and Joshi S.K., Temperature dependent photoluminescence in self assembled InAs

quantum dot arrays, *Physica Status Solidi B: Basic Research* 239, 353-360 (2003).

85. Luthra V., Singh Ramadhar, Gupta S.K. and Mansingh A., Mechanism of dc conduction of polyaniline doped with sulfuric acid, *Current Applied Physics,* 3, 219-222 (2003).

86. Mahajan K.K. & Dwivedi A.., Ionospheres of Venus and Mars: A comparative study., *Adv. Space Res.*, 33, 145-151 (2004).

87. Mahavir Singh, K.K. Pujara & V. Mohanan, Predicting the sound transmission through cavity stud wall panels, *J. Acoustical Society of India*, 31(1-2), 75, 2003.

88. Mahavir Singh, K.K. Pujara and V. Mohanan, Analysis of problems to express uncertainties of building acoustic measurements, *MAPAN-J. Metrology Society of India*, 18, 217- 223, 2003.

89. Mahavir Singh, K.K.Pujara and V.Mohanan, A working estimate of measurement repeatability and within-laboratory reproducibility for sound transmission through wall panels, *MAPAN- J. Metrology Society of India*, 18, Supplementary Issue, 101-106, 2003.

90. Mahendra Mohan & Tiwari M.K., Study of momentum transfers within a vegetation canopy, *Proc. Indian Acad. Sci. (Earth and Planet. Sci.)*, 113, 67-72 (2004).

91. Malhotra B. D. & Chaubey Asha, Biosensors for clinical diagnostics industry, *Sensors & Actuators B*, 91, 117-127 (2003).

92. Malhotra B. D. & Singhal Rahul, Conducting polymers based biomolecular electronic devices, *Pramana,* 61(2), 331-343 (2003).

93. Manish Uniyal, K. Singh, Sunil Bhatt, S.C. Bhatt, R.P. Pant, D.K. Suri and B.S Semwal, Preparation, characterization and dielectric studies of $K_{1-x}Na_xNbO_3$; *Indian J. Pure and Applied Physics,* 41, 305 (2003).

94. Marullo-Reedtz, G., Cerri, R., Blanc, I., Gunnersson, O., Williams, J., Raso, F., KIM, K.-T., Frenkel, R.B., Xiuzeng, Z., Katkov, A.S., Dziuba, R., Parker, M., Wood, B.M., Christian, L.A., Tarnow, E., Mahajan, S.K. and Singh, A.. Comparison CCEM-K8 of DC Voltage Ratio: Results. *IEEE Transactions on Instrumentation and Measurement, 52 (2), 419-423 (2003)*.

95. Mathur R. B., Bahl O. P., Dhami T. L. & Chauhan S. K., A novel route to realize high degree of graphitization in carbon-carbon composites derived from hard carbons, *Carbon Science,* 4(3), 111-116 (2003).

96. Mehrotra Ranjana & S. P. Varma, Infrared spectroscopy in sugar industry: an overview, *MAPAN- J. Metrology Society of India* , 18, 189-195 (2003).

97. Mehrotra Ranjana & H.W. Siesler, Application of MID infrared/Near infrared Spectroscopy in sugar industry, *Applied Spectroscopy Reviews*, 38, 307-354 (2003).

98. Misra S. C. K., Mathur Prafull & Srivastava B. K., Vacuum deposited nanocrystalline polyaniline thin film sensors for detection of carbon monoxide, *Sensors and Actuators A: Physical,* (2004).

99. Mondal N.C. & Sarkar S.K, Rain height in relation to 0°C isotherm height for satellite communication over the Indian subcontinent, *Theoretical & Applied Climatology*, 76, 89-104 (2003).

100. Moodley S.S., Mohd. Saleem & Saxena A.K. Progress on deriving the Farad from the Ohm at CSIR-NML, *MAPAN- Journal of Metrology Society of India*, 18, (3),147-153 (2003).

101. Nahar Singh, Sarkar A.K, Ramachandran R. & Lal Krishan, Determination of arsenic in fly ash and sulphide ore by flame atomic absorption spectrometry using hydride generator *Asian Journal of Chemistry*, I.15 (3&4), 1327-1330 (2003).

102. Nahar Singh & Sarkar A.K., Determination of mercury in fly ash by flameless cold vapour atomic absorption spectrometry using hydride generator, *Asian. Journal of Chemistry*, 15 (3&4), 1593-1597(2003).

103. Nahar Singh, Ramachandran R. & Sarkar A. K., Quantitative estimation of constituents in fly ash by lithium tetraborate fusion. *Journal of Environmental Analytical Chemistry* 83(10), 891-896(2003).

104. Nahar Singh, Rashmi &. Sarkar A.K, Application of fusion technique in synthetic diamond for the determination of impurities by flame atomic absorption spectrometry. *MAPAN-Journal of Metrology Society of India*, 18 (Supplementary Issue), 153-158 (2003).

105. Nahar Singh, Rashmi & Sarkar A.K., Determination of various impurities in synthetic diamond powder, *Journal of Materials Science*. 39, 1665-1669 (2004).

106. Niranjan K, Sridhar H.S., Rama Rao P.V.S., Garg S.C. & Subrahmanyam P., Evening enhancements in f-region electron temperature at subtropical latitudes during June solstice in the Indian SROSS C2 RPA data, *J. Atmos. & Solar Terr. Phys.*, 65, 813-819 (2003).

107. Ojha V N, Sudhir Kumar, Singhal S K, & Lamba G S, Insulation resistance measurement of high impedance accelerometers cables, *MAPAN- J. Metrology Society of India*, 19,(1-2) 117-120 (2004).

108. Omkar Nath, Naib Singh, Saxena A.K., Rao S.U.M. & Singhal R.P, Proficiency testing in AC resistance measurement for NABL accredited laboratories 2001/02, *MAPAN- Journal of Metrology Society of India,* 18 .(4), 243-250 (2003).

109. P.K. Singh,.Ranganath V.R,.Tarafder S, Prabha Prasad, Bhasina V., Vaze K.K., & Kushwaha. H.S., Effect of cyclic loading on elastic–plastic fracture resistance of pht system piping material of PHWR, *Int. J. of Pressure Vessel and Piping* 80,745-750 (2003).

110. Pandey V.K., Sethi N.K. & Mahajan K.K., Topside electron temperature models for low and high solar activity, *Adv. Space Res*, 33, 959-962 (2004).

111. Panwar O.S., Aparna Y., Shivaprasad S.M., Khan Mohd. Alim, Satyanarayana B.S. and Bhattacharyya R., XPS and XAES studies of As grown and nitrogen incorporated tetrahedral amorphous carbon films deposited by pulsed unfiltered cathodic vacuum arc process, *Appl. Surf. Sci*., 221 392-401(2004).

112. Panwar O.S., S.K. Gupta, Mohd. Alim Khan, B. S. Satyanarayana & R. Bhattacharya, Space charge limited conduction and electron paramagnetic resonance studies of As grown and nitrogen incorporated tetrahedral amorphous carbon films deposited by pulsed unfiltered cathodic vacuum arc process, *Diamond and Related Materials,* 13, 513-520, 2004.

113. Panwar O.S., Sharma Rajnish, Sushil Kumar and Dixit P.N., Electron field emission from diamond like carbon films grown by a saddle field fast atom beam source, *J. Vac. Sci. Technol.,* B 21, 1986-1995 (2003).

114. Panwar O.S., Sushil Kumar, Rajput S.S., Sharma Rajnish and Dixit P.N., Dependence of field emission threshold in diamond like carbon films grown by various techniques, *Vacuum*, 72, 183-192 (2004).

115. Pasricha P.K., B.S. Gera, S. Shastri, H.K. Mani, T. John, A.B. Ghosh, M.K. Tiwari and S.C. Garg, Role of the water vapour greenhouse effect in the forecasting of fog clearance, *Boundary Layer Metrology,* 107, 469-482, 2003 .

116. Prasad M.V.S.N. & Rajendra Singh, Terrestrial mobile communication train measurements in western India, *IEEE Trans. Veh. Technology*, 52, 671-682 (2003).

117. Rajput S. S., A wide range current electrometer**,** *Rev. Sci. Instrum.*, 74(6), 3120-3126, (2003).

118. Rajput S.S. and Jamuar S.S., A current mirror for low voltage high performance analog circuits, *Analog Integrated Circuits and Signal Processing*, 36, 221-233 (2003).

119. Ram Kishore, Arshad Shaik, H. A. Naseem and W. D. Brown, Atomic Force Microscopy and X-ray diffraction studies of aluminum induced crystallization of amorphous silicon in Al/α-Si:H, α-Si:H/Al, and Al/α-Si:H/Al Thin Film Structures, *Journal of Vacuum Science and Technology: B*, 21 1037-1047, (2003).

120. Ram Kishore, Atomic Force Microscopy Studies of Micro-crystallization of Amorphous Silicon, *EMSI Bulletin* 4 (1), 27-30 (2003).

121. Ram Kishore, Chris Hotz, H. A. Naseem and W. D. Brown, In–situ X-ray diffraction studies of aluminum–induced crystallization of hydrogenated amorphous silicon, *Journal of Applied Crystallography,* 36, 1236-1239 (2003).

122. Ram S. Shukla and R. P. Pant, Kinetic, mechanistic and thermodynamic investigations on ferrofluid catalysed oxidation of l-ascorbic acid by hydrogen in acidic aqueous solution ; *J. Colloidal and Interface Science*, 268,1,168-172 (2003).

123. Rashmi, X-ray diffraction study of defect-tetrahedral structure quaternary compound $CuZnGa_3Te_6$, *Powder Diffraction*, 18, 263-265 (2003).

124. Sanjid Arif, Singhal R.P., Chaudhary K.P., Kumar Vijay, Sameer, Investigation of Hysterisis loop in UMM and its effects on linear measurement, MAPAN-Journal of Metrological Soc. of India, 19 (1-2), 2004.

125. Sanjid Arif, Singhal R.P., Thejam A. Andhra, G. Shalini, A novel method to measure the decay frequency of a dynamically tuned gyroscope flexure, *Measurement Science and Technology,* . 14 2081-2088, (2003).

126. Sankaranarayanan V.K., Yongkang Hu, Cheol Gi Kim, Chong-Oh Kim and Heebok Lee, Junction size dependence of magnetic and magnetotransport properties in MTJs, *Korean Journal of Materials Research*, 13, 369-373 (2003).

127. Sankaranarayanan V.K.and Sreekumar C., Precursor synthesis and microwave processing of nickel ferrite nanoparticles, *Current Applied Physics,* 3, 205 (2003).

128. Sarkar S.K, Kumar R, Ahmed I., Pasad M.V.S.N & De A.K., Rain structure estimation from radar reflectivity measurements for radio system applications in microwave and millimeter wave frequency bands, *Ind. J. Radio & Space Phys*., 32, 98-103 (2003).

129. Sarkar S.K, Mali P. & Das J., Rain drop size distribution(RDSD) from radar reflectivity measurements, *Ind. J. Radio & Space Phys*., 32, 296-300 (2003).

130. Sarkar S.K., Kumar R & Das J, Rain attenuation at 13 GHz over a LOS terrestrial link situated in indian eastern sector, *Ind. J. Phys.,* 77b, 271-275 (2003).

131. Saxena Vibha & Malhotra B. D., Prospects of conducting polymers in molecular electronics, *Current Applied Physics*, 293-305 (2003).

132. Sen Gupta A. et al, Conjugate Regenerative Dividers, IEEE Transaction on Ultrasonics and Ferroelectrics Frequency Control, (2004).

133. Sethi N.K, Dabas R.S. & Vohra V.K., Diurnal and seasonal variations of hmF2 deduced from digital ionosonde over New Delhi and its comparison with IRI 2001, *Annales Geophysicae*, 22, 453-458 (2004).

134. Sethi N.K., .Dabas R.S, Lakha Singh, Vohra V.K., Veenadhari B. & Garg S.C., Results of foF2 and Ne-h profiles at a low latitude using recent digital ionosonde observations and their comparison with IRI-2000, *J. Atmos. Solar Terr. Phy*., 65, 749-755 (2003).

135. Sethi N.K., Pandey V.K. & Mahajan K.K., Sesaonal and solar activity changes of electron temperature in the F-region and topside ionosphere, *Adv. Space Res.*, 33, 970-974 (2004).

136. Sharma Amit L., Annapoorni S. & Malhotra B. D., Characterization of electrochemically synthesized film and its application to glucose biosensor, *Current Applied Physics*, 3/2-3, (2003).

137. Sharma D. R., Pressure drop during measurement in liquid displacement gas flowmeter of improved design, *Vacuum*, 70, 563-573 (2003).

138. Sharma D.K., Israil M., J.Rai, & Garg S.C., Lightning induced heating of the ionosphere, *Atmosfera* 31-38 (2004).

139. Sharma D.K., Jagdish Rai, Israil M., Shalini Priti, Subrahmanyam P., Chopra P. & Garg S.C., Sunrise effect on ionospheric temperature as measured by SROSS-C2 satellite, *J. Ind. Geophysical. Union*, 7, 117-123 (2003).

140. Sharma D.K., Jagdish Rai, Israil M., Subrahmanyam P., Chopra P & Garg S.C., Effect of lightning on ionospheric temperature determined by SROSS-C2 satellite, *Ind. J. Radio & Space Phys.,* 32, 93-97, (2003).

141. Sharma D.K., Jagdish Rai, Israil M., Subrahmanyam P., Chopra P. & Garg S.C., Enhancement in ionospheric temperatures during thunderstorms, *J. Atmos. & Solar Terr. Phys.,* 66, 51–56 (2004).

142. Sharma R. K., Jain Kiran and Rastogi A. C., Growth of CdS and CdTe thin films for the fabrication of n-CdS/p-CdTe solar cell, *Current Applied Physics*, 3 (2-3), 199-204 (2003).

143. Sharma R. K., Sharma S. N. and Rastogi A. C., Optical properties of CdS nanoclusters : effects of size, stoichiometry and alloying with Ag_2S, *Current Applied Physics*, 3 (2-3), 257-262 (2003).

144. Sharma Rajnish, Panwar O.S., Sushil Kumar, Sarangi D., Goullet A., Dixit P.N. and Bhattacharayya R., Effect of Substrate Bias on SE, XPS and XAES Studies of diamond like carbon films deposited by saddle field fast atom beam source, *Appl. Surf. Sci.*, 220, 313-320 (2003).

145. Sharma Rina, Error Analysis for mask to wafer alignment using modified moiré technique, et.al., MAPAN- *Journal of Metrology Soc of India,* 19(1-2), 2004.

146. Sharma S. N., Banerjee R. and Barua A. K., Effect of the oxidation process on the luminescence of HF-treated porous silicon, *Current Applied Physics*, 3(2-3), 269-274 (2003).

147. Sharma S. N., Kohli Sandeep and Rastogi A. C., Role of cadmium-related defects on the structural and electrical properties of nanocrystalline CdTe:TiO_2 sputtered films, *Current Applied Physics*, 3 (2-3), 263-267 (2003).

148. Sharma S.N., Zeena S. and Kamat P.V., Photoinduced charge transfer between CdSe quantum dots and p-phenylene diamine, *J. Phys. and Chem.,* B 107, 10,088 (2003).

149. Sharma Sudhir Kumar, Misra S. C. K. & Tripathi K. N., Polymer optical wave guide based on integrated optics, *International Journal for Light and Electron Optics*, 114, 106-108 (2003).

150. Sharma Sudhir Kumar, Misra S. C. K. & Tripathi K. N., Nonlinear optical devices: properties of polyaniline based conducting polymers, *Journal of Nonlinear Optical Physics & Materials*, 1239-1243 (2003).

151. Singh B. P., Singhal S.K., Chopra R. & Sharda K. D., Behaviour of glassy carbon under high pressure and temperature in the presence of invar alloy catalyst, *J. Cryst. Growth*, 254, 342- (2003).

152. Singh Janardan, Soni S.N. and Srivastava S.L., Dielectric and piezoelectric properties of neodymium oxide doped lead zirconate titanate ceramics, *Bull. Mat. Sci.*, 26 (4), 397-399 (2003).

153. Singh M.P., Ajay, Govind and Gupta B.R.K., Role of CuO chains on the supercurrent density in bilayer cuprate superconductors, *Indian Journal of Physics,* 77(A) (5), 441-447 (2003).

154. Singh P.K., Kumar Ravi, Vinod P.N., Chakravarty B.C. & Singh S.N., Effect of spectral variation of incident radiation on the spectral response of a large area silicon solar cell and the cell parameters determined from it, *Solar Energy Materials and Solar Cells*, 80, 21-31 (2003).

155. Singh Ramadhar, Amarjeet Kaur, Yadav K.L. and Bhattacharya D., Mechanism of dc conduction in poly (3-methyl thiophene), *Current Applied Physics,* 3, 235-238 (2003).

156. Singh V.R. and Kaur Palwinder, Surface morphology of gall bladder stones, *Ind. J. Pure & Applied Physics, 42, 189-194.(2004)*.

157. Singhal Rahul, Chaubey Asha, Kaneto Keiichi, Takashima Wataru & Malhotra B. D., Poly-3-hexyl thiophene Langmuir-Blodgett for application to glucose biosensor, *Biotechnology and Bioengineering*, 85(3), 277-282 (2004).

158. Singhal Rahul, Chaubey Asha, Srikhirin Toemsak, Aphiwantrakul Sukanya, Pandey S. S., Annapoorni S. & Malhotra B.D., Immobilization of glucose oxidase into Langmuir-Blodgett films of poly (3-hexyl thiophene), *Current Applied Physics*, 3, 275 (2003).

159. Siwach P K, Singh D P, Singh H K, Khare N, Singh A K & Srivastava O N, Effect of substrate on magneto-transport properties of poly crystalline manganite films, *J Phys.D:Appl Phys, 36, 1361-1365 (2003)*.

160. Sonar Prashant, Sharma Amit L., Chandra Amita, Muellen Klaus & Srivastava Alok, Synthesis and study of conductivity behaviour of blended conducting polymer films irradiated with swift heavy ions of silicon, *Current Applied Physics,* 3, 247-250 (2003).

161. Srivastava A.K., Electron microscopy of a rapidly solidified Al-Mn-Cr-Si alloy, *EMSI Bulletin* 4 (2) 25-31, (2003).

162. Srivastava Arun, Jain V.K. & Dutta H.N., Surface wind characterization at an Antarctic coastal station, Maitri, *Mausam*, 55, 95-102. (2004).

163. Srivastava, A.K. Kasturi Lal, Sukhvir Singh and Ram Kishore, Preparation and chracterization of standard gold resolution test specimen for electron microscopy, *MAPAN – Journal Metrology Society of India*, 18, 159-164, (2003).

164. Sushil Kumar, Dixit P.N., Panwar O.S. and Bhattacharyya R., Correlation of Residual Stress with Optical Absorption Edge in Diamond Like Carbon Films, *Diamond Related Materials,* 12,1576-1583, (2003).

165. Sushil Kumar, Dixit P.N., Sarangi D. and Bhattacharyya R., High rate deposition of diamond like carbon films by very high frequency plasma enhanced chemical vapour deposition at 100 MHz**,** *J. Appl. Phys*., 93(10), (2003).

166. Tarafder S,.Rangnath V.R,.Sivaprasad S &.Johri. P, Ductile Fracture behaviour of primary heat transport piping material of nuclear reactors. *Sadhana* 28 (1&2) 167-187 (2003).

167. Tewari Jagdish, Mehrotra Ranjana & Irudyaraj Joseph, Direct near infrared analysis of sugar cane clear juice using a fiber-optic transmittance probe, *J. Near Infrared Spectroscopy,* 11, 351-356 (2003).

168. Thakur A. K., Sharma D. K., Singh S. P., Bawa S. S. & Biradar A. M., Dielectric relaxation near the transition temperature of Sm C*-Sm A phase in ferroelectric liquid crystal, *Ferroelectrics,* 289, 63-75 (2003).

169. Thiyagarajan P., Mathur R. B. & Dhami, T. L., Thermomechanical properties of carbon fibres and graphite powder reinforced asbestos free brake pad composite materials, *Carbon Science,* 4(3), 117-120 (2003).

170. Tripathi O.P. & Jain S.L., Abrupt change in total ozone column over Indian Antarctic Station; *Ind. J. Radio & Space phys.,* 32 38-42 (2003).

171. Upreti U.C., Fe content variation and superconducting order parameter dimentionality in $ErBa_2Cu_{3-x}Fe_xO_{7-\delta,}$ *Ind. J. Pure & Appl. Phys*. 42, 38-42 (2004).

172. Upreti U.C., Zn content variation effect on excess conductivity, superconducting order parameter dimensionality and interlayer coupling in $ErBa_2Cu_{3-x}Zn_xO_{7-\delta,}$ *Ind. J. Pure & Appl. Phys*. 42, 195-200 (2004).

173. V. Mohanan, Omkar Sharma & Mahavir Singh, Noise control measures for electrical machines with special emphasis on diesel generating sets, *J. Acoustical Society of India,* 31(1-2)-019 (2003).

174. Varshney P., Deepa M., Agnihotry S.A. & Ho K.C., Photopolymerized films of lithium ion conducting solid polymer electrolyte for electrochromic windows, *Solar Energy Materials & Solar Cells,* 79(4), 449- 458 (2003).

175. Yadav S., R. Agrawal, Surekha Bhanot, A K Bandyopadhyay, D R Sharma and A. C. Gupta, Modern instrumentation techniques in pressure metrology under static conditions, *MAPAN-Journal of Metrology Society of India*, 18, 2, 57-82 (2003).

Papers presented/published in conference/ symposia and workshop proceedings

1. Aggarwal Malini, Joshi H.P., Iyer K.N., Garg S.C. & Subrahmanyam P., Electron and Ion temperatures at 500 km altitude: Comparison with an empirical model, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

2. Aggarwal R. K., Bhatia G., Raman V., Bhardwaj S., Mishra A. K. & Kaushik N. K., Studies on the reduction of harmful polycyclic aromatic hydrocarbons in coal tar pitches, *Proc. of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 290-297 November 25-26, 2003.

3. Agrawal A. K., Prabhat K. Gupta & Krishan Lal, Preparation of Certified Reference Material of Methane in Nitrogen, Proc. Ninth International Symposium on Biological and Environmental Reference Materials (BERM 9), Published by BAM Federal Institute for Materials research and Testing, Berlin, Germany, pp. B-03, 2003.

4. Agrawal A. K., R. K. Saxena, Abha Bhatnagar & Sunita Ganju, Proficiency Testing of Testing Laboratories (Hindi), National Workshop on Metrology and Low Temperature Physics, NPL, New Delhi, January 20-21, 2004.

5. Agrawal A. K., Requirement of Environmental and Biological Certified Reference Materials in India, Proc. Ninth International Symposium on Biological and Environmental Reference Materials (BERM 9), Published by BAM Federal Institute for Materials research and Testing, Berlin, Germany, pp. S5-5, 2003.

6. Agrawal A. K., Certified Reference Materials: Essential for Monitoring and Control of Pollution and Health, Proc. of National Conference on Environment, Health and Sustainable Development, published by International Development center Foundation, New Delhi, pp. 13-18, 2004.

7. Agrawal A. K., Importance of Certified Reference Materials in Quality Control of Measurements (Hindi), National Workshop on Metrology and Low Temperature Physics, NPL, New Delhi, January 20-21, 2004.

8. Agrawal A. K., R. K. Saxena, Abha Bhatnagar, Sunita Ganju & Krishan Lal, Assessment of Quality of Water, Proc. International Conference on Water and Environment: Environmental Pollution, Eds.

Vijay P. Singh & Ram Narain Yadava, Allied Publishers Pvt. Ltd., New Delhi, pp. 3-9, 2003.

9. Amarjeet Kaur, Singh Ramadhar, Yadav K.L. and Bhattacharya Dipten, Charge transport in poly pyrrole-heparin composites, presented at ST Memorial Annual Symposium held at U Mass, Lowell, USA, Dec. 5, 2003.

10. Ansari M. A., Awana V. P. S., Gupta Anurag, Saxena R.B. and Kishan H. Effect of Sr substitution on the stability of $Cu_{1-\delta}$ chains in oxygen and nitrogen annealed $Ba_{2-x}Sr_xCu_3O_{7-\delta}$ (x = 0.0, 0.5, 1.0) superconducting system Presented at National Conference on Materials and their applications, held at Kurukshetra during March 11-13, 2004.

11. Arora Manju & S. K. Gupta Characterization of hydrogenated amorphous silicon nitride thin films by IR and EPR Spectroscopy, International Conference on Optoelectronic Technology held at North Maharashtra University, Jalgaon, Jan.12-14,2004.

12. Arya B. C., Jain S. L. & Arun Kumar, Monitoring of particulate matter at New Delhi; Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

13. Arya B. C., Jain S. L., Ghude Sachin & Arun Kumar, Photochemical Production of Carbon – Monoxide in Antarctic Atmosphere; Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

14. Ashok Kumar, Reeta Gupta, and Yudhisther Kumar, Calibration of FBH Ultrasonic standards reference blocks, National Symposium on Ultrasonics (NSU-XII), GND Univ. Amritsar, Nov. 3-5, 2003.

15. Ashok Kumar, Tapeshwar Kumar, Yudhisther Kumar and Reeta Gupta , Dependence of ultrasonic time of flight or moisture in composite, National Symposium on Ultrasonics (NSU-XII), GND Univ. Amritsar, Nov. 3-5, 2003.

16. Ashok Kumar, Yudhisther Kumar and Reeta Gupta, Performance evaluation of ultrasonic NDT Transducers , National Symposium on Ultrasonics (NSU-XII), GND Univ. Amritsar, Nov. 3-5, 2003.

17. Awana V.P.S., Ansari M.A., Gupta Anurag, Saxena R.B., Kishan H. and Malik S.K. Co-existence of magnetism and superconductivity in $RuSr_2GdCu_2O_{8-\delta}$ (Ru-1212) and $RuSr_2Gd_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$ (Ru-1222) Rutheno-cuprate compounds Proc. National Seminar & Conference on Cryogenics and its Frontier Applications, pp 1-6, Kolkata, 25-27th March 2004.

18. Awana V. P. S., Ansari M. A., Nigam Rashmi, Gupta Anurag, Saxena R.B. and Kishan H. Comparison of the superconducting critical transition temperature of $LaBaCaCu_3O_{7-\delta}$ and $NdBaCaCu_3O_{7-\delta}$ Presented at National Conference on Materials and their applications, held at Kurukshetra during March 11-13, 2004.

19. Badarinath K. V. S., K. M. Latha, Prabhat K. Gupta, S. A. Christopher and J. Zhang, Biomass Burning Aerosols Characteristics and Radiative Forcing - A Case Study from Eastern Ghats, India. IASTA Conference on Aerosol Remote Sensing in Global Change & Atmospheric Pollution (IASTA-2002), VSSC, Trivandrum, Sept. 18-20, 2002.

20. Bahl O. P. & Dhami T. L., Recent trends in carbon/carbon composites *Proc. National Symposium on Strategic Materials & Technologies for Composites*, Hyderabad, pp. 151-162, August 8-9, 2003.

21. Bandyopadhyay A. K., Douglas A. Olson and Albert Lee, Characterization of a 200 MPa Controlled Clearance Piston Gauge, Proceedings of NCSL International Conference, The Spectrum of Metrology:, From the State-of-the-Art to the Everyday, Tampa, Florida (USA), August 17-21, 2003.

22. Banerjee P, Concept of Time and Techniques of Time Transfer via GPS", topics covered in "GPS Study Programme: GPG-ENGG.A" (Lyra Aviation), ISRO, 28 April –10 May, 2003.

23. Banerjee P. & Chatterjee A., A preliminary study on the Algorithm for the Improvement of Time Scale by the Enssaemble of Cs Atomic Clock at NPL, INCURSI, November 2003.

24. Banerjee P. & Suri A. K., A Novel technique to improve the accuracy of Time Service via Telephone line, INCURSI, November 27-29, 2003 (Best poster Paper).

25. Banerjee P., Bose Anindya & Dasgupta Ashish, On the performance of GPS receivers for online timing Applications, INCURSI, November 2003.

26. Banerjee P. & Singhal R. P., naap-tol aur samay maapan ka vigyan, participated as Experts, AIR Broadcast of Phone-in Karyakram Broadcast , New Delhi, 0920-1000Hrs, 28.06.2003.

27. Banerjee P. K. & Sengupta A, A remote victim locator, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

28. Bhagavannarayana G. and S.K. Halder, "Physics of Semiconductor Devices", Determination of Ge Content, Relaxation and Thickness of $Si_{1-x}Ge_x$/Si Epitaxial layers by High-resolution XRD method using Computer Simulations Eds.) K. N. Bhat and A. Das Gupta, P. 340-342, 2003.

29. Bhagavannarayana G., *R.V. Anantha Murthy, G.C. Budakoti, K.S. Bartwal and B. Kumar, Effect of annealing on crystalline perfection of Fe doped $LiNbO_3$ single crystals grown by CZ method, XXIII National Seminor on Crystallography held at NCL, Pune during Jan. 8-10, 2004.

30. Bhagavannarayana G., S.N. Sharma, R.K. Sharma and S.T. Lakshmikumar HRXRD and PL studies of porous silicon formed on polished and textured (100)Si, Spain 4th International Conference on 'Porous Semiconductor Science and Technology' held at Cullera-Valencia, Spain during March 14-19, 2004.

31. Bhagavannarayana G., Study of porous silicon by high resolution XRD, "In-house Brain Storming Seminar on Nano-materials" held at NPL on Dec. 12, 2003.

32. Bhatia G., Raman V., Aggarwal R. K., Sengupta P. R., Mishra A. & Saha M., Development of pitch based carbon fibres through polymer blend technique, *Extended Abstracts – International Conference on Carbon,* Oviedo, Spain (Carbon 2003), CD / pdf 388, July 06-10, 2003.

33. Bhatia G., Raman V., Aggarwal R. K., Sengupta P. R., Mishra A. & Saha M., Development of carbon-ceramic composites with improved oxidation resistance, *Proc. of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 272-277, November 25-26, 2003.

34. Bhatia S. K. & Goel M. K., On Anomalous Increase in O^+ Density During Storm Time Condition, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

35. Bhattacharyya R. and Kumar Sushil, Surface engineering of materials by cold plasma processing, *Surface Engineering : Process Fundamentals and applications, Lecture Notes of SERC School on Surface Engineering*, International Advanced Research Centre for Powder Metallurgy & New Materials (ARCI), Hyderabad, India, August 2003.

36. Bhupender Singh, Dutta H. N. & Kaushik Anubha, Ecological restoration by fog water harvesting, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

37. Bhupender Singh, Dutta H. N. & Kaushik Anubha, Vertical distribution of water vapour content in the atmosphere for locating fog water harvesting sites, Paper presented at the *National Conference on Emerging Environmental issues and technological challenges,* Guru Jambheshwar Univ., Hisar, Sept. 1-2, 2003.

38. Bhupender Singh, Dutta H. N. & Kaushik Anubha Hava mein dhundh ka adhyanan, Paper presented at the *Third All India Vigyan Sammelan*, NPL, New Delhi, February 19-21, 2004.

39. Bishnoi Laxmi, Jaswant Singh, Bhupender Singh, Kh Gajananda & Dutta H.N., Schirmacher chetra ke ooper bani jheelon ke pani ka bhotik-rasayan adhyanan, Paper presented at the *Third All India Vigyan Sammelan*, NPL, New Delhi, February 19-21, 2004.

40. Bose D.N, S. Pal, S.K.Ray and B.R. Chakraborty, Novel gate dielectrics for nanoscale semiconductor devices" Paper presented at the National Seminar on Science & Technology of Nanomaterials, held at IACS, Kolkata, during March 6-7, 2003.Published as proc. in a special issue of 'Indian Jour. Physics" in Jan. 2004.

41. Budakoti G.C., G. Bhagavannarayana, R.V.Anantha Murthy, L.C. Lim[c], B. Kumar, G.K. Chadha and G.C. Trigunayat, High resolution X-ray diffractometric and topographic study of (1-x)$Pb(Zn_{1/3}Nb_{2/3})O_3$-x$PbTiO_3$ single crystals, , XXXIII National Seminar on Crystallography held at NCL, Pune during Jan. 8-10, 2004.

42. Chakraborty B.R., Characterization of nanoscale oxide layers at the interfaces of semiconductor devices by SIMS depth profiling, Paper presented at the 12th Int. workshop on Physics of semiconductors, held at IIT-Madras, during 16-20th Dec.2003. Published in the proceedings as,Physics of Semiconductor devices.(IWPSD-2003), Ed. K.N. Bhat and A. Dasgupta, Narosa Pub. House. Vol. I, p-158. 2003.

43. Chakravarty B.C., Lal M. and Singh S.N., The study of the growth kinetics of porous silicon (PS) for application in terrestrial silicon solar cell as antireflection coating (ARC), *Proc. of 12th International Workshop on the Physics of Semiconductor Devices*, Indian Institute of Technology Madras, Chennai, Tamilnadu (India), Vol.II, pp.1808-1010.

44. Chander H., Haranath D., Sharma P., Synthesis of Nanostructured Zinc Sulfide by New Technique, *International Conference on Nano Science and Technology (ICONSAT-2003)*, Hyatt Regency, Kolkata, p.163, 17-20 Dec. 2003.

45. Chander Harish, Ghosh P K, Shanker V., Haranath D. and Sharma Pooja, Rashtriya Bhautik Paryogshala men deeptisheel padarthon v upkarano ka swadeshI vikas, *Tritiya Bharatiya Vigyan Sammelan*, p. 431, NPL, New Delhi, 19 – 12 February 2004.

46. Chauhan S. K., Bahl O. P., Dhami T. L. & Mathur R. B., Effect of chopped carbon fiber volume fraction on the thermal properties of carbon-carbon composites, *Extended Abstracts – International Conference on Carbon,* Oviedo, Spain, (Carbon 2003), CD / pdf 581, July 06-10, 2003.

47. Chawla Santa & Sengupta A., Efforts towards Optical Setup of a laser Cooled Cs Fountain at NPL, India , INCURSI, November 27-29, 2003.

48. Clive Green, Saxena G.M. et al, IEEE Freq. Control Symp. Tampa F1, USA, May 4-8, 2003.

49. Dabas R. S., Vohra V. K., Veenadhari,B. . Garg S.C, Devasia C. V., Subbarao K. S. V., Niranjan K. & Rama Rao P. V. S., Study of Occurrence Characteristics of Spread F Irregularities in the Indian Zone Using Multi-Station Ionosonde Data and Their Predictions, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

50. Darshan Singh, Manjit Singh, Dhillon G.S. & Dutta H.N., Study of planetary boundary layer under abnormal weather conditions over Patiala, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

51. Das Shompa, Mandal T.K., Parmar R.S., Zalpuri K.S., Sharma C., Jain S.L., Mitra A.P., & Dutta A., Impact of Air Pollution on Human Health During Diwali, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

52. Das Gupta A., Ray S., Paul A., Banerjee P. & Bose A., Errors… Scintillations in the Indian Zone, Proc. Xth International Effects Symposium-2002 (IES-2002), Alexandria, Virginia, USA, May 7-9, 2002.

53. Dhakate S. R., Aoki T. & Ogasarwara T., Comparison between fracture behaviour of 0/90 cross ply carbon-carbon composites occurring during bending and tensile test at high temperatures, *8th Japan International SAMPE Symposium & Exhibition (JISSE-8)*, Tokyo, Japan, November 18-21, 2003.

54. Dhakate Sanjay, Toshio Ogasawara & Takuya Aoki, Microstructure of SiC fiber reinforced carbon matrix composites after partial oxidation at different temperatures, *IUMRS-ICAM 2003*, Yokohama, Tokyo, Japan, October 8-13, 2003.

55. Dhakate Sanjay, Toshio Ogasawara & Takuya Aoki, Effect of controlled oxidation on bending and interfacial shear strength of 3D woven SiC fiber reinforced carbon matrix composites, *5th International Meeting of Pacific-Rim Ceramic Societies (PACRIM 5)*, Nagoya, Japan September 29–October 02, 2003.

56. Dhami T. L., Mathur R. B., Bahl O. P., Dhakate S. R. & Chauhan S. K., Interface and microstructure development in carbon/carbon composites, *Proc. of National Conference on Carbon (Indo-Carbon 2003)*, Kanpur, pp. 248-261, November 25-26, 2003.

57. Dhami T. L., Mathur R. B., Chauhan S. K., Bahl O. P., Dhakate S. R. & Rand B., Relationship between thermal properties and microstructure of carbon/carbon composites, *Extended Abstracts – International Conference on Carbon,* Oviedo, Spain, (Carbon 2003) , CD / pdf 582, July 06-10, 2003.

58. Diva, D. Kabiraj, B.R. Chakraborty, S.M. Shivaprasad, Pratap Sahoo & D.K. Avasthi., Monotonic mixing in Fe/Si due to swift heavy ions.,Paper presented at the DAE Solid State Symposium, held during 26-30 Dec. 2003 at Gawalior.

59. Dixit Vivechana, Misra S. C. K. & Mathur Prafull, Detection of ammonia using vacuum evaporated polyaniline thin film gas sensors, Presented at *National Conference on Materials, Components and Applications, KIIT*, Bhubneswar, February, 2003.

60. Dutta H N, Bhupender Singh & Sarkar S K, Water Vapour in the Atmosphere and Its Applications, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003)*, NPL, New Delhi, Nov. 27-29, 2003.

61. Dutta H.N., Bhupender Singh, Gupta V. & Kaushik Anubha, Fog water harvesting potential over northern India, Paper presented in the *International Conference on Water Environment-2003*, RRL, Bhopal, Dec., 2003.

62. Dutta H.N., Bhupender Singh & Kaushik Anubha, Role of western disturbances in the development of fog over northern India, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

63. Dwivedi A.K. & Mahajan K.K., Comparison of EUV flux with solar indices (sunspot numbers, solar radio flux, F10.7 and solar magnetic field) during solar cycle 21, 22 and 23, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

64. Dwivedi A.K. & Mahajan K.K., EUV Measurements During Solar Cycle 21, 22 and 23, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003)*, NPL, New Delhi, Nov. 27-29, 2003.

65. Dwivedi A.K., Effect of inhomogeneous magnetic field and general distribution function on auroral current by kinetic Alfven wave. paper presented at *Autumn college on Plasma Physics, ICTP, Trieste (ITALY)*, October 13- November 7, 2003.

66. Gajananda Kh, Kaushik Anubha, Bhupender Singh, Gupta V., Gera Neha. & Dutta H.N., Drinking water quality assessment over the Schirmacher region, east Antarctica, Paper presented in the *International Conference on Water Environment-2003*, RRL, Bhopal, Dec., 2003.

67. Gera B. S., H. N. Dutta, P. K.Gupta, A. B. Ghosh , S. L. Jain, H. K.Maini, G. Singh, V. K. Ojha (NPL, New Delhi), N. Gera & P. Goyal (IIT, Delhi) Sodar studies of foggy boundary layer in relation to air quality management and control Conference on Urban Air Pollution Monitoring and Management, India International Centre, New Delhi, Sept. 22-23, 2003.

68. Gera B. S., G.Singh, V. K. Ojha & H. N. Dutta Mixing height studies for Chemical Industrial Zone, Vapi : Engineering & Environmental Issues and Technological challenges, Hisar, Sept. 1-2, 2003.

69. Gera B. S., Omkar Sharma, Mahavir Singh, G. Singh & V.K. Ojha Development of low cost acoustic shield for sodar antenna National Symposium on Acoustics (NSA- 2003), ARAI , Pune Oct.30-Nov.1, 2003.

70. Gera Neha, Goyal P., Kaushik Anubha, Gurbir Singh, Gera B. S. & Dutta H. N., Sodar studies in relation to EIA for a chemical industrial zone, Paper presented at the *National Conference on Emerging Environmental issues and technological challenges,* Guru Jambheshwar Univ., Hisar, Sept 1-2, 2003.

71. Ghosh A. B., Banerjee P. & Suri A. K., A Study on the Improvement of Time Link of NPL with BIPM by Introducing a Ray Tracing Model for Ionospheric and Tropospheric Time Delay, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

72. Ghude S. D., Jain S. L., Arya B. C. & Pandey P. C., High Total Column Water Vapour During 2002 at Maitri, Antarctica, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

73. Ghude S. D., Jain S. L., Ashoka Kumar & Arya B. C., Measurement of Surface Concentration of CO_2 and CH_4 at Maitri, Antarctica, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

74. Golia S., Study of electrochemically deposited cadmium tin telluride films for solar cells, presented at *IWPSD*, Chennai, Dec.16-20, 2003.

75. Golia S., Study of electrochemically deposited zinc oxide thin films, presented at *National Symposium on Ultrasonics*, Guru Nank Dev University Amritsar, Nov. 3-5, 2003.

76. Golia Santosh, Cathodic electrodeposition of antimony telluride on glass, presented at *15th AGM of MRSI,* BHU Varanasi, Feb 8-11, 2004.

77. Golia Santosh, Characterization of films formed by spray pyrolysis , presented at *Akhil Bhratiya Vigyan Sammelan,* NPL, New Delhi, February 19-21. (In Hindi) 2004.

78. Golia Santosh, Study of electrochemically deposited zinc telluride thin films, presented at the 15th AGM of MRSI, BHU Varanasi, Feb 8-11, 2004.

79. Ghosh A. B., Y. Kant, V. K. Prasad, K. V. S. Badarinath, Prabhat K. Gupta, M. K. Tiwari and S. C. Garg. Inter-comparision of Sun-photometer and Satellite Data for Visibile and Infrared Sensing of Aerosol Characteristics over Urban Areas. International Symposium on Optical Science and Technology organized by the International Society

for Optical Engineering (SPIE), August 3-8, 2003, San Diago, California USA.

80. Gupta Anil K., Advanced manufacturing technology – R&D capabilities in India, *Proceedings of International Workshop on Advanced Manufacturing Technology – Past, Present & Future,* Organised by Korea Advanced Institute of Science & Technology, Korea, pp. 101-125, February 9-10, 2004.

81. Gupta Prabhat K., Arvind K. Jha, S. Koul, Pratul Sharma, Vaishali Pradhan, Vandana Gupta, C. Sharma and Nahar Singh., Methane and nitrous oxide emission from livestock waste management practices in India in relation to global climate change.Paper presented in the International conference on "Coastal and Freshwater Issues (COFIS 2003)", December 8-10, 2003, Anna University, Chennai, T.N.

82. Gupta Prabhat K., Shivraj Sahai, Nahar Singh, Vandana Gupta, C.K.Dixit, D.P.Singh, Pratul Sharma, S. Koul, C.Sharma, A. K. Sarkar, M.K.Tiwari and S. C. Garg; Implication of mechanised harvesting and related crop residue burning in rice-wheat cropping system. Proceedings of the International Seminar on Downsizing Technology for Rural Development – Vol.I (ISDTRD-2003), Regional Research Laboratory, Bhubanesswar, India, Oct. 7-9. S. Kuntia, A. Parida, Vibhuti N. Mishra (eds), Allied Publishers Ltd. pp411-415.

83. Gupta S K, Ramadhar Singh¸ Luthra V. and Arora M., ESR and DC conductivity studies of polyaniline doped with phosphoric acid, presented at *15th AGM- MRSI*, BHU Varanasi, Feb. 8-11, 2004.

84. Gupta S.K., Ramadhar Singh, V.Luthra & M.Arora, ESR and d.c. conducitivity studies of polyaniline doped with phosphoric acid, 15th AGM and MRSI Symposium on 'Materials for light and smart structures" held at BHU, Varanasi, Feb.9-11,2004.

85. Gupta V.K., Sanjay Yadav, A.K. Bandyopadhyay and A.C. Gupta, Daab Dial Gauge Ke Anshankan Ki Vidhi Avam Anishchita Ka Aaklan, Paper presented during Workshop on Mapiki Avam Nimn Taap Bhotiki" during Feb, 19-21, 2004 at NPL, New Delhi.

86. Gupta Ajay K., Khare Neeraj, Bhalla G.L. & Gupta A.K. Study of temperature dependence of resistivity, susceptibility and low field magnetoresistance of double layered $La_{1.4}Ca_{1.6}Mn_2O_7$ manganite. National Workshop on Metrology and Low Temperature Physics (in Hindi), National Physical Laboratory, New Delhi, 20-21 January, 2004.

87. Halder S. K., K. K. Maurya and G. Bhagavannarayana, Study of biaxial stress and crystalline perfection of device quality silicon wafers with PECVD grown thin silicon nitride films, 15th AGM of Materials Research Society of India, , held at BHU, Varanasi during Feb. 8-11, 2004.

88. Haranath D., Chander H., Nitesh and Sharma Pooja, Luminescence of ZnS:Mn Nanophosphors Embedded in Porous Silica Matrix using Sol-gel Method, *National Conference on Materials and Their Applications (NCMA-2004)*, Kurukshetra University, Kurukshetra, Page 41, 11-13 March 2004.

89. Haranath D., Chander H., Sharma Pooja, Synthesis of Long decay $SrAl_2O_4:Eu^{2+}$, Dy^{3+} Phosphor in Nanocrystalline Phase, *International Conference on Luminescence and its Applications (ICLA-2004)*, BARC, Mumbai, p.166, 9-12 Feb. 2004.

90. Harish Bahadur, Ram Kishore , K.N. Sood, Rashmi, D.K. Suri , M. Kar , A. Basu, G. Bose and Sudhir Chandra, Preparation and Characterization of ZnO Thin films on Silicon using Sol-Gel Process 12th IWPSD, Chennai, December 16-20, 2003.

91. Harish Bahadur, Ram Kishore, Sood K. N., Rashmi, Suri D. K., Kar M., Basu A., Bose G. and Sudhir

Chandra, Preparation and characterization of ZnO thin films on silicon using sol-gel process, *International Workshop on Physics of Semiconductor Devices (IWPSD-2003)*, IIT Chennai, Dec. 2003.

92. Harish Bahadur, Tiwari M.K. & Garg S.C., On Achieving Radiation Hardness in Quartz Resonators for Satellite Communication - An Overview, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

93. Harish Chander, R & D in Alkaline Earth Sulphides for Electroluminescence (Invited Talk), *International Conference on Luminescence and its Applications (ICLA-2004),* BARC, Mumbai, p. 53, 9-12 Feb. 2004.

94. Jain A. R., Das Siddarth Shankar, Mandal Tuhin Kr. & Mitra A. P.,Observation of extremely low cold point tropopause (CPT) temperature over Indian Tropical region during summer monsoon months: possible implications for stratospheric water vapour, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

95. Jain K, Kumar V. and Lakshmikumar S. T., Semiconductor tin oxide gas sensor: effect of dopants, presented at *IKONSAT*, Kolkata Dec.17-20, 2003.

96. Jain Kiran, Vipin Kumar and Lakshmikumar S. T., Preparation of thick film tin oxide gas sensor, presented at Conference on Science and Technology of Nanomaterials, Thapar Institute of Engineering and Technology, Patiala, September 2003.

97. Jain M., Height-wise trend analysis of Umkehr data over Indian subcontinent, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

98. Jain S. C. & Singh P. K., Fabrication of micro channels and membranes in PDMS elastomer for biological and biochemical applications, *MRSI 2004*, Varanasi, February 8-10, 2004.

99. Jain S. C., Singh P. K. & Tanwar V. K., Micropatterning of gold and silver surfaces using contact printing of self-assembled monolayer precursors, *Physics of Semiconductor Devices (IWPSD-2003),* Editors: K. N. Bhatt and A. Das Gupta, Narosa Publishing House, New Delhi, pp. 1139-1141, 2003.

100. Jain S. L., Arya B. C. & Arun Kumar, Measurements of Water Vapour, Surface Ozone, Ammonia and Ethylene Using Differential Absorption Lidar, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

101. Jain S. L., Arya B. C. & Sachin D Ghude, Measurements of Various Minor Constituents using a Differential Absorption Lidar, Paper presented at *National Symposium on Instrumentation(NSI)*, G. B pant University, Pantnagar. 3-5 Nov. 2003.

102. Jain S. L., Arya B. C. & Sachin D Ghude, Online Measurement of Greenhouse gases using gas Chromatograph at Maitri, Antarctica, Paper presented at *National Symposium on Instrumentation(NSI)*, G. B pant University, Pantnagar. 3-5 Nov. 2003.

103. Jain S. L., Arya B. C., Arun Kumar, Kulkarni Pavan & Ghude Sachin, Surface Ozone Measurements at NPL, New Delhi, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

104. Jain S. L., Arya, B. C., Pankaj Singh, Tiwari M. K. & Garg S. C., Measurements of Aerosol Size Distribution And Other Atmospheric Parameters at Hanle, Leh and New Delhi, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

105. Jain S. L., Ghude D. Sachin, Arun Kumar, Ashoka Kumar & Arya B.C.; Measurement of Total

Column Ozone During Ozone Hold of 2002 at Maitri, Antarctica, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

106. Jain,S.L., Arya B.C., Arun Kumar & Sachin D. Ghude, Solar UV- B Radiation over New Delhi and Antarctica, Paper presented at *International Solar Cycle Studies Symposium 2003 on 'Solar variability as an input to the earth environment'* Tatranska Lomnica, Slovakia, June 23-28, 2003.

107. John Thomas, Garg S. C., Subrahmanyam P., Bahl Madhu, Chopra Parvati, Maini H.K., Vishram Singh & Dhan Singh., Top and bottom side F-region plasma density irregularities during high solar activity period as observed from SROSS-C2 Ion RPA data, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

108. John Thomas, Maini H. K., Chaunal D. S. & Garg S.C., A low-cost Short range Telemetry for slow Speed Data Transmission, Paper presented at *National Symposium on Instrumentation(NSI)*, G. B pant University, Pantnagar. 3-5 Nov. 2003.

109. Kandpal H. C. and Suman Anand , Correlation properties of moving diffuser by spectral analyses of the scattered light emerging from two pinholes Internatinal Conference on Optoelectronic Technology (ICOT-2004) at Jalgaon, Maharashtra held during January 10-14, 2004.

110. Karar N., Suchitra R. and Singh F., Properties of Nanocrystalline ZnS:Mn, *International Conference on Materials for Advanced Technologies (ICMAT-2003)*, Suntec Singapore International Convention and Exhibition Center, p. 383, 7-12 Dec. 2003.

111. Kaur S., Thakur A. K., Bawa S. S. & Biradar A. M., Bistable phenomemon in deformed helix ferroelectric liquid crystal, *National Workshop on low temperature physics and measurement*, NPL, New Delhi, January 20-21, 2004.

112. Kedar Ashutosh, Kataria N. D. & Gupta K.K. Attenuation and Q value Measurement in HTS-CPW Structure, International Conference on Computers and Devices for Communication, CODEC04, held at Calcutta, India from Jan 1- 3, 2004.

113. Khanna R.M., Bahl Madhu, Gupta Beena & Garg S. C. Doppler Sodar & High resolution measurements of Atmospheric Winds, Paper presented at *International Conference on Natural Hazards (Intropmet 2004),* Hyderabad February 24- 25-2004.

114. Khare Neeraj & Singh D. P., Investigation of grain boundary transport in doped rare earth manganite using artificial grain boundary in $La_{0.67}Ba_{0.33}MnO_3$ thin film. Indian Science Congress, Punjab University, Chandigarh, 3-7 January, 2004.

115. Khare Neeraj, Gupta Ajay K., Bhalla G. L. & Gupta, A.K. Study of low field magnetoresistance of double layered $La_{1.4}Ca_{1.6}Mn_2O_7$ manganite. AGM - MRSI Meeting, Banaras Hindu University, Varanasi, 9-11 Feb 2004.

116. Khare Neeraj, Singh D. P. & Gupta A. K. SQUID for measurements of extremely weak magnetic fields. *National Conference on Radio Science,* National Physical Laboratory, New Delhi, 27-29 November 2003.

117. Khare Neeraj, Singh D. P., Bhalla G. L. & Gupta A. K. Study of conductance and magnetoresistance of artificial grain boundary in $La_{0.67}Ba_{0.33}MnO_3$ epitaxial thin film and its dependence on magnetic field. National Workshop on Metrology and Low Temperature Physics (in Hindi), National Physical Laboratory, New Delhi, 20-21 January, 2004.

118. Khare Neeraj, Singh, D. P., Bhalla, G. L. & Gupta, A.K. Magnetic field dependence of conductance and magnetoresistance of artificial grain boundary junction in $La_{0.67}Ba_{0.33}MnO_3$ epitaxial thin film at 77K. *15th AGM - MRSI Meeting,* Banaras Hindu University, Varanasi, 9-11 Feb 2004.

119. Koireng R. R., Kumar Lokendra, Dhawan S. K., Shivaprasad S. M., Kamalasanan M. N., Tandon R. P. & Chandra Subhas, X-ray photoelectron spectroscopy (XPS) studies on surface treated indium tin oxide thin films, *International Conference on Advances in Surface Treatment: Research and Application (ASTRA)*, Hydrabad, November 3-6, 2003.

120. Krishan Lal & A. K. Agrawal, Planning, Preparation and Dissemination of Certified Reference Materials of Trace Contaminants in Water, Proc. Ninth International Symposium on Biological and Environmental Reference Materials (BERM 9), Published by BAM Federal Institute for Materials research and Testing, Berlin, Germany, pp. S3-7, 2003.

121. Kumar Lokendra, Koireng R. R., Dhawan S. K., Kamalasanan M. N. & Chandra Subhas, Optical and luminescence properties of lithium tetra- (8-hydroxy -quinolinato) boron complex for organic light emitting diodes applications, Presented at *National Conf. on Materials and Their Applications,* Kurukshetra March 11, 2004.

122. Kumar Sushil, Godet C., Goudovskikh A., Kleider J.P. and Chu V., Nitrogen induced ordering of the localized electronic π states distribution of a-C:H films, presented at *International conference on amorphous and microcrystalline semiconductors (ICAMS) -20*, Campos do Jordoo, Brazil, August 25-29, 2003.

123. Lal Mohan, Chakravarty B. C. & Rahman M., Stability of H-terminated Si (111) and Si (100) Surfaces, *Proc. of 12th International Workshop on the Physics of Semiconductor Devices*, Indian Institute of Technology Madras, Chennai, Tamilnadu (India), Vol. I, pp. 471-473, 2003.

124. Lochab, Jyoti, Singh, V.R. and Bansal, M.C., "Ultrasonic Measurements in Some Clinical Liquid Materials", Proc. Second IASTED International Conference on Biomedical Engineering (BioMed 2004), February 16-18, 2004, Innsbruck, Austria, ppr no. 417-814.

125. Mahajan K. K. & Dwivedi A. K., Plasma distribution and ionospheric magnetic fields at Venus and Mars, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

126. Mahavir Singh, K. K. Pujara and V. Mohanan, Single-figure sound transmission loss rating for space enclosures Proc. Of 10th International Congress on Sound and Vibration (ICSV10-2003), Sweden, 4609-4615, July,2003.

127. Maini H. K., Subrahmanyam P., Bahl Madhu, John Thomas, Chopra P., Vishram Singh, Dhan Singh & Garg S. C., A PC based Ground Checkout System (GCS) for satellite payloads, Paper presented at *National Symposium on Instrumentation (NSI)*, G. B. Pant University, Pantnagar. 3-5 Nov. 2003.

128. Maini H. K., Pasricha P. K., Subrahmanayam P., John Thomas, Bahl Madhu, Tiwari M.K. & Garg S. C., Height Variation of Temperature and Humidity in the Foggy Layer Over Delhi, Measured Using Tower-Based and Balloon-Based Techniques, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

129. Mathur Prafull, Vivechana Dixit & Misra S. C. K., Nanocrystalline polymeric sensors for detection of HCl, Presented at *National Conference on Materials, Components and Applications, KIIT*, Bhubneswar, February 2003.

130. Mathur R. B. & Lal Chhotey, Fabrication and characterization of well dispersed carbon nanotubes/coal tar pitch composites , *Proc. of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 430-434, November 25-26, 2003.

131. Mathur R. B., Dhami T. L., Bahl O. P. & Chauhan S. K., High thermal conductivity carbon/carbon composites derived from hard Carbons, *Proc. Of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 235-247, November 25-26, 2003.

132. Mathur R. B., Dhami T. L., Goel P. K., Sharma R. K., Sharma C. P., Rangarajan J. & Choudhury S. R., Porous conducting carbon paper as electrode for Fuel Cell, *Proc. of Seminar on Fuel Cell – Materials, Systems and Accessories, NMRL,* Ambernath, pp. 14-20, September 25-26, 2003.

133. Mathur R. B., Lal Chhotey, Seth R. K. & Dhami T. L., Thermal Gravimetric studies on the as-produced and purified nanotube-rich carbon soot, *Proc.of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 423-429, November 25-26, 2003.

134. Mehrotra Ranjana and H. C. Kandpal, Experimental verification of doppler-like wavelength shift conference Internatinal Conference on Optoelectronic Technology (ICOT-2004) at Jalgaon, Maharashtra held during January 10-14, 2004.

135. Mishra A. K., Bhardwaj S., Bhatia G., Aggarwal R. K., Raman V. & Kaushik N. K., Studies on physical methods of reducing the benzo(a)pyrene content in coal tar pitches, *Sovenier – IUPAC Conference on Green Chemistry,* New Delhi, p. 51, January 26-31, 2004.

136. Misra Aparna, Kumar Lokendra, Koireng R. R., Kumar Pankaj, Dhawan S. K., Kamalasanan M. N. and Chandra Subhas, Blue color electroluminescence device based on *para-hexaphenyl (PHP) oligomer, National Conf. on Materials and Their Applications*, Kurukshetra, March 11, 2004.

137. Misra S. C. K. & Mathur Prafull, Advanced sensors for environment monitoring, Presented at *National Symposium on Instrumentation (NSI-28)*, Pantnagar, November 3-5, 2003.

138. Misra S. C. K., Mathur Prafull & Sharma R. P., Preparation and characterization of nanocrystalline polyaniline thin films for electronic applications, Presented at *International Conference on Opto-electronic and Technology*, ICOT-2004, Jalgaon, January 12-14, 2004.

139. Misra S.C.K., Mathur Prafull & Srivastava B. K., Intelligent instrumentation for measurement of microbiological activity, Presented at *National Symposium on Instrumentation (NSI-28)*, Pantnagar, November 3-5, 2003.

140. Mukesh Chandra and Ashok Kumar, On the design of high power ultrasonic transducer for air borne application, National Symposium on Ultrasonics (NSU-XII), GND Univ. Amritsar, Nov. 3-5, 2003.

141. Mukesh Chandra and Ashok Kumar, Experimental investigation of truncated underwater parametric acoustic arrays in a glass tube, National Symposium on Acoustics (NSA-2003) Oct. 30 to Nov. 1, 2003 at Pune.

142. Naveen Garg, Mahavir Singh, K.K. Pujara and V.P. Agrawal, Prediction of airborne sound transmission through wall panels using Statistical Energy Analysis, Proc. of National Conference on Recent Developments in Mechanical Engineering (NCME-2003), Patiala, 102-109, Oct. 2003.

143. Negi P. S. & Swarup R., "Effect of Pin depth on repeatability of 7 mm sexless coaxial connectors at radio frequencies", *Workshop-cum-Symposium on Microwave Applications in Medicine, Remote Sensing and Industry* (MA:MRSI-2K4), Solid State Physics Laboratory, Lucknow Road, Delhi-110007, Feb. 20-21, 2004.

144. Om Prakash, Focometer method modification for measurement of large focal length of lenses, 4th International Workshop on Adaptive Optics for Industry and Medicine, conducted at the University of Applied Science, Muenster, Germany, during Oct., 2003.

145. Om Prakash, "Measurement of focal length of microscope eyepieces", Published in the

Proceedings of Conference of Optical Society of India, on Optics and Photonics in Engineering (COPE-03), conducted at the Netaji Subhash Institute of Technology (NSIT), Dwarka, New Delhi, 2003.

146. Pandey V. K., Sethi N. K. & Mahajan K. K., Low Latitude Midnight temperature anomaly and its relationship with F-region ion drifts, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

147. Pandey V. K. & Seth N. K, Variability of Slab Thickness and Its Relation with Electron Temperature, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

148. Pandey V. K. and Mahajan K. K., Midnight Temperature Bulge and its relationship with ion drifts at a low latitude station,, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

149. Panwar O. S., Khan Mohd. Alim, Satyanarayana B. S., Dixit P. N., Kumar Sushil and Bhattacharyya R., Investigations on Tetrahedral Amorphous Carbon Films Grown Using an Indigenously Developed Filtered Cathodic Vacuum Arc System, *Physics of Semiconductor Devices* ed. K. N. Bhat and A. D. Gupta, Narosa Publishing House, New Delhi, pp.1148-1150,2004.

150. Parashar D. C., Garg S. C. & Mitra A. P., Parameters controlling production and emission of methane from paddy fields, *Proc. of 3rd International Methane and Nitrous Oxide Mitigation Conference,* Beijing, China, 17-21 Nov. 2003.

151. Pasricha P.K., Prasad M.V.S.N. & Sarkar S.K., Computation of Evaporation Duct Height in the Indian Ocean Area Using the INDOEX Observations, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

152. Prabhakaran Nayar S. R., Lalitha T. Alexander, Radhika V. N. , Vijayakrishnan M. V., John Thomas, Subrahmanyam P., Chopra Parvati, Bahl Madhu, Maini H. K., Vishram Singh, Dhan Singh & Garg S. C., Characteristics of the long period evolution of Te and Ti in the upper atmosphere, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

153. Prabhakaran Nayar S. R., Lalitha T. Alexander, Radhika V. N., Vijayakrishnan M. V., John Thomas, Subrahmanyam P., Chopra Parvati, Bahl Madhu, Maini H. K., Vishram Singh, Dhan Singh & Garg S. C., Features of diurnal variation in Te and Ti at the low latitude upper ionosphere and its dependence on altitude and latitude, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

154. Prasad M. V. S. N., Sarkar S. K., Bandopadhyay L. & Kumar S., A Study of Micro Cellular Communications for Indian Coal Mines, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

155. Prasad M. V. S. N., Rama Rao T. & Bhaskar Rao S.V.Vijay, Mobile Communication Experiments Over Southern India, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

156. Prasad M. V. S. N., VLF receivers developed at NPL and propagational problems, *Brain storming session* on *VLF communication problems related to Naval communications*, INS Katta Bomman, Jan. 21-22 2004.

157. Rama Rao T. & Prasad M. V. S. N., Influence of Fast Fading on Indoor Propagation Channels, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

158. Ramadhar Singh, Sinha R. D. P., Amarjeet Kaur and Jitendra Kumar, AC Conductivity and dielectric relaxation behaviour of solution grown poly(vinylidene fluoride) films, presented at *4th Asian Meeting on Ferroelectrics (AMF-4)*, MRC, IISc Bangalore, Dec. 12-15, 2003.

159. Raman V., Bhatia G., Aggarwal R. K., Sengupta P. R. & Bhardwaj S., Development of SiC Nanofibres through polymer blend and sol-gel techniques, *Proc. of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 286-289, November 25-26, 2003.

160. Raman V., Bhatia G., Aggarwal R.K., Sengupta P. R., Saha M., & Mishra A., Effect of heat treatment temperature on the development of pitch based carbon fibres, *Proc. of National Conference on Carbon (Indo-Carbon 2003),* Kanpur, pp. 278-285, November 25-26, 2003.

161. Ravat K. B. & Mahajan S. K., Development of Copper-Cadmium alloy for high voltage transmission line, Proc. of XXIV annual conference on electron microscopy & allied field, CPRI, Shimla, April 16-18, 2003.

162. Ravi Kumar, Das Shompa, Mandal T. K., Peshin S. K. & Mitra A. P., A comparative study of the International ozone loss at Maitri and Syowa stations of Antartica from 1988 to 1999, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

163. Risal Singh, Tanwar R. S. & Shambhu Nath, Dilli Men Kohre ka Saur Vikiran ke Paravaigni avam Drishya Aayamon par Prabhav, *III Akhil Bhartiye Vigyan Sammelen*, NPL. New Delhi, 19 - 21 February, 2004.

164. Risal Singh, Tanwar R. S. & Shambhu Nath, Evaluation of Parameters Necessary to Define the UV-B Radiation Field Related Minimum Erythemal Dose (MED) in Indian Context, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

165. S. Pal, S. K. Ray, B. R. Chakraborty, S. K. Lahiri & D. N. Bose, 'Study of high-k gate dielectrics for MOS devices". Paper presented at the 12th Int. workshop on Physics of semiconductors, held at IIT-Madras, during 16-20th Dec.2003. Published in the proceedings as,Physics of Semiconductor devices.(IWPSD-2003), Ed. K.N. Bhat and A. Dasgupta, Narosa Pub. House. Vol. I, p-495., 2003.

166. Saha M., Mishra A., Aggarwal R. K., Raman V., Sengupta P. R. & Bhatia G., Studies on the development of carbon-ceramic composites with high oxidation resistance, *Sovenier – Third All India Hindi Science Conference,* New Delhi, p. 443. February 19-21, 2004.

167. Sanjay Yadav, A. K. Bandyopadhyay, V. K. Gupta and A. C. Gupta, "Dravchalit Daab Mapan Ke Rashtriya Mankon Ki Ek Jhalak, Paper presented during IIIrd Akhil Bhartiya Vigyan Sammelan at NPL, New Delhi, during Jan. 20-21, 2004.

168. Sanjay Yadav, A. K. Bandyopadhyay, V. K. Gupta and A. C. Gupta, 140 MPa Tak Daab Mapan Ke Dravchalit Sthantaran Daab Manak Ki Anumargniyta Avam Sthayitavta, Paper presented during Workshop on Mapiki Avam Nimn Taap Bhotiki at NPL, New Delhi, during Jan, 20-21, 2004.

169. Sanjay Yadav, V. K. Gupta and A. K. Bandyopadhyay, Characterisation of Controlled Clearance Pressure Balance for Hydrostatic Pressure Measurements up to 500 MPa, Proceedings NSCL Conference, Tampa, Florida, USA, pp 1-16, August 17-18, 2003.

170. Sankaranarayanan V. K., Coercivity variations at the top and bottom NiFe layers in NiFe/FeMn/ NiFe trilayers, Oral Presentation at *International Symposium on Magnetic Materials and Applications SOMMA 2003*, Chungnam National University, Korea, Dec. 3-6, 2003.

171. Sankaranarayanan V. K., CheolGi Kim, Chong-Oh Kim, and Heebok Lee, Cobalt ferrite nanoparticles synthesized by a self ignition reaction, *Proceedings of the Summer Conference of the Korean Magnetic Society*, Busan, Korea, June 19-21, 2003.

172. Sankaranarayanan V. K., Cobalt ferrite nanoparticles synthesized by a self ignition reaction, Poster presentation, Summer Conference of the Korean Magnetic Society, Busan, Korea,19-21 June, 2003.

173. Sankaranarayanan V. K., Distribution of interlayer-exchange coupling on MTJ multilayer, Oral Presentation at *International Symposium on Magnetic Materials and Applications*, *SOMMA 2003*, CNU, Korea, Dec. 3-6, 2003.

174. Sankaranarayanan V. K., Distribution of interlayer-exchange coupling on MTJ multilayer, Poster Presentation at *International Symposium on Magnetic Materials and Applications*, *SOMMA 2003*, CNU, Korea, Dec. 3-6, 2003.

175. Sankaranarayanan V. K., Y. W. Lee, E. E. Shalyguina, CheolGi Kim, Chong-Oh Kim, Exchange bias in NiFe/FeMn/NiFe multilayers, *Proceedings of the 2003 Spring Symposium of KIEEME, KERI,* Changwon, Korea, p.55, May 23, 2003.

176. Sankaranarayanan V. K., Yongkang Hu, CheolGi Kim, Chong-Oh Kim, M. Tsunoda, and Takahashi M., Correlation among exchange coupling, surface roughness and junction size in magnetic tunnel junctions, poster presented at *International Conference on Magnetism*, Rome, Italy, July 27-Aug. 1, 2003.

177. Satyanaryana B. S., Panwar O. S. and Khan Mohd. Alim, Field Emission from Tetrahedral Amorphous Carbon Films Grown Using a Trigger Less Pulsed Cathodic Arc Sources (P 1-44), *Proc. Int. Microelectronic Vacuum Conference (IVMC)*, Osaka (Japan), July 7-11, 2003.

178. Saxena G. M. & Agarwal A., Laser cooling in noisy quadrature of squeezed vacuum for cesium fountain clock, *IEEE Freq. Control Symp*. Tampa F1, USA, May 4-8, 2003.

179. Saxena R. B., Ansari M.A., Kumar Ashok, Gupta Anurag, Kishan Hari and Sharma R.G. Design and development of Niobium-Titanium superconducting magnets at NPL, Proc. National Seminar & Conference on Cryogenics and its Frontier Applications, pp 105-109, Kolkata, 25-27th March 2004.

180. Saxena R. K., High Quality Activated Porous Carbon Cloth (Hindi), 3rd National Indian Science Congress, NPL, New Delhi, February 19-21, 2004.

181. Saxena T. K., Piplani S. and Agnihotry S. A., ECD characterization unit developed at NPL, *National Symposium on Instrumentation (NSI-28)*, G.B.Pant University of Agriculture & Technology, Pantnagar (Uttaranchal), 3-5 November 2003.

182. Sen Gupta A., High spectral purity microwave oscillator design using conventional air-dielectric cavity, *IEEE Freq. Control Symp.* Tampa F1, USA, May 4-8, 2003.

183. Sengupta A., High Spectral Purity Cavity Stabilised Microwave Oscillator, INCURSI, November 27-29,2003.

184. Sethi N. K. & Dabas R. S., Solar activity variations of hmF2 derived from NPL and IRI models over Indian region and their comparisons., Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

185. Sethi N. K. & Pandey V. K., TEC behaviour over Arecibo during solar maximum and its comparison with IRI-2001, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

186. Sethi N. K., Dabas R. S., Vohra V. K., Veenadhari B. & Lakha Singh., Diurnal and seasonal variations

of bottomside TEC derived from digital Ionosonde over Delhi, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

187. Shahzada Ahmad, Sharif Ahmad and S. A. Agnihotry, Composite polymeric electrolytes based on PMMA-$LiCF_3SO_3$-SiO_2, presented at *International Conference on Ionic Devices*, Chennai, India, November 28 - 30 , 2003.

188. Shambhu Nath , Tanwar R. S. , Risal Singh, & Garg S.C., Andaman Dwip Kshetra avam Delhi Kshetra men Paravaigni Saur Kirno ka Tulnatmak Adhyayan, *III Akhil Bhartiye Vigyan Sammelen*, NPL, New Delhi, 19 - 21 February, 2004.

189. Sharma D. K., Jagdish Rai, Israil M., Subrahmanyam P., Chopra P. & Garg S. C., Effects of solar flare on ionospheric temperatures, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

190. Sharma Pooja, Chander H. and Haranath D., Alumina Dependent Luminescence in Calcium Aluminate Phosphor, *International Conference on Luminescence and its Applications (ICLA-2004)*, BARC, Mumbai, p. 135, 9-12 Feb. 2004.

191. Sharma S N, Kohli S, Shivaprasad S M and Rastogi A C, Quantum confinement studies of CdTe nanocrystals sequestered in TiO_2 matrix : effect of oxygen incorporation, presented at *International Conference of Nanoscience and Technology ICONSAT*, Kolkata, Dec. 17-20, 2003.

192. Sharma S N, Zeena S and Kamat P V, Photophysics and photochemistry of quantized CdSe nanoccrystals : role of amines as a surface modifier, *International Workshop on Physics of Semiconductor Devices (IWPSD-2003)*, IIT Chennai, Dec. 2003.

193. Shukla A. K., Agarwal V. K., Soni N. C., singh D. P. and Singh Janardan, Room temperature piezoelectric response of lead lanthanum zirconate titanate in morphotropic phase boundary region, 4th Asian Meeting on Ferroelectrics (AMF –4), IISc, Bangalore, Dec. 12 –15, 2003.

194. Singh Janardan, Soni N. C., Shukla Anoop, Srivastave S. L., Agarwal V.K., Sharma A. K., Mehta H. R. and Mohan D., Development of piezoelectric transducer ceramic material and their characterization for AE sensors, *National Symposium on Ultrasonics (XII – NSU)*, Guru Nanak Dev University, Amritsar, Nov. 3 – 5, 2003.

195. Singh Sachchidanand, Ghosh Ashish Kumar, Jain A. R. & Mahajan K. K., ITCZ Oscillations and Associated Rainfall Activity Observed by Indian MST Radar, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003)*, NPL, New Delhi, Nov. 27-29, 2003.

196. Singh Sachchidanand, Kohli Ramesh, Tanwar R S, Shambhu Nath & Risal Singh, Study of Aerosol Optical Depth and Radiation Flux Over Delhi During Sand Storm Period, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

197. Singh Sachchidanand, Pankaj Singh & Risal Singh, Solar Ultraviolet Irradiance Measurements for Clear sky From Very High Altitude at Hanle - A Case Study, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

198. Singh S. and Singh, V. R., "Ultrasonic and Micro-hardness Study of Renal Calculi", Proc. Second IASTED International Conference on Biomedical Engineering (BioMed 2004), Innsbruck, Austria, ppr no. 417-815, February 16-18, 2004.

199. Singh, V. R., "A Smart Sensor for the Calibration of Acoustic Lithotripters", Journ of Acoustical Soc of India, also, Proc. National Symposium on Acoustics, Pune, Oct. 31-Nov.1, 2003.

200. Singh V. R., "Acoustic Noise Effect on Stone Fragmentation", Internoise 2003, Jeju, Korea, Aug. 25-28, 2003.

201. Singh V. R., "EM Interaction Study in Bones", Proc. Fifth Int. Conf. on EM Wave Interaction with Water and Moist Substances (ISEMA-2003), Rotorua, New Zealand, March 23-26, 2003.

202. Singh V. R., "Enhancement of Kidney Stone Disruption Efficiency of Lithotripters", Proc. 10th Congress of the World Fed. for Ultrasound in Medicine and Biology (WFUMB), Montreal, Canada, ppr 32948, .June 1-4, 2003.

203. Singh V. R., "Measurement of Uncertainties in Shock Wave Lithotripters", NCSL Int. Conf., Tampa, USA Aug. 17-21, 2003.

204. Singh V. R., "Modelling of Thermal Profile in Brain Tumour under Focussed Ultrasound", Proc. Int. Conf. on Mathematical Biology, Kanpur, Feb. 19-21, 2004.

205. Singh V. R., "Nanotechnology in Bio-medical Instrumentation", Proc. 90th Session of Indian Science Congress, Bangalore, Jan. 3-7, 2003.

206. Singh V. R., "National Status of Metrology for Manufacturing of Sophisticated Health Care Systems", Proc. All India Seminar on Advances in Metrology for Manufacturing Technology, Durgapur, pp. i-ix, February 7-8, 2004.

207. Singh V. R., "New Piezo-electric Biomedical Materials for Sensors Applications", National Conf. on Materials, Components and Applications, Bhubnaneswar, Feb. 15-16, 2003.

208. Singh V. R., "Role of R&D Institutes for Effective Engineering Education in India", Proc. Second TIET Foresight Symp. On Higher Technical Education – Issues of Access and Delivery (TFS-II), Patiala, Nov. 22-23, 2003.

209. Singh V. R., "Smart Lithotripsy Sensor", Proc. Second IASTED International Conference on Biomedical Engineering (BioMed 2004), Innsbruck, Austria, ppr no. 417-812, February 16-18, 2004.

210. Singh V. R., "Ultrasonic and SEM Study of Human Teeth", Proc. 10th Congress of the World Fed. for Ultrasound in Medicine and Biology (WFUMB), Montreal, Canada, ppr 32947, June 1-4, 2003.

211. Singh V. R., Bansal Vakul Gehlot, S. and Saini, S., "IR and SEM Analysis of the Teeth", Proc. Second IASTED International Conference on Biomedical Engineering (BioMed 2004), Innsbruck, Austria, ppr no. 417-816, February 16-18, 2004.

212. Singh V. R., Chaudhary, M. and Bhatnagar, I.K., "Investigative Techniques for the Damage Assessment of the Monuments", Heritage Conservation and Preservation (eds. S. P. Singh and A. S. Bisht), Agam Kala Prakashan, New Delhi, 2003.

213. Singhal A. L. & Singhal Rahul., Immobilzation of lactate oxidase onto electrochemically prepared poly (aniline-co- fluoroaniline) films, Presented at *International Workshop on Biosensors*, Mysore, India, August 11-13, 2003.

214. Singhal Rahul & Malhotra B. D., Immobilzation of glucose oxidase into Langmuir-Blodgett films of poly-n-vinyl carbazole, *International Workshop on Biosenors*, Mysore, India, August 11-13, 2003.

215. Sinha S. P., Singh P. K., Lal M., Kumar R., Chakravarty B. C. & Singh S. N., Effect of temperature on performance parameters and spectral response of silicon solar cells, *Proc. of 12th International Workshop on the Physics of Semiconductor Devices*, Indian Institute of Technology Madras, Chennai, Tamilnadu (India), Vol.II, pp. 959-961, 2003.

216. Srivastava A. K., S. Saxena, K. N. Sood, R. Kishore, C. Xu and B.Q Characterization of Carbon Nanotubes Produced by Catalytic Chemical Vapour Deposition. Wei, 12th IWPSD, Chennai, December 16-20, 2003.

217. Srivastava A. K., R. Kishore, G. Bhatia and V. Raman, Microstructural Features Associated with

Nano-sized SiC Whiskers from Coconut Shells,International Conference on Nanoscience and Technology (ICONSAT 2003), Kolkata, p. 103, Dec 17-20, 2003.

218. Subrahmanyam P., Garg S. C., Chopra Parvati, Bahl Madhu, H. K. Maini., John Thomas, Vishram Singh & Dhan Singh, A novel approach for the correct determination of Te from electron RPA data in the presence of photoelectric contamination, Paper presented at *XIII National Space Science Symposium*, Kottayam, February 17-20, 2004.

219. Subrahmanyam P., Jain A. R., Lakha Singh & Garg S.C., Evidence of Changes in Electric Field and Meridional Winds Following Major Solar Weather Events : In-situ Measurements by Indian Satellite SROSS-C2, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

220. Sukhvir Singh, Kasturi Lal and Ram Kishore, Effect of Substrate Temperature on Electrical Resistivity and microstructural Features of Thermally Evaporated InSb Thin films, 12th IWPSD, Chennai, December 16-20, 2003.

221. Sukhvir Singh, Kasturi Lal, K. N. Sood, D. P. Singh and Ram Kishore, Growth and micro structural characterization of thin films of $Bi_{0.5}Sb_{1.5}Te_3$ XII International Workshop on Physics of Semiconductor Devices, IIT Madras, Chennai, Dec 16-20, 2003.

222. Suman Anand and H. C. Kandpal, Spectral anomalies in Fraunhofer diffraction pattern an-experimental study of conference Internatinal Conference on Optoelectronic Technology (ICOT-2004) at Jalgaon, Maharashtra, held during January 10-14, 2004.

223. Tanwar R. S., Shambhu Nath , Dutta H N & Risal Singh, Measurement of Solar Radiation Fields in Different Wavelength Regions During Fog/Smog, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003),* NPL, New Delhi, Nov. 27-29, 2003.

224. Tanwar R. S., Risal Singh, & Shambhu Nath, Grishma Kalin Rajasthani Dhool Dwara Dilli Vaaisayon ka saur parabaigni Kirano se bachav, *III Akhil Bhartiye Vigyan Sammelen*, NPL. New Delhi, 19 - 21 February, 2004.

225. Tarafdar S., V. R. Rangnath, P. Johri and K. K. Ray, Cyclic Fracture Resistance of PHT Piping Material of Indian PHWR's. Proceedings of 41st National Metallurgist day. 57th Annual Technical Meeting, Science City, Kolkata,14-16th Nov. 2003.

226. Thakur A. K., Kaur S. K., Chauhan R., Biradar A. M. & Bawa S. S., Continuous phase transition in Sm C*-Sm A phase of electroclinic liquid crystal, *Third All India Science Conference*, NPL, New Delhi, February 19-21, 2004.

227. Thiyagarajan P., Mathur R. B. & Dhami T. L., Thermochemical properties of carbon fiber reinforced and graphite powder added asbestos free brake pad material., *Extended Abstracts– International Conference on Carbon,* Oviedo, Spain, (Carbon 2003) , CD / pdf 583, July 06-10, 2003.

228. Tyagi Sarika, Bhupender Singh, Gera B. S., Dutta H.N., Kaushik Anubha & Kaushik C.P., Investigation of atmospheric parameters related to January 26, 2001 Bhuj earthquake, Paper presented at the *National Conference on "Emerging Environmental issues and technological challenges,* Guru Jambheshwar Univ., Hisar, Sept 1-2, 2003.

229. Upadhyay P. L. and Mishra D. R. A comparative study of magnetization and superconductivity in Y- and Nb-substituted Bi(Pb)SrCaCuO superconductor: Evidence of d-level filling Proc. National Seminar & Conference on Cryogenics and its Frontier Applications, pp 300-305, Kolkata, 25-27th March 2004.

230. Vasant D. Vankar, Sanjay K. Srivastava and Vikram Kumar, Electronic properties and application of

microcrystalline diamond thin film, Proc. of 12th International Workshop on the Physics of Semiconductor Devices, (IWPSD-2003), Indian Institute of Technology, Madras, Chennai, Tamilnadu (India) Vol.2 pp 1191-1196, 16-20 December, 2003.

231. Veenadhari B., Dabas R. S., Vohra,V. K. Niranjan K. & Devasia C. V., Severe Magnetic Storm Effects on F region Parameters in Indian Zone Using Digital Ionosonde Data, Paper presented at *National Conference on Radio Science in INDIA (INCURSI-2003)*, NPL, New Delhi, Nov. 27-29, 2003.

232. Verma Amita, Kar M., Agnihotry S. A. and Bakhshi A. K., Sol-gel derived CeO_2:TiO_2 coatings for Electrochromic Devices, presented at *International Conference on Ionic Devices*, Chennai, India, November 28-30, 2003.

233. Vijay Kumar, D. Arun, D. R. Sharma and A. C. Gupta, Development of data base for pressure/ vacuum gauge calibration, Presented at the National Symposium of Instrumentation (NSI-28), at GB Pant University, Pantnagar, 3-5 Nov., 2003.

234. Vijayakumar P. N., Khanna R. M., Madhu Bahl & Garg S. C., Correlation technique for the estimates of atmospheric wind parameters with a Doppler sound radar, Paper presented at *National Symposium on Instrumentation (NSI-28)*, Pant Nagar, Nov 3-5, 2003.

Papers in Hindi

1. नायब सिंह, मो. सलीम और ए. के. सक्सेना, एन. पी. एल. में प्रेरकत्व का मुल्यांकन और इसके अंशांकन की सुविधाएं, presented in national Conference on Metrology and Low Temperature Physics held on 21nd-23th Jan. 2004 at National Physical Laboratory New Delhi.

2. राम स्वरूप व पी. एस. नेगी, ''समाक्षीय कनेक्टरों की अपुनरावर्तनीयता का रेडियो फ्रीक्वेंसी पर अध्ययन'', सारांश पुस्तिका, मापिकी एवं निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, राष्ट्रीय भौतिक प्रयोगशाला, 2004, 37–38.

3. रावत कुलभूषण और महाजन एस, के दिष्ट धारा उच्च बोल्टता मानक द्वारा अंशाकन मापिकी एवं निम्न ताप भौतिकी कार्यशाला, 20–21 जनवरी 2004 राष्ट्रीय भौतिक प्रयोगशाला।

4. रावत कुलभुषण और महाजन एस के राष्ट्रीय भौतिक प्रयोगशाला में दिष्ट धारा उच्च बोल्टता मानक की स्थापना तृतीय अखिल भारतीय विज्ञान सम्मेलन, 19–20 फरवरी 2004.

5. रावत कुलभूषण और महाजन एस, के दिष्ट धारा उच्च बोल्टता मानक द्वारा अंशाकन मापिकी एवं निम्न ताप भौतिकी कार्यशाला, 20–21 जनवरी 2004 राष्ट्रीय भौतिक प्रयोगशाला।

6. एस. के. गुप्ता, आर. पी. पंत और मंजु अरोरा आयनिक तरललौह का विभिन्न निम्न तापमानों पर इलेक्ट्रान पैराचुम्बकीय अनुनाद तकनीक द्वारा अन्वेष्ण, तृतीय अखिल भारतीय विज्ञान सम्मेलन 19–21 फरवरी 2004 रा. भौ. प्र. नई दिल्ली–12.

7. मंजु अरोरा एवं एस. के. गुप्ता अवरक्त व इलेक्ट्रान पैराचुम्बकीय अनुनाद स्पेक्ट्रोमिकी द्वारा अर्धचालक तनुपरतों का निम्न ताप पर अभिलक्षण मापिकी एवं निम्न ताप भौतिकी राष्ट्रीय कार्यशाला 2021 जनवरी 2004 रा. भौ. प्र. नई दिल्ली–12.

8. मंजु अरोरा एवं एस. के. गुप्ता हाइड्रोजनीक अक्रिस्टलीय सिलिकन तनु परतों का अवरक्त व इलेक्ट्रान पैराचुम्बकीय अनुनाद अभिलक्षण तृतीय अखिल भारतीय विज्ञान सम्मेलन 19–21 फरवरी 2004 रा. भौ. प्र. नई दिल्ली–12.

9. अवाना वी.पी.एस., अंसारी एम.ए., गुप्ता अनुराग, निगम रश्मि, सक्सैना आर.बी. एवं किशन हरि $RuSr_2Gd_{1.5}Ce_{0.5}Cu_2O_{10-\delta}$-(Ru-12222) रूथैनो क्यूपरेट मिश्रणो में चुम्बकीय Aitcaalakta ''मापिकी एवं निम्न ताप भौतिकी'' पर राष्ट्रीय कार्यशाला, 20–21 जनवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

10. अंसारी एम. ए., अवाना वी. पी. एस., गुप्ता अनुराग, सक्सैना आर. बी. एवं किशन हरि आक्सीजन और नाइट्रोजन वातावरण में अनील किए गए $RBa_{2-x}Sr_xCu_3O_{7-\delta}$ (x=0,0.5,1.0) में अतिचालकता ''मापिकी एवं निम्न ताप भौतिकी'' पर राष्ट्रीय कार्यशाला, 20–21 जनवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

11. किशन हरि, शर्मा शिव दत्त एवं सिंह भीकम सुवाह्य आपेक्षिक आर्द्रता उत्पादको का विकास 'मापिकी एवं निम्न ताप भौतिकी'' पर राष्ट्रीय कार्यशाला, 20–21 जनवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

12. सक्सैना आर. बी., अंसारी मुबीन, कुमार अशोक, किशन हरि एवं शर्मा राम गोपाल राष्ट्रीय भौतिक प्रयोगशाला में अतिचालक चुम्बको के अभिकल्प एवं विकास पर शोध कार्य एक समीक्षा तृतीय अखिल भारतीय विज्ञान सम्मेलन, 19–21 फरवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

13. पंवार नीरज, सेन विक्रम, कुमार अजय, अग्रवाल एस. के. एवं पांडया डी. के. बृहत चुम्बकत्व– प्रतिरोधक पदार्थों में प्रतिस्थापन द्वारा धातु – अधातु संक्रमण तामपान पर प्रभाव तृतीय अखिल भारतीय विज्ञान सम्मेलन, 19–21 फरवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

15. सेन विक्रम, पंवार नीरज, सिंघल एस. के., सिंह बी.पी. एवं अग्रवाल एस.के. बृहत चुम्बकीय प्रतिरोधक पदार्थों में अधात्विक–धात्विक संक्रमण पर बाहय और रासायनिक दबाव का प्रभाव तृतीय अखिल भारतीय विज्ञान सम्मेलन, 19–21 फरवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

16. अग्रवाल एस.के. एवं कुमारास्वामी बी.वी. $CuBa_2(Ca_{1-x}Mg_x)Cu_4O_{12-y}$ अतिसंवाहकों में अन्तर – करणीय क्रान्तिक विधुत धारा घनत्व का निम्न शक्ति चुम्बकीय प्रवृति द्वारा अध्ययन तृतीय अखिल भारतीय विज्ञान सम्मेलन, 19–21 फरवरी, 2004 राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

17. ओझा विजय नारायण, सिंह अजीत, शर्मा सुधीर कुमार एवं जायसवाल शिव कुमार (2004) राष्ट्रीय भौतिक प्रयोगशाला में दिष्ट धारा मानकों की भूमिका. मापिकी एवं निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, (20–21 जनवरी 2004)।

18. जायसवाल शिव कुमार, ओझा विजय नारायण एवं सिंह अजीत (2004) राष्ट्रीय भौतिक प्रयोगशाला में उच्चतम प्रतिरोधकों के अंशांकन में मापन अनिश्चितता का आकलन. मापिकी एवं निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, (20–21 जनवरी 2004)।

19. सिंह अजीत एवं ओझा विजय नारायण (2004). उच्च परिशुद्ध दिष्ट धारा प्रतिरोध का अंशांकन अनुपात विधि के द्वारा, मापिकी एवं निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, (20–21 जनवरी 2004)।

20. शर्मा सुधीर कुमार, ओझा विजय नारायण एवं गुप्ता अशोक कुमार (2004). जेनर अन्तरणीय वोल्ट मानक बैंक के द्वारा अन्य जेनर वोल्ट मानक का अंशांकन तथा उसकी अनुमार्गनीयता. मापिकी एवं निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, (20–21 जनवरी 2004)।

21. शर्मा रीना, चौधरी के. पी. और सिंघल आर. पी., लम्बाई मानक एवम् लम्बाई मापिकी:नई चुनौतियॉ, मापिकी एवम् नन्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, 20–21 जनवरी, 2004, राष्ट्रीय भौतिकि प्रयोगशाला, नई दिल्ली।

22. सिंघल आर. पी., अग्रवाल एन. के., ''विमिय मापन में अनिश्चितता'' मापिकी एवम् निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, 20–21 जनवरी, 2004, राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

23. सिंघल आर. पी., अग्रवाल एन. के., देश के भीतर उद्योग के विकास में माप विज्ञान की भूमिका, मापिकी एवम् निम्न ताप भौतिकी पर राष्ट्रीय कार्यशाला, 20–21 जनवरी, 2004, राष्ट्रीय भौतिक प्रयोगशाला, नई दिल्ली।

Articles in Book/Book edited/Bood Published/ Special Research Reports:

1. Neeraj Khare edited Handbook of High Temperature Superconductor Electronics: Publisher – Marcel Dekker, NY, USA (May 2003)

2. S.S. Moodley and A. K. Saxena Guest Editor, MAPAN- Journal of Metrology Society of India Focal Theme 'Impedance Metrology' Vol 18, No. 3, 2003.

3. Singh V. R., Chaudhary M. and Bhatnagar, I. K., 'Investigative Techniques for the Damage Assessment of the Monuments', Heritage Conservation and Preservation (eds. S. P. Singh and A. S. Bisht), Agam Kala Prasashan, New Delhi, 2003.

4. Saxena Vibha and Molhotra B. D. Electro-chemical Biosensors Advances in Biosensors, Elsevier, Netherlands, 2003.

5. Kumar Arun, Kamalasanan M. N., Singh Mangu, Chauhan Pratima & Molhotra B. D. Diognostics Applications of Enzyme Doped Sol-Gel Derived Glasses Advances in Biosensors, Elsevier, Netherlands, 2003.

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APPENDIX - 2

PATENTS

Patents filed in India

S. No.	Title	NF No.	Application No.	Filing Date	Inventors
1.	An apparatus for measuring sieve dimensions and a method therefrom.	0197NF2003	0869DEL2003	03.07.2003	K.P. Chaudhary S.Singh Chandra Shekhar
2.	A compact dew point generator.	0346NF2001	0916DEL2003	22.07.2003	Hari Kishan S.K. Agarwal R.B. Saxena, Bhikham Singh Shiv Dutt Sharma
3.	A phased array acoustic atmosph eric profiling radar.	0300NF2003	1096DEL2003	02.09.2003	R.M. Khanna S.C. Garg Madhu Bahl Beena Gupta Dhann Singh Omkar Sharma V. Mohanan V. Jha Sushma Roy G. Chakraborty
4.	A patterned liquid crystal display for storing information useful for aligning liquid crystals.	0043NF2004	0198DEL2004	12.02.2004	S.C. Jain

Patents Granted in India

S. No.	Title	Patent No.	Grant Date	Inventors
1.	An improved device for rotating a disk using ultrasonic vibrations	188324	13.06.2003	T.K. Saxena M. Chandra
2.	An improved process for the production of high density monolithic graphite from mesocarbon microbeads	189155	10.10.2003	G. Bhatia R.K. Aggarwal O.P. Bahl N. Punjabi
3.	A device for automatic time comparison using passive T.V. technique	189491	23.01.2004	P. Banerjee M. Saxena

S. No.	Title	Patent No.	Grant Date	Inventors
4.	A device useful as an improved mask aligner for automatic alignnment of mask with wafers	189301	23.01.2004	V.T. Chitnis R Sharma A K Kanjilal R Narianm Rashmi V D Dandwate S Raizada J R Anand A G Bhat K Vardhan B P Singh

Patents Filed Abroad

S. No.	Title	Appl. No.	Country	Filing Date	Inventors
1.	A new method for detection of a Precursor for major earthquake	0059 NF 2004	PCT	23.02.2004	B S Gera H N Dutta Gurbir Singh V K Ojha
2.	A process for the preparation of a low current resistance contact on a high transition temperature superconductors	016NF2004	USA	March 2004	S N Ekbote G K Padam N K Arora Mukul Sharma Ramesh Sethi M K Banerjee

Patents Granted Abroad

S. No.	Title	Patent No	Country	Grant Date	Inventors
1.	Formulation for iron chelation, a process for preparing the formulation and a method of treating Thalassemia	ZL 96119785.4	CN	28.05.2003	Sarkar A K K Sudarshan P Harsh K S Rattan D Ghansham
2.	A simulation circuit layout design for low voltage, low power and high performance type II current conveyor for analog signal processing applications	94796	SP	31.07.2003	S S Rajput S S Jamuar

S. No.	Title	Patent No	Country	Grant Date	Inventors
3.	A process for the preparation of conducting polymeric membrane and a conducting polymeric membrane prepared therby useful as a filter for capturing viruses in potable liquids	116022	MY	31.10.2003	Ramadhar Singh Subhas Chandra Hawa Singh Amarjeet Kaur Narula Shobha Broor
4.	A reusable heat pack	2223071	RU	10.02.2004	C P Sharma R K Sharma C Kant A K Sarkar

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APPENDIX – 3

TECHNOLOGIES MARKETED

S. No.	Technology Developed	Licensee	Premia	Date of Transfer
01	Carbon composite rings for Ilizarov fixator for orthopaedic applications	Agrawal Orthopaedic Hospital, Gorakhpur (UP)	Rs 80,000/-	26.02.2004
02	Development of teleclock receiver	Electronics Equipment Company, Kolkata	Rs. 1,50,000/-	11.03.2004
03	Development of teleclock receiver	Conic Electronics, Kolkata	Rs 1,50,000/-	12.03.2004

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APPENDIX – 4

R & D COLLABORATIONS

Collaborators

Collaborating Institute	Area
General Motors R&D, USA	Extrusion technology of Mg-alloys
Institute of Experimental Physics, Kosice under Slovak Academy of Science,Slovak	Development of nano materials of magnetic fluids and its polymer composites
Institute for Reference Materials and Measurements (IRMM), Belgium	International key inter-comparison programme on chemical measurements
Institute for Reference Materials and Measurements (IRMM),: National Analytical Reference Laboratory (NARL), Australia:	Bilateral exchange project on "International key inter-comparison programme
Asian Pacific Metrology Programme (APMP)	Technical committee on quantity of matter
Cooperation on International Traceability in Analytical Chemistry (CITAC):	Cooperation on International Traceability in Analytical Chemistry (CITAC)
Tokyo Institute of Technology, Yokohama, Japan National institute of Material Science, Tsukuba, Japan University of Campinas, Instituto de Fisica, Brazil University of Sao-Carlos, Brazil Rachi Institute of Physics, Hebrew University, Jerusalem, Israel Universitaet des Saarlandes, Saarbruecken, Germany	Basic superconductivity
Clemson University, Clemson, USA	Applications of carbon nanotubes in composites-adhesion and alignment problems
Heat and Mass Transfer Institute (HMTI), Minsk, Belarus	Synthesis of carbon nanotubes, their application in composites and hydrogen storage
Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram	Spray forming of Mg-alloys
Shriram Institute for Industrial Research (SRI), Delhi	Development of coal tar pitch with a reduced content of benzo (a) pyrene.
Naval Materials Research Laboratory (NMRL), Ambernath	Development of porous conducting carbon paper
Bhabha Atomic Research Centre (BARC), Mumbai	Development of Silicon Photodiodes

Collaborating Institute	Area
Delhi University, Department of Chemistry	Conjugated polymers, Electrochromic electrodes
Jamia Millia Islamia, Department of Chemistry	Polymeric Electrolytes
Banaras Hindu University Institute of Technology	Gas sensors
ISRO-GBP, Dept. of Space	Study of atmospheric aerosols, radiation & trace gases
Central Pollution Control Board, New Delhi -NPL	Anthropogenic influence on fog
NRSA Hyderabad	Study of biomass burning and related trace gas emission using IRS-P3 satellite data
Sher-e-Kashmir University of Agr. Science & Technology	Impact of climate change on agro- ecosystem of high altitude cold arid region: Leh (Ladakh) in collaboration with regional agricultural station
Bhabha Atomic Research Centre (BARC), CBRI, CFTRI, CSMCRI, IICT, IIP, ITRC, NBRI, NEERI, NGRI, NIO, NML, RRL(Bhub), RRL(Jor), NTPC(R&D)	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of elemental solutions.
BARC, CBRI, CFRI,IARI, NBRI, NRSA, RRL(Bhub), RRL (Jor), RRL(T), IOC(R&D),NTPC(R&D),	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixture.
BARC, CFTRI, IRRI, IICT, IIP, ITRC,	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of pesticide.
CGCRI, NAL, NCL,	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of silicon powder for X-ray diffraction.
Central Rice Research Institute, Dhanbad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixtures.
National Centre for Compositional Characterization of Materials, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of elemental solutions, pesticides and gas mixture.
National Remote Sensing Agency, Hyderabad	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixture.
AES Testing & Research Laboratory, Gottambudha Nagar	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of elemental solutions, pesticide and gas mixture.
Gharda Chemicals Ltd., Dombivli	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of pesticide.

Collaborating Institute	Area
The Energy and Resources Institute, New Delhi	Preparation and dissemination of Bharatiya Nirdeshak Dravyas of gas mixture.
Physics department, M.D. University, Rohtak, Haryana	Characterization of materials
Indian Agricultural Research Institute, New Delhi	Free air CO_2 enrichment studies on crops and gas emission using FACE and OTC facilities
National MST Radar Facility, Tirupati	Lower atmosphere and F-region studies
Central Pollution Control Board, New Delhi	Study of fog/smog in and around the city of Delhi
Indian Space Research Organisation, Bangalore and Universities of Osmania, Roorkee, Waltair, Dibrugarh, Kolkata, Saurastra, Kerala and BHU,	RPA Aeronomy Payload onboard SROSS-C2 satellite, data management and data analysis
Indian Meteorological Department, New Delhi	Rain effects on microwave communications
S.V. Univ, Tirupati	Mobile communications
NERTU, Hyderbad	Mobile communications
Department of Ocean Development	Green house gases at Antarctica
Department of Ocean Development	PBL & UV-B studies over Antarctica
Indian Statistical Institute, Kolkata	Estimation of rain characteristics using X-band radar
Space Application Centre, Ahmedabad	Ionospheric correction in sea surface temperature measurements by radiometer onboard IRS Indian satellite
Bose Institute, Darjeeling, Kolkata University, Kolkata, Jadavpur University, Kolkata Centre for Electro Chemical Ceramics Research Central Road Research Institute, New Delhi West Bengal Pollution Control Board, West Bengal	Atmospheric Chemistry and Monitoring Studies
Tata Institute of Fundamental Research, Mumbai Inter-University Consortium, Indore Banaras Hindu University, Varanasi Indian Institute of Technology, New Delhi	Basic superconductivity

APPENDIX -5

SPONSORED/SUPPORTED R&D PROJECTS

New Projects

Sl. No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
1	Development of organic light emitting diodes	DIT, CGO Complex	47.488
2	Development of injection solar cells utilizing dye sensitised nano-crystalline TiO_2 Films	MNES	15.000
3	Micro-patterining of solid surfaces for technological application in the field of microelectronics, sensors and displays	DST	17.000
4	Setting Up of Test and Calibration Facility for Ceramic Sensors	DST	17.000
5	Design & development of ceramic based oxide sensor	DST	17.000
6	Design, development and fabrication of sensors and electrometers for the study of maxwell current density and schumann resonances	IIG	5.000
7	Development of DNA biosensor	DST	25.000
8	Development of transducer elements for acoustic emission (ae) sensor	BARC	3.000
9	Synthesis of carbon nanotubes and their applications in composites and hydrogen storage	DST	0.900
10	Study of initial stage of formation of metal-semiconductor interface	DST	5.440
11	Studies on the effect of dynamic multiple scattering on frequency shift of spectral lince and applications	DST	20.120
12	Carrying capacity studies of Teesta basin in Sikkim	IIT, Delhi	0.500
13	Development of nanophosphors for industrial application	DST	55.350
14	Study of atmospheric aerosols radiation and trace gases under ISRO-GBP road campaign during February 2003: Delhi-Hyderabad-Delhi corridor	Physical Research Lab.(RRL) Navrangpura	3.450

Sl. No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
15	NIR spectroscopy techniques for cellulosic materials	Birla Management Corporation Limited	15.000
16	Design development and fabrication of 500 Kg dead weight machine to calibrate the load cell used for weighing purposes	RRSL, Min.(CAF& Pub Jakkur, Bangalore)	6.496
		Sub Total New Projects	**253.744**
	Continuing Projects		
1	Sascom activity as meeting on Indo-Gangetic plain research effort	Int.Start Secr.	0.000
2	Operation of the south asian regional research centre (SAS-RRC) for study of global change under sascom	Int.Start Secr.	9.935
3	Surface order and structure studies of polymer solid interfaces	Indo-US	0.000
4	Growing by mbe method of epitanial sturcture on the basis of compound a"b" gaas, al in gaas of different composition for various applications	Indo-Russia	0.000
5	To develop 10 pf capacitor using ule quartz for use by accredited calibration laboratory	DST	0.000
6	Planning preparation and dissemination of certified reference materials for quality assurance in analytical measurements	DST (NABL)	0.000
7	Studies on bio-mass burning and related trace gas emissions using IRS-P3 satellite data	NRSA	2.000
8	Sross-C2 satellite rpa aeronomy payload data management	ISRO	0.000
9	Studies on fog ocurrence in Delhi	CPCB	0.000
10	Faraday correction for 6.6 GHz radiometer data from IRS-P4 using global positioning system (GPS) observations	DOS	0.000
11	Development of ultrathin magnetic films for engineering applications in magnetic recording & sensing	DST	0.000
12	Photoinduced superconductivity and non-equilibrium states	DST	2.500
13	Development of specific methods to identify adulterants in milk and to develop a spot testing kit	DMS	0.000

Sl. No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
14	Synthesis and properties of conducting polymers for biosensors	Indo-Polish	0.000
15	Development of strain gauge force transducer to measure forces upto 1 MN with accuracy ± 0.03%	DST	0.000
16	Application of carbon nanotubes in composites-alignment and adhesion problems	DST/NSF	0.000
17	Self assembled layers of conducting polymers for molecular devices	DST	1.500
18	R&D in non-invasive optical fiber probe based near-infrared spectroscopy (nirs) for accessing brain activity	DST	0.000
19	Development of piezo electric accelerometers for general purpose applications	DRDO, Hyederabad	0.000
20	Monitoring of green house gases at Maitri-Antarctica	DOD, Goa	0.000
21	Studies on spatial-coherence spectral filters and their applications	DST	6.000
22	Development of cholesterol biosensors	DBT	3.580
23	To conduct inter-laboratory proficiency testing amongst the NABL accredited calibration laboratories in india	DST (NABL)	50.000
24	Development of polymeric sensors for detection of environmentally hazardous gases and micro-organisms	ME&F	2.334
25	Application of some conducting polymers films	Indo-Japan (DST)	0.000
26	Studies on humidity standards	Indo-Japan	0.000
27	Studies on critical current and vortex dynamics in high Tc superconducting bulk samples and tapes	Indo-Japan	0.000
28	A new approach for memory effect in ferro-electric liquid crystal materials based on charge accumulation phenomenon	DST	2.500
29	Development of new formulation of indelible ink	Election Commission of India	0.000
30	Impact of climate change on human health	ME&F	1.971
31	Reducing uncertainties in emission of CH_4 and N_2O from livestock in india in relation to the enabling activities for intial communication to UNFCCC	ME&F (Winrock)	2.456

Sl. No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
32	Measurement of CH_4 & N_2O emissions from rice/ wheat ecosystem in relation to reducing uncertainties in emission factor for enabling activities for intial communication UNFCCC	ME&F (Winrock)	6.660
33	Reducing uncertainties in emissions CO_2,CH_4 and N_2O from Biomass Burning in India in Relation to the enabling activities for intial Communication to UNFCCC	ME&F (Winrock)	5.675
34	Agriculture sector inventory	ME&F (Winrock)	5.276
35	Development of hard coating of Cubic Boron Nitride for industrial applications	DST	0.000
36	Development of ultrasonic method to evaluate moisture in composite materials	ARDB	0.000
37	Development of spray forming technology of magnesium alloys	VSSC, Thiruvanthapuram	0.000
38	Growth of nearly perfect single crystal of oxide materials with technological applications	Indo-Russia (ILTP)	0.000
39	Smart electro-chromic windows for energy conservation	MNES	0.000
40	Assessment of impacts of climate change on human health	ME&F (Winrock)	1.150
41	Spin effects and interactions in the quantum dots	DST	0.000
42	Development of a coal tar pitch with a reduced content of polycyclic aromatic hydrocarbons	ME&F	5.420
43	Plasma assisted deposition of hydrogenated amorphous silicon films at high rates at VHF (CW and Pulsed)	DST	0.000
44	A study of the formation of delta-doped silicon structures by surface phase control and solid phase epitaxy	DST	0.000
45	Setting up of facilities for dissemination of Indian Standard Time in North-Eastern States	DST	0.000
46	Pressure induced phase transitions and metrological applications	DST	0.000
47	A study of metal oxide coatings on glass substrated by sol-gel technique	DST	0.000
48	Semiconductor silicon for applications in solar energy microelectronics and power electronics	Indo-Russia (ILTP)	7.500
		Sub Total Continuing Projects	**116.457**

Completed Projects

Sl. No.	Title	Agency/Client	Amount Received (Rs. In Lakhs)
1	Interaction with Universities/Laboratories in the area of superconductivity	UGC	3.291
2	Tetrahedral amorphous carbon (ta-c) films deposited by a filtered vacuum arc discharge (FVAD) technique	DST	3.550
3	Spin fluctuations and high temperature superconductivity in bilayer cuprates	DST	0.000
4	Development of superconducting magnet	IPR	0.750
5	Development of silicon photodiodes for use with scintillating crystals for detection of gamma rays	DAE	0.450
6	Swift heavy ion induced mixing at the interface	DST	1.500
7	The budgets of GHGs, urban air pollutants and their future emission scenarios in selected mega-cities in Asia	APN,IGES, Japan	1.308

Sub Total Completed Projects	**10.849**
Grand Total	**381.050**

APPENDIX - 6

RECEIPTS THROUGH CONSULTANCY PROJECTS

Consultancy Projects

Sl. No.	Client	Title	Amount Received (Rs.Lakhs)
1	Atcom Technologies, Mumbai	Improvement in the accuracy of load cell used for weighing purposes	1.444
2	Hunter Dougles India Pvt, Ltd, New Delhi	Removal of coating from Al surface & ascertain its thickness	0.200
3	BHEL, Hardwar	To develop the technique & measurement system	3.939
4	Accord Software & System Pvt Ltd, Bangalore	Optimisation,evaluation and certification of GPS Clock	0.490
5	IGCAR, Kalpakkam	11 Tesla superconducting magnet development	1.900
6	Director, Lighthouse, Jamnagar,Gujarat	Installation, commissioning and verification of DGPS station	0.933
7	Mitutoya South Asia Pvt. Ltd	Setting up calibration facility in dimensional measurement as per NABL guidelines	3.380
8	Nirmal Steel Corporation, Bangalore	Dissolution of Gold and Platinum in ores	0.250
9	Samtel Colour Ltd Ghaziabad	Design,fabricate large area reactors for coatings MgO films	1.375
		Sub-Total Consultancy Projects	**13.911**

Sponsored Projects

Sl . No.	Client	Title	Amount Received (Rs.Lakhs)
1	Prolific Engineers, Noida	Supply of three Piezoelectric Accelerometer	0.459
2	Prolific Engineers, Noida	Supply of three Piezoelectric Accelerometer	0.459
		Sub-Total Sponsored Projects	**0.918**

Technical Services Projects

Sl. No.	Client	Title	Amount Received (Rs.Lakhs)
1	Ministry of External Affairs, New Delhi	Installation of Teleclock service in NSBM, Nepal	4.310

Sub-Total Technical Services Projects	**4.310**
Grand Total	**18.221**

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APPENDIX - 7

EARNINGS FROM CALIBRATION & TESTING

Physico-Mechanical Standards

Activity	Gr. Code	No. of Reports	Charges (Rs.)
Dimension metrology	2	548	3678194
Mass, density, volume & viscosity	3	669	2577962
Force & hardness standard	4	459	4181205
Pressure & vacuum standard	5	145	1727333
Temperature standard	6	329	1851400
Optical radiation standard	7	396	2784940
Acoustic standard	10	151	1028300
Ultrasonic standard	11	23	305800
Humidity standard	12	51	229300
Fluid flow standard	13	3	34500
	Sub Total	**2774**	**18398934**

Electrical & Electronics Standards

Activity	Gr.Code	No.of Reports	Charges (Rs.)
Power & energy standards	20	211	2550063
AC & LF standards (CT/PT)	21	33	615200
DC standards	22	43	316374
HF & MW attenuation standard	23	23	235156
LF & HF impedance standard	24	57	413920
HF & MW standards	25	37	615044

Activity	Gr.Code	No.of Reports	Charges (Rs.)
Magnetic measurement activity	26	26	149600
Time & freqency standard	27	42	193884
DC high voltage	28	2	18500
	Sub Total	**474**	**5107741**

Testing

Activity	Gr.Code	No. of Reports	Charges (Rs.)
Materials	30	2	44500
Chemical analysis	31	67	300600
Indian reference materials	32	4	291000
Electron microscope	34	20	245169
Surface area & porosity	36	1	9300
Metals & alloys	43	21	55000
X-ray, SEM,Carbon,Elect.		-	2000
	Sub Total	**115**	**947569**

Job Work

Activity	Gr.Code	No.of Reports	Charges (Rs.)
Piezo-electric accelerometer	46	-	99600
Central workshop	47	-	—
Thin Film	48	-	19900
Cryogenics	52	-	—
	Sub Total		**119500**
	Transfer Entry		**210100**
	Surplus in Calibration		**194250**
	Service Tax		**104232**
	Grand Total	**3363**	**25082326**

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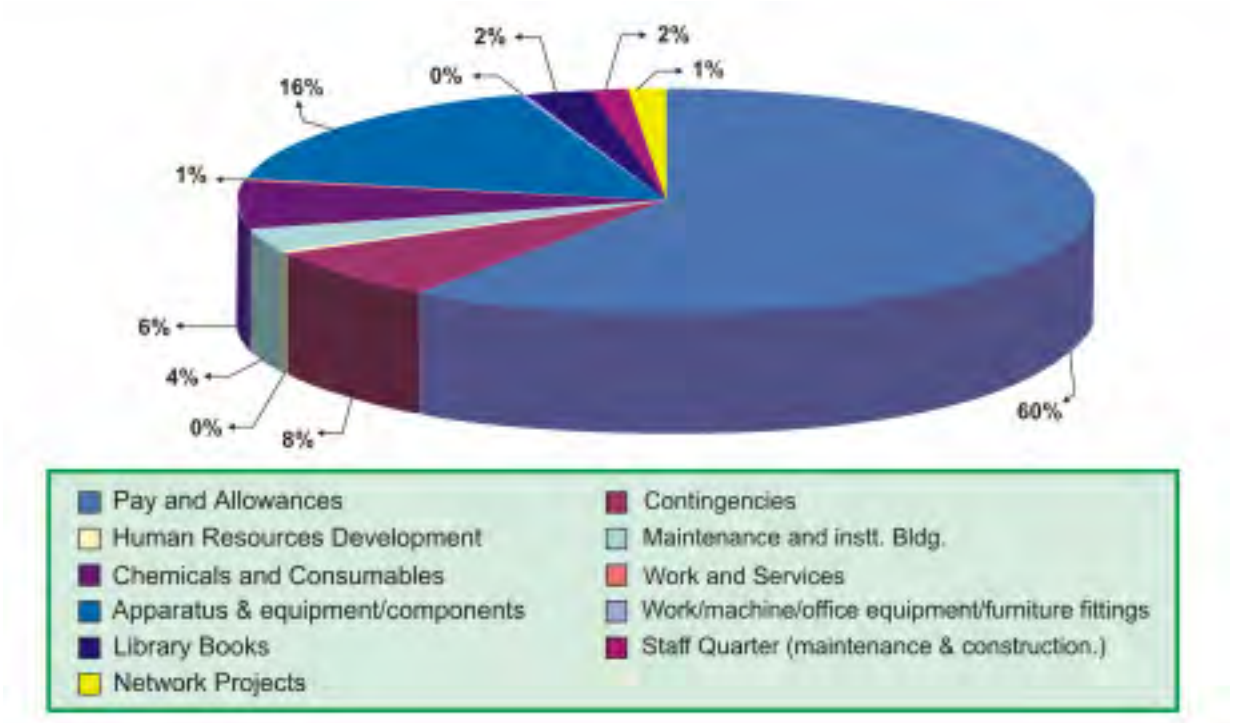
APPENDIX - 8

ACTUAL EXPENDITURE 2003-04

Sl.No.	Budget Heads	Expenditure (Rs. In Lakhs)
1	Pay and Allowances	1931.387
2	Contingencies	244.900
3	Human Resources Development	15.323
4	Maintenance and instt. Bldg.	114.302
5	Chemicals and Consumables	210.200
6	Work and Services	17.543
7	Apparatus & equipment/components	529.457
8	Work/machine/office equipment/furniture fittings	3.621
9	Library Books	80.525
10	Staff Quarter (maintenance & construction.)	49.439
11	Network Projects	42.149
	Total	**3238.846***

*Source of funds : CSIR Grant

In addition, funds were generated through sponsored projects, grant-in-aid projects, consultancy, calibration & testing, transfer of technology etc.



APPENDIX - 9

HONOURS AND AWARDS

Dr. Vikram Kumar, Director

Chairman : Device development, National Pogramme on Smart Materials; Working Group on Nanotechnology, Deptt. of Information Technology; Governing Council, National Accreditation Board for Laboratories; CSIR Steering Committee on Antartic Research (CSIR-SCAR).

President : Metrology Society of India (MSI).

Member : Science and Engineering Research Council (SERC-DST); Nanoscience Technology Initiative (DST); Governing Council/Executive Committee, Bureau of Indian Standards (BIS); Governing Council, Quality Council of India (QCI).

Distinguished Visiting Professor (INAE) : Deptt. of ECE, IISc, Bangalore

Editorial Board : Bulletin of Material Science; J. IETE; IETE Tech Reviews; Indian J. of Engineering and Material Sciences.

Invited to deliver 1st Satish Dhawan Memorial Lecture at ISO1 Symposium Pantnagar, Nov., 2003.

Dr. Anil K. Gupta, Sc G

Joined as Member, Board of Studies, MATS University (Mahavir Academy of Technology & Sciences), Bangalore.

Dr. V. R. Singh, Sc G

Was elected as a Member of Fellowship & Awards Comm., IEEE- Delhi.

Has been elected as a Member of IPC (International Programme Committee) of BioMED- 2005, Feb, 2005, Innsbrug, Austria.

Was elected as Chairman of BIS Comms on Electromedical Equipment Committee (ET-41) and Dental Materials Comm (MHD-19).

Has been nominated as a Member of the Council of Academic Affairs, NSIT-Delhi, 2003-05.

Dr. R. P. Singhal, Sc G

Member, Technical Advisory Committee, Chandigarh Industrial and Tourism Development Corporation Ltd. Chandigarh.

Member, Accreditation Committee and Technical committee on Uncertainty in Measurement, National Accreditation Board for Testing and Calibration Laboratories, DST, New Delhi.

Chairman of Sieves Sizing and Other Sizing Methods Sectional Committee CED55 of Bureau of Indian Standards, India.

Nominated as Member, Technical Advisory Board of Fluid Control Research Institute, Palghat, Kerala .

Nominated as Member, National Advisory Committee of All India Seminar by Institute of Engineers (India), Durgapur Chapter, Durgapur.

Dr. P. Banerjee, Sc G

Was awarded Fellow IEE (UK)

Has been elevated to Senior Member IEEE (USA).

Mr. A. C. Gupta, Sc G

Nominated as the member of "International Union for Vacuum Science, Technique and Applications" (IUVSTA).

Chairman, Basic Standards and Sectional Committee (BP 01), Bureau of Indian standards, New Delhi.

Member, Accreditation Committee National Accreditation Board for Testing and Calibration Laboratories, New Delhi.

Dr. A. Sen Gupta, Sc F

Awarded prestigious O. P. Bhasin Award for Science & Technology for the year 2002 in the field of Electronics and Information Technology.

Dr. S. L. Jain, Sc F

Program Committee Member for SPIE's Fourth International Asia-Pacific environmental Remote Sensing Symposium 2004: Remote Sensing of the Atmosphere, Ocean, Environment, and Space held in Honolulu, Hawaii at the Waikiki Beach Marriott Resort from 8-12 November, 2004.

Chairman and convener to hold symposium titled "Ozone, Aerosol and Atmospheric composition" to be held at SCAR meeting during July 25 – 30, 2004 I Bremen, Germany

Main organizer of Session OA16 titled "Tropospheric Ozone over Asia" in Joint AOGS (Asia Oceania Geoscience Society) 1st Annual Meeting & APHW (Asia Pacific Association of Hydrology and Water Resources) 2nd Conference at Suntec Singapore International Convention & Exhibition Centre during 5-9 Jul 2004.

Member of Steering committee on LIDAR project constituted by Ministry of Information Technology (Department of Electronics) , Govt. of India.

Dr. Ashok Kumar, Sc F

Distinguished Service Award was conferred upon by the Acoustical Society of India for the year 2000-2002.

Chief Editor, Journal of Pure and Applied Ultrasonics

Chief Editor, Acoustical Society of India

Chairman, Ultrasonic NDT Committee, BIS

V. K. Rustagi, Sc F

Has been appointed a reviewer by APMP Technical Committee for Electricity and Magnetism for reviewing CMCs of different countries in the area of AC-DC Transfer.

Dr. R. S. Dabas, Sc F

Nominated Co-Chairman, Space Climatology Working Group and Member, National Steering Committee for "Climate and Weather of Sun Earth System (CAWSES - India) ", the Indian component of the international CAWSES program.

Dr. H. C. Kandpal, Sc F

Appointed as Chairman of the Cinematographic and Photographic Committee of the Bureau of Indian Standards (ME 24), New Delhi.

Appointed as Principal Member of Electro-Technical Committees (ET-23) of the Bureau of Indian Standards, New Delhi.

Nominated as a member of the Editorial Board of the Journals/ Magazines Science Encyclopedia-Wealth of India and Indian Scientist and Industrial Research published by NISCAIR, New Delhi.

Mr. Tripurari Lal, Sc F

Nominated as a Member of the Working Group on Viscosity Measurements of the Consultative Committee on Mass (CCM) the International Conference on Weights & Measures (CIPM) in January 2004.

Dr. B. D. Malhotra, Sc F

Was presented the Materials Research Society of India (MRSI) Medal at 15th Annual General Body Meeting held at Banaras Hindu University, Varanasi, during February 9-11, 2004.

Dr. A. K. Agrawal, Sc F

Elected Member, Co-operation on International Traceability in Analytical Chemistry (CITAC).

Nominated Principal Member, Inorganic Chemicals and Photographic Materials Section Committee, CHD 1 of Bureau of Indian Standards, New Delhi.

Dr. Ranjana Mehrotra, Sc EII

Appointed as Co-Chairperson of the Cinematographic and Photographic Committee of the Bureau of Indian Standards (ME 24), New Delhi.

Neeraj Khare, Sc EII

Rajib Goyal prize for young Scientist in the area of Physics, March 2004.

Elected President of Material Science Section of Indian Science Congress Association in 2003 for the year 2004-2005.

Dr. R. P. Pant, Sc EI

Elected as President of Indian Society of Magnetic fluid Research (ISMFR).

Dr. Sushil Kumar, Sc B

Was conferred with the CSIR Young Scientists Award for the year 2003 in Physical Sciences for his innovative contribution in the development of the process to grow low stress diamond like carbon films by plasma enhanced chemical vapour deposition technique.

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APPENDIX :10

VISITS ABROAD

Name & Designation	Country Visited	Duration	Purpose
Dr Krishan Lal Director	France	04-04-2003 to 05-04-2003	To attend Natural Gas Hydrates meeting
Dr Anil Kr. Gupta Sc G	Japan	12-05-2003 to 15-05-2003	To deliver a talk on precision forging 3rd JSTP-ISPF
Dr A.Sen Gupta Sc F	USA	25-04-2003 to 08-05-2003	To collect measurement results and present a paper at joint meeting of the 2000 IEEE International Programme
Ashok Kumar Sc B	USA	01.04.2003 for 4 years, (2yrs. Study leave, 2yrs. EOL)	To avail overseas scholarship offered by Min.of Social Justice under the scheme of National Overseas Scholarship for SC & ST candidates for doing Ph.D.
Dr.R S .Dabas Sc F	USA	19-05-2003 to 22-05-2003	To attend International Space Environment Services (ISES) Meeting & to visit NOVA Space Centre Boulder
Dr A K Agarwal Sc EII	Germany	15-06-2003 to 19-06-2003	9th Int.Symposium on Biologial & Environment Reference Materials
Dr G.M.Saxena Sc F	USA	05-05-2003 to 08-05-2003	To attend IEEE International Frequency Control Symposium
Dr. A. B.Ghosh Sc F	USA	13-07-2003 to 18-07-2003	To present a paper in International conference(Solar Radiation and Climate)
Dr. K.P. Chaudhary Sc EII	Germany	17-09-2003 to 18-11-2003	Under INSA-FFG Exchange Programme
Dr. N.D. Kataria Sc F	Canada, Germany	21-07-2003 to 01-08-2003	For political inspection of model 6800 A Quantum Hall Resistance and to visit PTB Germany
Dr. B.R. Chakraborty Sc F	Germany	01-08-2003 to 30-09-2003	To Univ.of Muenstes under DAAD reinvitation Programme, 2003.
Dr. V.T. Chitnis Sc G	Japan	01-08-2003 to 31-01-2004	To avail Daiko Fellowship to work at Inst.of Technology as a visiting Professor to study the implementation of R&D development system under sabbatical leave

Name& Designation	Country Visited	Duration	Purpose
Dr. P. Banerjee Sc G	Nepal	01-09-2003 to 07-09-2003	To visit NBSM,Nepal for study prior to installation of Teleclock services.
Sh.S. K. Sharma Tech. Asstt.	Singapore	13-10-2003 to 14-10-2003	To undergo equipment Training on Advance Precision Measurement on the highly sophisticated DC Voltage divider
Dr. R.S. Dabbas Sc. F	Australia	15-10-2003 to 24-10-2003	To visit Regional warning center under the auspices of International Space environment services
Dr. Vikram Kumar Director	Iran	27-10-2003 to 28-10-2003	As a member of delegation to attend Indo Joint Meeting
Dr.Vikram Kumar Director	France and Belgium	13-10-2003 to 22-10-2003	To attend 22nd General Conf. On Weights & Measures at BIPM and to visit IMEC,Belgium
Dr. V.K. Rustagi Sc F	France	03-11-2003 to 04-11-2003	To attend BIPM Meeting
Dr. S.K. Jain Sc F	China	03-11-2003 to 06-11-2003	To attend Asia Pacific Symp.on Measurement of Mass , Force and Torque (APMF-2003)
Dr. R.B. Mathur Sc F	Belarus	30-10-2003 to 13-11-2003	Visit to Vatinel Inst.of Science under project synthesis of carbon and nano tubes and their applications in composites and hydrogen storage.
Dr. Krishan Lal Director Gr.Sc.	Thailand	13-11-2003 to 16-11-2003	To attend 2nd General Assembly ANMET
Dr. S.K. Sarkar 2003. Sc F	Brazil	17-11-2003 to 19-11-2003	To attend International Conference CLIM
Dr. N.D.Kataria Sc F	Taiwan	16-11-2003 to 20-11-2003	To attend Int.East Asia Symp.on Superconducting Electronics.
Dr. B.D. Malhotra Sc F	Japan	11-12-2003 to 13-12-2003	To attend Indo –Japan workshop on advanced molecular electronics and bionics
Dr. P.C. Kothari Sc G	Singapore	01-12-2003 to 05-12-2003	19th APMP General Assembly and TCOs Meeting and Workshop & Symposium
Sh. A.C. Gupta Sc G	Singapore	01-12-2003 to 05-12-2003	19th APMP General Assembly and TCOs Meeting and Workshop & Symposium
Dr. R.P. Singhal Sc G	Singapore	01-12-2003 to 05-12-2003	19th APMP General Assembly and TCOs Meeting and Workshop & Symposium

Name& Designation	Country Visited	Duration	Purpose
Dr.Vikram Kumar Director	Saudi Arabia	04-01-2004 to 08-01-2004	As a leader of delegation to revise and renew the ongoing SASO-CSIR Programme of Technical Cooperation
Sh.Alok Mukherjee Tech. Asstt.	Nepal	15-12-2003	To attend the adhoc meeting of SASCOM
Dr.P.Banerjee Sc G	Japan	13-01-2004 to 20-02-2004	CRL invited Research Programme.
Dr.Anil Kr.Gupta Sc G	South Korea	09-02-2004 to 11-02-2004	To attend the workshop on advanced manufacturing tech-nology organised by Korean Advanced Institute of Science & Technology (KAIST)
Dr.R.B.Mathur Sc F	USA	01-03-2004 to 31-03-2004	To work on an DST / NSF Project on application of Carbon Nano Tubes in composition alignment and adhesive problems at Clemson University
Dr. K.K.Jain Sc F	USA	01-03-2004 to 31-05-2004	To visit NIST as a Guest Researcher

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APPENDIX - 11

Ph.D. AWARDS BASED ON RESEARCH WORK DONE AT NPL

Title	Awardee	University/Institute	Guide(s)
Processing and characterisation of P-N junction based silicon solar cells	P.N. Vinod	University of Delhi	Dr. S.N.Singh, NPL Dr. R.P.Tandon, DU
Moedlling of katabatic winds over Schirmacher region of east Antarctica and prediction of impact of global warming on katabatic winds.	Ashok Kumar	Devi Ahilaya University, Indore	Dr H N Dutta, NPL Dr V B Gupta, DAU
Study of Atmospheric Parameters in relation to Antarctic ecosystem over Schirmacher region of east Antarctica	K.H. Gajananda	Guru Jambheshwar University, Hisar.	Dr. H N Dutta, NPL Anubha Kaushik, GJU
Studies on the accuracy of Timing via Satellites and Positioning via GPS	Anindya Bose	Burdwan University	Dr. P. Banerjee, NPL
Application of poly-N-vinyl carbazole poly-3-dedoecyl thiophene and poly-3-hexylthiophene Langmuir-Blodgett films to some biosensors	Rahul Singhal	Delhi University	Dr. B. D. Malhotra NPL Dr. S. Annapoorni DU

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APPENDIX - 12

HUMAN RESOURCE DEVELOPMENT ACTIVITIES

1. Participation of NPL Personnel In Various Events:

Financial support towards registration and travel cost is provided to scientists / technical staff for attending and presentation of papers at national / international seminars/symposia/conference/workshop organized elsewhere in India in areas relevant to research activities being carried out at the institute. This is primanily to enable them to put forward views on their research results and interact with the leading national/international experts on the current development in their research areas.

About 316 persons were deputed to attend various seminars/ symposia/ conference /workshop held within India: XXVI Annual Conference on Electron Microsopy and Applied Fields, held at Shimla on 16th to 18th April 2003, 5th National Symposium on Advances in Microwave and Lightwave, held at Delhi 11th to 14th October 2003, XIIth International Workshop on the Physics of Semiconductor Divices held at Chennai, 16th to 20th December, 2003, National Seminar on Fuel – Cell Material System & Accessories, held at Ahemedabad on 25th & 26th September 2003, 15th Annual General Meeting (MRSI), held at Varanasi on 9th to 11th February, 2004, XIII National Space Science Symposium NSS – 2004, held at Kottayam 17th to 20th February, 2004.

2. Training Programmes Organised:

The objective of this training programme is to impart training through class room lectures, demonstration and hands on training in the lab to participants from industrial houses as per training calendar at a nominal course fee. The internal candidates desirous of attending such Training Programmes are nominated by their divisional heads.

An in house Training Course on "Evaluation & Expression of Uncertainity in Measurements" for NPL staff with Standards & Calibration Activity was held on 5 –6 Sept., 2003.

3. Programme Attended:

(i) One person attended "IV SERC school on Numerical Weather Prediction in Tropics: Process Modelling" held from 14th April to 10th May, 2003 at IIT Delhi.

(ii) One person attended the 4th CSIR Orientation Programme held at CSIO, Chandigarh 17 – 21 November, 2003

(iii) Three persons were deputed to attend the CSIR 2nd Orientation Programme held at Lucknow from 27 – 29 Nov., 2003.

(iv) Four persons attended "ISO 9000: Awareness and Implementation Programme for CSIR" conducted by HRDC & CDC (MIN. of Science & Technology) from 29 – 30 Jan, 2004 at New Delhi.

(v) Ten persons including eight scientists attended workshop on Crafting and Winning Teams at NPL organized by HRDC, Ghaziabad, during 9th & 10th February, 2004. Mr. Ian Dean CEO, Groman Consulting International Ltd., South Africa led the workshop.

(vi) One person attended the Basic Training in Recombinent Technology DNA Technology& PCR held at Banglore from 17 – 20 February, 2004.

4. Students Training:

NPL provides training, short term (six weeks plus) and long term (three months plus),to students of various disciplines from Colleges/Universities/Engineering colleges from all over India mainly during Summer and Winter Semesters. They get acquainted with emerging research area / techniques.

131 students from various educational institutions carried out their dissertation work at NPL and undertook training towards the fulfillment of their academic work.

5. Research Fellow

Research followship (JRF/ SRF) as per the CSIR-UGC and any other departmental norms are provided for a period of five years (max.). Several new research fellows were inducted. NPL R & D facilities thus were made available to Young Researchers to help them carry out research in emerging areas leading to Ph.D. awards and fulfilling the need of developing highly skilled human resource required for the industrty as well as academic institutes.

6. Functions Organised

(i) CSIR Programme on Youth Leadership in Science (CPYLS)

The CSIR programme on Youth Leadership in Science (CPYLS) for the year 2003 was organized on 3 – 4 February, 2004 for the students who excelled in their CBSE Secondary Examination in 2003. Dr. Vikram Kumar, Director gave a brief overview of Research activities at NPL. Dr. G.K. Mehta, Vice Chancellor, Allahabad University gave a keynote lecture on "Excitements of 21st Century Science". The programme consisted of several lectures by senior scientists and visit to different R&D activities in NPL. More then 20 students participated in the programme and took part in the interactive discussions. They were awarded certificates.

(ii) The XXIX Krishnan Memorial Lecture

The Prestigious XXIX Krishnan Memorial Lecture was held at NPL on 24th Fevruary, 2004. It was delivered by Dr. Kota Harinarayana, Vice Chancellor, University of Hyderabad (Formerly, Project Director, Light Combat Aircraft, LCA). The Title was "Towards Development of Complex Systems – Issues & Challenges". The programme was well attended.

7. Visits to NPL

232 visitors consisting of post graduate / engineering student, technical teachers from about ten Institutes including I.I.T. Delhi visited different activity labs at NPL.

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APPENDIX - 13

CONFERENCES, SYMPOSIA, WORKSHOPS AND EVENTS ORGANIZED BY NPL

NPL supports with its infrastructure facilities in organization of national / international seminar / symposia at NPL in related area by various agencies / societies.

11 May, 2003

Technology Day Celebration.

25 June, 2003

Brain storming session on Ultrasonics, Health Care & Education.

17 – 19 September, 2003

The 2nd Workshop on Force Metrology in association with MSI was organised by the Force and Hardness Group at NPL from Sept 17-19, 2003. During the Workshop about 65 participants from different industries, government organisations, academic and technical institutions, etc. were provided training in a two and a half day program comprising of theoretical lectures and hands-on practical experience on Force, Torque and Hardness measurement.

23 September, 2003

A seminar was organized by Plasma Processing of Materials Group on "Plasma Processing of Advanced Materials". There were about fifty participants from various universities, institutions and industries.

26 September, 2003

Celebration of CSIR Foundation Day and NPL Open Day.

27 – 29 November, 2003

National Symposium on Radio Science in India (INCURSI-2003)

20 - 21 January, 2004

मापिकी एवं निम्नताप भौतिकी

23 January, 2004

"Quality Systems Mutual Recognition Arrangement and World Trade Organization in Present Scenario".

19 - 21 February, 2004

तृतीय अखिल भारतीय विज्ञान सम्मेलन

APPENDIX – 14

LECTURES BY EMINENT SCIENTISTS

S.N.	Name & Address	Date	Topic
1.	Dr. Joseph Shapira, Chairman, Celletra Ltd. Israel	24-04-2003	Cost effective capacity Maximization of the CDMA cellular systems
2.	Prof. Don Kenall, Emeritus Prof., University of New Mexico & CEO of Star- Mega Corporation	28-04-2003	A practical silicon- based nanotechnology from 0.6 to 5.4nm
3.	Prof. Ajeet Rohatgi, Director, University Center of Excellence for Photovoltaics, Georgia Instt. of Technology, Atlantica Drive, Georgia	05-06-2003	Recent advances in silicon solar cell technology
4.	Prof. O. N. Srivastva, Physics Department, BHU, Varanasi	11-07-2003	Emergence of nano science
5.	Dr. Y. P. Kathuria, Ritsumeikan University, Japan	29-08-2003	Laser application in micro & nanotechnology
6.	Prof. T. Venkatesan, Neocera,Inc.& University of Maryland, USA	04-09-2003	Scanning SQUID microscope for semiconductor failure analysis: A case study of technology transfer from academia to the industry.
7.	Prof. Masao Doyama, University of Tokyo Japan	19-09-2003	"My last Dream"
8.	Dr. C. N. Ramchand, Sun Pharma Company,Baroda	01-10-2003	An overview of targeted drug delivery and biotechnological applications of magnetic fluids.
9.	Dr. H. H. Weetal, U. S. Environmental Protection Agency,Las Vegas, USA	21-10-2003	The preparation and characterization of a sol-gel and polymet bound acetylcholineesterase adducts for the detection of pesticides, hermicides and nerve agents.

S.N.	Name & Address	Date	Topic
10.	Dr. Arun Madan Director, MVS Systems, USA	29-10-2003	Recent advances in thin film silicon based solar cells
11.	Dr. H. H. Weetall U. S. Environmental Protection Agency, USA	07-11-2003	Electropolymerized molecular separator electrode for electrochemical detection of 2,4 dichlorophenoxyacetic acid
12.	Dr. T. Suzuki Toyota Central Research and Development Center, Japan	11-11-2003	Surface modification of boron modified low carbon steel plates by electron beam irradiation
13.	Prof. J. M. D. Tascon, National Instt. of Carbon, Oviedo, Spain	25-11-2003	Application of scanning probe microscopies to the characterisation of microporus and mesoporous materials : strength and limitations
14.	Prof. T. Sudarshanan, South Carolina University, USA	08-12-2003	Non destructive SiC wafer characterization and new chanllenges in the fabrication of high power p-I-n diode
15.	Dr. Yogesh B. Gianchanani, University of Michigan, USA	17-12-2003	Exploring microdischarges for manufacturing and sensing applications
16.	Dr. Deepak Srivastvva, NASA AMES Centre, CA, USA	24-12-2003	Computational nanotechnology of carbon nanotubes : molecular electronics and composite materials
17.	Dr. Partha S. Dutta, Rensselaer Polytechnic Inst., Troy,New York,USA	29-12-2003	Nanoparticle synthesis of metal, semiconductor and dielectric materials and their applications
18.	Prof. A.M.Stoneham, FRS, Department of Physics and Astronomy, University College, London	15-01-2004	Exciting materials : materials modification by electronics excitings
19.	Dr. Kota Harinarayana, Vice Chancellor, University of Hyderabad	24-02-2004	Towards development of complex systems-issues and challenges

S.N.	Name & Address	Date	Topic
20.	Prof.Tamio Endo Faculty of Engineering, Mie University Japan	10-03-2004	Thin film fabrication of YBCO,LBMO double layers of YBCO/LBMO and their properties
24.	Prof. WuYang Shanghai Research Institute of Materials, China	11-03-2004	Testing and evaluation of SCC susceptibility of nuclear power materials on simulated reactor environment
25.	Prof. A. V. Rao Physics Dept. Shivaji Univ. Kolhapur	19-03-2004	Aerogels and their applications
26.	Dr. Lutz Bruggemann Germany	26-03-2004	Characterization of nano materials by SAXS

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APPENDIX – 15

INVITED TALKS, LECTURES BY NPL SCIENTISTS

Speaker's Name	Topic	Event and Venue
A. K. Agrawal	Measurement of uncertainty in chemical testing.	Bureau of Indian Standards, New Delhi, March 4, 2004.
A. K. Agrawal	Importance of certified reference materials, calibration and traceability.	Importance of Laboratory Accreditation, Kanpur, February 28, 2004
A. K. Agrawal	Inductively coupled plasma emission spectrometer.	Operation, maintenance & repair of analytical equipments, at Central Scientific Instruments Organization, February 10, 2004, New Delhi
A. K. Agrawal		National seminar on quality system, mutual recognition arrangement and world trade oganization in present indian scenario, NPL, New Delhi, January 23, 2004.
A. K. Agrawal	Measurement of uncertainty in chemical testing.	Central Pollution Control Board, Parivesh Bhawan, New Delhi December 23, 2003.
A. K. Agrawal	Evaluation of uncertainty in chemical testing.	Lakshmi Precision Screws Ltd., Rohtak (Haryana) April 26, 2003
A. K. Agrawal	Uncertainty in measurement in chemical testing.	Workshop on NABL Accreditation for Regional Sophisticated Instrumentation Centres (RSIC), New Delhi, April 9-10, 2003.
S. A. Agnihotry	Smart electrochromic windows (SECWs) for energy management	International conference on ionic devices, Nov. 28 - 30, 2003, Chennai, India
V. P. S. Awana	Magneto-superconductivity of rutheno cuprates	24th March 2004 at CGCRI, Kolkata.
B. R. Chakraborty.	Need for surface characterization and high resolution depth profiling by SIMS at NPL	IACS, Kolkata, on 28th May, 2003.

Speaker's Name	Topic	Event and Venue
B. R. Chakraborty.	Recent SIMS activity at NPL.	Muenster, Germany, 6th Aug. 2003.
B. R. Chakraborty.	Characterization of nanoscale oxide layers at the interfaces of semiconductor devices by SIMS depth profiling.	IWPSD, held at IIT-Madras, during 16-20th Dec.2003.
Harish Chander	R & D in alkaline earth sulphides for electroluminescence	International conference on luminescence and its applications (ICLA-2004), 9-12 Feb. 2004, BARC, Mumbai.
Harish Chander	R & D luminescent materials and devices at National Physical Laboratory	National conference on materials and their applications (NCMA-2004), 11-13 March 2004, Kurukshetra University, Kurukshetra.
R. S. Dabas	Ionospheric tomography	National conference on radio science in India (INCURSI-2003), NPL, New Delhi, Nov. 27-29, 2003
R. S. Dabas	Space weather effect on radio communications	ISES & Space weather conference, Boulder, USA, 18-24 May, 2003.
H. N. Dutta	New dimensions in atmospheric sciences	National conference on "Emerging environmental issues and technological challenges" Guru Jambheshwar Univ., Hisar, Sept 1-2, 2003.
H. N. Dutta	World's most efficiently coupled ice-air-ocean interactive system	Directorate of Training & Technical Education, Pitampura, New Delhi, March 4, 2004.
H. N. Dutta	Precursor of major earthquakes: new dimension in atmospheric sciences	UGC special lecture Series Program at the Department of Physics, Saurashtra University, Rajkot, March 9-10, 2004
H. N. Dutta	Fog water harvesting potential over India and its applications	UGC special lecture Series Program at the Department of Physics, Saurashtra University, Rajkot, March 9-10, 2004
H. N. Dutta	Acoustic remote sensing of atmosphere: Need to induct 3 km probing range systems in India	UGC special lecture Series Program at the Department of Physics, Saurashtra University, Rajkot, March 9-10, 2004

Speaker's Name	Topic	Event and Venue
H. N. Dutta	Antarctica: unique environment & its future	UGC special lecture series program at the Department of Physics, Saurashtra University, Rajkot, March 9-10, 2004
H. N. Dutta	PC based acoustic sounder	Christ College, Rajkot, March 10, 2004.
H. N. Dutta	Installation of earthquake precursors in Gujarat	Regional Science Centre, Saurashtra Education Foundation, Race Course, Rajkot, March 11, 2004.
H. N. Dutta	Antarctica	Regional Science Centre, Saurashtra Education Foundation, Race Course, Rajkot, March 11, 2004.
H. N. Dutta	Antarctica: Engineering needs	Directorate of Training & Technical Education, Kasturba Polytechnic Auditorium, Pitam Pura, March 16, 2004.
H. N. Dutta	Precursor of major earthquakes: new dimension in atmospheric sciences.	UGC sponsored summer school for university teachers at the Guru Jambheshwar University, Hisar, March 23, 2004.
H. N. Dutta	Antarctica:Unique environment & its future	UGC sponsored summer school for university teachers at the Guru Jambheshwar University, Hisar, March 23, 2004.
A. C. Gupta	BIPM, Mutual recognition arrangement (MRA) and implementation at NPL-India	ISAS (Indian Society of Analytical Scientists) Seminar on quality system, MRA and WTO in present Indian scenario 23rd January, 2004 at NPL, New Delhi.
P. K. Gupta	Atmospheric chemistry studies at NPL including India's initial communication (NATCOM) to the UNFCCC	Astro-particle physics and space science, at Bose institute, April 6-8, 2003, Darjeeling, W.B..
P. K. Gupta	Global climate change studies in India and its impact, GHGs emission studies from various sources with special emphasis on agriculture sector	Regional Agricultural Research Centre (RARS) of SKUAST-K in Leh, July 18, 2003.

Speaker's Name	Topic	Event and Venue
P. K. Gupta	Greenhouse gas emission studies in agriculture sector: India's national communication to UNFCCC	Institute for ocean management in the International conference on "Coastal and Freshwater Issues (COFIS) 2003", Anna University, Chennai, T.N., December 10, 2003.
P. K. Gupta	Greenhouse gas emission studies in India in relation to India's national communication to UNFCCC	University & college teachers at Dept. of Env. Sc. & Engg., GJ Univ., Hisar, Haryana. March 9-29, 2004"
P. K. Gupta	Indian ocean experiment and atmospheric brown haze: new areas for concern.	University & college teachers at Dept. of Env. Sc. & Engg., GJ Univ., Hisar, Haryana. March 9-29, 2004"
P. K. Gupta	Aerosols and trace gas emissions from Indian Agriculture Sector.	National workshop on tropical atmospheric chemistry and aerosols on March 25-26, 2004, at Physical Research Laboratory, Ahmedabad, Gujarat.
S. R. Gupta ,	"The basics of transformers and its applications"	To the students of B.Tech. Electrical Engg. of Bharti Vidyapeeth College of Engg., New Delhi-110 063 on 29 March 2004.
S. L. Jain	Measurement of vertical profiles of ozone using laser heterodyne system	National symposium on engineering optics, Dept. of Physics, CCS University, Meerut , April 6-7, 2003
S. L. Jain	Monitoring of various atmospheric parameters over Maitri, Antarctica	Annual General Body meeting of Geophysical Society of India held at NCAOR, Goa during Nov. 3-5, 2003
S. L. Jain	Atmospheric probing using laser systems.	CEP course on "Lidar Techniques and Applications" Laser Science & Technology Centre, Metcalfe House, Delhi May 7-8, 2003
S. L. Jain	Laser heterodyne systems for atmospheric probing	CEP course on "Lidar Techniques and Applications" Laser Science & Technology Centre, Metcalfe House, Delhi - 110 054 May 7-8, 2003.
S. L. Jain	Indian Antarctica Activities	CEP course on "Lidar Techniques and Applications" Laser Science & Technology Centre, Metcalfe House, Delhi - 110 054 May 7-8, 2003.

Speaker's Name	Topic	Event and Venue
H.C. Kandpal	NPL-an overview	National symposium on engineering optics at CCS University, Meerut during April 6-7, 2003
H.C. Kandpal	Applications of correlation-induced and diffraction-induced spectral changes	91st Indian Science Congress at Chandigarh during January 3-7, 2004, Punjab University, Chandigarh
Ashok Kumar	Application of ultrasonic measurement in dimensional metrology	National symposium on Acoustics (NSA-2003), Pune.
Vikram Kumar	Semiconductor devices for future computers	K V Annual PG training school, Delhi on June 7, 2003
Vikram Kumar	conduction in polymer electronic materials	NPL Seminar, Delhi on August 28, 2003
Vikram Kumar	Inaugural address related to R & D work in the area of noise pollution control, material development significant to acousticians and acoustic standards in the country	National symposium on acoustics at Pune on 31 oct.-Nov., 2003
Vikram Kumar	MEMS based sensors	ISOI symposium, Pantnagar on November 3, 2003
Vikram Kumar	Current transport in conducting polymers	IWPSD at IIT, Madras on December 16, 2003
विक्रम कुमार	व्यापार और समाज में मापिकी	मापिकी तथा निम्न ताप भौतिकी पर राष्ट्रीय संगोष्ठी जनवरी 2004
Vikram Kumar	Nanotechnology a brief overview	National Seminar on Nanotechnology at Jamia Millia Islamia, Delhi on March 11, 2004
Vikram Kumar	Progress in MEMS devices	Advances in Smart Materials at IISc, Bangalore on March 17, 2004
Vikram Kumar	Polymers for future electronics	Materials for future at IISc, Bangalore on March 22, 2004
Krishan Lal	Certified reference materials for water analysis: *Toxic metals and anions,*	*2nd General Assembly of ANMET, Bangkok*, November, 2003

Speaker's Name	Topic	Event and Venue
Krishan Lal	Certified reference materials for XRD *a-alumina powder,*	*2nd General Assembly of ANMET*, Bangkok, November, 2003
Krishan Lal	Challenges in structural characterization and long-term reliability of micro machined sensors,	Invited talk: *International Conference on Commercialization of Microsystems and Nanotechnology,* New Delhi, February 2004.
Krishan Lal	Traceability - international scenario,	*Special Lecture*: Workshop on NABL accreditation for regional sophisticated instrumentation centres, Indian Institute for Foreign Trade (IIFT), New Delhi, April 2003.
Krishan Lal	Impact of precision measurements on S & T and economic development	*General Talk: IIP Dehradun,* May 2003.
Krishan Lal	Management in R&D organizations	*Training Course for CSIR common cadre officers, HRDC, IIP Dehradun,* May 2003.
Krishan Lal	Fascinating world of crystals,	*Summer training programme,* CEI, Delhi University, Delhi, May 2003.
Krishan Lal	Recent advances in crystal physics,	*Presentation for Delhi school teachers,* Dte. of Education, Delhi May 2003.
Krishan Lal	Impact of precision measurements on S&T and economic development,	*General Talk: NIO Goa* June 2003.
Krishan Lal	Characterization of solid state devices,	*Annual Function, CEERI Pilani*, September, 2003.
Krishan Lal	Vital role of metrology in progress of science, industry, trade, and society,	*Training Course, Group III Scientists,* IICT, Hyderabad, September 2003.
Krishan Lal	Measurement, traceability and calibration: criticality in R&D,	*2nd Orientation Training Programme, Group III Scientists,* NBRI, Lucknow, 29 Nov. 2003.
Krishan Lal	High resolution X-ray diffraction studies of single crystals of technological importance,	National Seminar on *Advanced X-ray Techniques in Research and Industry (XTRI-2003), DMRL Hyderabad,* December 2003.

Speaker's Name	Topic	Event and Venue
Krishan Lal	Fascinating world of crystals,	*S. P. Suri Memorial Award Function,* Zakir Hussain College, University of Delhi, Delhi December 2003.
Krishan Lal	Recent advances in high resolution X-ray diffraction studies of crystals,	Plenary Talk: *XXXIII National Seminar on Crystallography*, NCL Pune, 10 Jan 2004.
कृष्ण लाल	अति शुद्धता पूर्ण मापन तथा अन्तर्राष्ट्रीय मानकों के साथ अटूट अनमार्गीयता	आमन्त्रित वार्ता मापिकी तथा निम्न ताप भौतिकी पर राष्ट्रीय संगोष्ठी जनवरी, 2004
Krishan Lal	MRA, traceability and certified reference materials,	Invited Talk, *ISAS Seminar on Quality System, MRA and WTO in the Present Indian Scenario*, NPL, January 2004.
Krishan Lal	Challenges in modern quality management and accreditation	*Inaugural Speech NABL Workshop,* Kanpur, February 2004.
Krishan Lal	Recent advances in growth and structural characterization of nearly perfect crystals,	*Seminar on Growth and Characterization of Nearly Perfect Crystals,* Physics Department, Jammu University, Jammu, March 2004.
R. Mehrotra	Infrared Spectroscopy Applications of IR and NIR Spectroscopy	Applications of NIR spectroscopy at CSIO Complex, New Delhi.
V. Mohanan	Fundamentals of noise controls'	Workshop on control of noise pollution from D.G. sets arranged by Gurgaon, Industrial Association on 17 May, 2003 at GIA House, Gurgaon.
V. N. Ojha	"Uncertainty in measurement and related metrological terms In seminar on practical training & importance of calibration in industries",	Organised by 'Bagson Calibration Laboratory', held at 'India International Centre', 40 Max Mueller Marg, New Delhi - 1100 03 on 19th April, 2003.
V. N. Ojha,	"Evaluation and expression of uncertainty in measurement In training-cum-workshop on uncertainty in measurement",	Orgainsed by 'Central Pollution Control Board', Ministry of Environment & Forests, Govt. of India, held at Parivesh Bhawan, East Arjun Nagar, Delhi - 110 032 on 21st May, 2003.

Speaker's Name	Topic	Event and Venue
V. N. Ojha	"Uncertainty in measurement and related metrological terms In seminar on practical training & importance of calibration in industries",	Organised by 'Bagson Calibration Laboratory', held at 'India International Centre', 40 Max Mueller Marg, New Delhi - 1100 03 on 24th May, 2003.
V. N. Ojha	"Evaluation and expression of uncertainty in measurement: A general introduction In IIQM course on ISO/IEC 17025 and uncertainty in measurement",	28-30 July 2003, held at Indian Institute of Quality Management, Jaipur.
V. N. Ojha	"Evaluation and expression on uncertainty in electrical measure-ments- A case study In IIQM course on ISO/IEC 17025 and uncertainty in measurement",	28-30 July 2003, held at Indian Institute of Quality Management, Jaipur.
V. N. Ojha,	"Uncertainty in measurement : related metrological terms In training course on evaluation and expression of uncertainty in measurement",	5-6 September 2003, held at National Physical Laboratory, New Delhi .
V. N. Ojha,	"Uncertainty in measurement : evaluation and expression In training course on evaluation and expression of uncertainty in measurement",	5-6 September 2003, held at National Physical Laboratory, New Delhi .
V. N. Ojha,	"Manual calibration and evaluation of uncertainty of high precision multifunction calibrator in DC mode In training course on evaluation and expression of uncertainty in measurement",	5-6 September 2003, held at National Physical Laboratory, New Delhi .
V. N. Ojha,	"Uncertainty in measurement : related metrological terms In one day seminar on recent trends in metrology",	12 September 2003, held at Centre for Electronics Test Engineering, Noida, under STQC Directorate, Department of Information Technology, Ministry of communications and IT, Government of India.

Speaker's Name	Topic	Event and Venue
V. N. Ojha,	"Uncertainty in measurement : evaluation and expression in one day seminar on recent trends in metrology",	12 September 2003, held at Centre for Electronics Test Engineering, Noida, under STQC Directorate, Department of Information Technology, Ministry of communications and IT, Government of India (As Invited Faculty Member).
V. N. Ojha,	"Generic development of nano-metrology for nano-technology at NPL"	In one day brain stroming on "Nanoscience and nano-technology", by National Physical Laboratory, New Delhi, 12th December 2003.
V. N. Ojha,	"Fabrication of low Tc Josephson tunnel junctions and arrays"	In seminar on 'refresher course in physics and electronics' by 'Center for Professional Development in Higher Education' (CPDHE), University of Delhi, 5-24, January, 2004, New Delhi.
V. N. Ojha,	"Establishment of low Josephson series arrays voltage standard"	In seminar on 'refresher course in physics and electronics' by 'Center for Professional Development in Higher Education' (CPDHE), University of Delhi, 5-24, January, 2004, New Delhi.
V. N. Ojha,	"Uncertainty in measurement : Related metrological terms"	In two days workshop on "Uncertainty in measurement", 19-20 February 2004, held at Centre for Electronics Test Engineering, Noida, under STQC Directorate, Department of Information Technology, Ministry of communications and IT, Government of India .
V. N. Ojha,	"Uncertainty in measurement : evaluation and expression In two days workshop on uncertainty in measurement",	19-20 February 2004, held at Centre for Electronics Test Engineering, Noida, Information Technology, Ministry of Communications and IT, Government of India .
V. N. Ojha,	"Evaluation and expression on uncertainty in electrical measure-ments- A case study Uncertainty in measurement"	19-20 February 2004, held at Centre for Electronics Test Engineering, Noida, under STQC Directorate, Department of Information Technology, Ministry of communications and IT, Government of India.
S. S. Rajput	Low voltage analog VLSI [11 lectures]	IIT Roorkee.

Speaker's Name	Topic	Event and Venue
V. K. Rustagi,	" Uncertainty in AC voltage, AC current and RF power measurements: case studies", was delivered by Mr. V. K. Rustagi in the training course on "uncertainty in measurement: case studies",	Organised at NPL during 30th April to 1st May 2004 for participants from NABL and NPL.
V. K.Sankaranarayanan	Investigation of exchange coupling in nife/femn/nife multilayers by ar ion beam surface etching	International symposium on advanced magnetic technologies, Academia Sinica, Taipei, Taiwan, Nov. 13-16, 2003.
S. K. Sarkar	Air cells characteristics related to thunder storm	Brain storming session, Indian Institute of Technology, Kharagpur, 7-18 April 2003.
	Radio climatology and its effects on communication	Bharati Vidyapeeth College of Engineering, New Delhi, 1st Oct., 2003,
A.K. Saxena	"Unceratinty in capacitance measurement: case study"	Delivered in Training course on "uncertainty in measurements: case studies" organised by NPL for NABL and NPL participants at NPL on 30th April and 1st May 2004.
Rina Sharma	Evaluation of uncertainty in gauge block calibration Evaluation of uncertainty in the temperature related calibration	Uncertainty in measurement and ISO 17025 on July 2003 at IIQM, Jaipur. NIO, Goa during November, 2003.
Rina Sharma	Temperature standards and calibration on International Temperature Scale, 1990 (ITS-90)	January 22, 2004 during the training of participants from industries at Regional Testing Centre, Okhla, New Delhi.
Rina Sharma	New techniques for temperature measurement and calibration of temperature measuring instruments on ITS-90	March 18, 2004 during the training of participants from industries and laboratories at Regional Testing Centre, Okhla, and New Delhi.
Ramadhar Singh	Polymers : charge transport mechanism and applications	4th Asian meeting on ferroelectrics (AMF-4) held at MRC, IISc Bangalore, Dec. 12-15, 2003
Ramadhar Singh	Conducting polymers : charge transport and its applications	Centre for P D H E, University of Delhi, Delhi, Jan.23, 2004
S. N. Singh	Solar photovoltaics - a clean source of energy	Ambedker College of Agri. Engg., Etawah (U.P.), February 28, 2004

Speaker's Name	Topic	Event and Venue
V. R. Singh	"Future directions in ultrasonics and an invited talk on Piezo-Electric MEMS"	National Symposium on Ultrasonics, Amritsar, Nov.3-5, 2003.
V. R. Singh	'National status of metrology for manufacturing of sophisticated health care systems"	All India Seminar on Advances in Metrology for Manufacturing Technology, organized by Instn of Engineers (India) held at CMERI, Durgapur, on February 7-8, 2004.
V. R. Singh	"Mathematical modelling of thermal profile in brain tumour under focussed ultrasound"	Int. Conf. on Mathematical Biology (ICMB), organised at IIT-Kanpur on Feb. 19-21, 2004.
V. R. Singh	"Nano-biomedical sensors"	'Workshop on Bioinformatics Tools in Biology Research', AMU, Aligarh, March 9-10, 2004.
V. R.Singh	"Smart sensors and nano-devices"	Jan 22, 2004 at G.G.D.S.D. College, Palwal (Haryana)
V. R.Singh	"Emerging trends in piezoelectric and piezoresistive sensor technology"	CEP Course on 'Advanced Sensor Technologies', Feb 9-13, 2004.
V. R.Singh	"Role of R & D Institutes in the promotion of higher technical education"	Forecast in Higher Technical Education, Patiala, Feb, 2004.
V. R.Singh	"Role of IT in the upliftment of socially and physically challenged communities in India"	A Seminar organised by WDC on March 25-26, 2004.
V. R.Singh	"Advances in nano-bioinstrumentation systems for bioinformatics research"	IETE 35th Mid Term Technical Symposium, Nagpur, April 3-4, 2004.
V. R.Singh	"Advances in diagnosis of biological tissues"	2nd Int. Conf. on Diagnostic Procedures & Techniques, IIT-Madras, Chennai, April 1-3, 2004.
V. R.Singh	"Standardisation and calibration of biomedical equipment"	Seminar organized by Metrology Society of India and Weigh India, on December 27, 2004 at New Delhi.
V. R.Singh	"Smart sensors and nano piezo-electric devices"	13th National symposium on Ultrasonics on December 21-23, 2004 at Jhansi.

Speaker's Name	Topic	Event and Venue
R. P. Singhal	माप तोल व समय मापन विज्ञान कार्यक्रम	All India Radio direct Relay-Phone-in-Programme on Delhi A Indraprashta Channel at 366.3 MHz 9:20 am to 10 am on 28 June, 2003.
R. P. Singhal	Evaluation of uncertainty in mass measurements.	In-house training course on evaluation and expression of uncertainty in measurement, 5-6 Sep., 2003 at NPL.
R. P. Singhal	Recent developments at NPL India	TCL workshop, during APMP 19th General Assembly, organised by Asia Pacific Metrology Programme with SPRING Singapore at Singapore, Dec. 1- 5, 2003.
R. P. Singhal	Practical training and importance of calibration in industries,	India International Centre, New Delhi on April 19,2003, Organized by Bagson Calibration Lab, Delhi.
R. P. Singhal	Beginner's guide for evaluation of measurement of uncertainty	On 27 June, 2003 at Faridabad organizd by Beltz Instrumens(I) Ltd ,Faridabad.
R. P. Singhal	Characterization of proficiency testing	10 July 2003 at Kolkatta, organized by CII,New Delhi.
R. P. Singhal	Dimensional metrology: measurements, relevant to industrial principle of metrology	36th International training program on standardization, quality assurance and management systems for developing countries, 22 Oct. 2003, at BIS, New Delhi.
R. P. Singhal	Traceability in measurements	National awareness seminar on traceability in measurement process, 14 Feb. 2004 at Bangalore organized by CII, Institute of Quality, Bangalore.
R. P. Singhal	Laboratory report of NPL India	APMP 19th General Assembly, Dec 1-5, 2003, organised by Asia Pacific Metrology Programme with SPRING Singapore at Singapore.
Ram Swarup	"Estimation of uncertainty in attenuation & impedance measurement at HF and microwave frequencies – A case study"	In-House training course on evaluation and expression of uncertainty in measurement, organized by NPL, New Delhi, 5 – 6 Sept. (2003).

Speaker's Name	Topic	Event and Venue
Ram Swarup,	"Precision measurement at microwave frequencies",	Invited Lecture delivered at Workshop -cum-Symposium on *Microwave Applications in Medicine, Remote Sensing and Industry* (MA:MRSI-2K4), Solid State Physics Laboratory, Lucknow Road, Delhi-110007, 20 - 21 Feb. (2004)
P. N. Vijaykumar	Virtual instrumentation in research and industry	National symposium on instrumentation (NSI-28) held at G.B. Pant university of agriculture and technology, Pant Nagar, Uttaranchal, 3-5 Nov. 2003.
P. N. Vijaykumar	Phased array signal processing	Instrumentation department, Indian Institute of Science, Bangalore, 26 Dec. 2003.
Sanjay Yadav	Manual computations of hydraulic pressure generated / measured by reference hydraulic pressure standard	April 6, 2003 at NMCL, SASO, Saudi Arabia.
Sanjay Yadav	Manual computations of pressure and associated uncertainties during calibration of digital pressure calibrator.	April 13, 2003 at NMCL, SASO, Saudi Arabia.
Sanjay Yadav	Evaluation of effective area and associated uncertainties in pressure metrology.	April 28, 2003 at NMCL, SASO, Saudi Arabia.
Sanjay Yadav	Pressure metrology: concept, theory and practice	Jan. 23, 2004 at RTC, Okhla, New Delhi.
Sanjay Yadav	Calibration of pressure measuring instruments	Jan. 23, 2004 at RTC, Okhla, New Delhi.
Sanjay Yadav	New techniques for pressure measurements	March 16, 2004 at RTC, Okhla, New Delhi.
Sanjay Yadav	Calibration of pressure measuring instruments and their associated uncertainties	March 16, 2004 at RTC, Okhla, New Delhi.
K. S. Zalpuri	Short and long term processes affecting the conc. of GHGs, aerosols, fog/smog radiations and their impact	National level brain storming session on aerosols, minor constituents & radiations in Bangalore, 22 April 2003.

❑❑❑❑❑

APPENDIX – 16

HUMAN RESOURCE

As on March 31, 2004

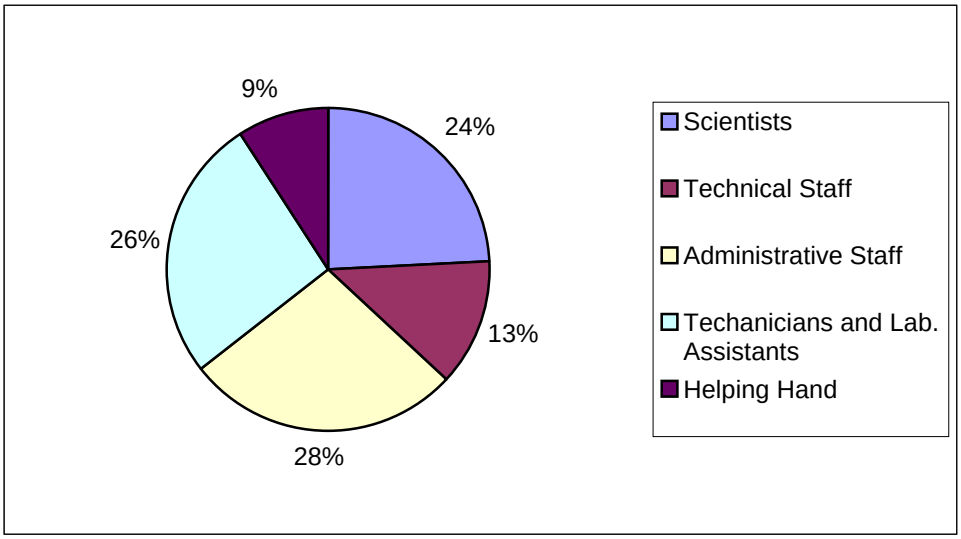
GROUP IV	
Director	1
Sci (Dir Grd)	1
Scientist G	11
Scientist F	81
Scientist EII	65
Scientist EI	21
Scientist C	24
Scientist B	15
	219

GROUP III	
TO (EII)	1
TO (EI)	7
Exe. Engg.	1
Assist. Exe. Engg.	3
TO (C)	23
TO (B)	40
TO (A)	15
STA	9
Junior Engg.	2
Tech. Asst. VIII	14
	115

GROUP II	**239**

GROUP I	**83**
ADMN-A	8
ADMN-B	87
ADMN-C	55
ADMN-D	97
	247

Grand Total	**903**



Scientists and Officers *as on 31.03.2004*

Name	Designation	Decision Package
	Physico-Mechanical Standards	
	Head : Dr Raghunandan Prasad Singhal	
Dr Raghunandan Prasad Singhal	Scientist G	OLP0002
Sh Akhilesh Chandra Gupta	Scientist G	OLP0006
Sh Tripurari Lal	Scientist F	OLP0001
Sh S Uma Maheshwar Rao	Scientist F	OLP0002
Dr Hem Chandra Kandpal	Scientist F	OLP0004
Dr Kamlesh Kumar Jain	Scientist F	OLP0005
Dr Sushil Kumar Jain	Scientist F	OLP0005
Dr Ashis Kumar Bandhyopadhyay	Scientist F	OLP0006
Dr Desh Raj Sharma	Scientist F	OLP0006
Dr Bibhash Ranjan Chakraborty	Scientist F	OLP0055
Dr Pardeep Mohan	Scientist F	OLP0006
Dr Om Prakash	Scientist F	OLP0053
Dr Vellur Mohanan	Scientist F	OLP0007
Dr Bhim Sain Gera	Scientist F	OLP0007
Dr Jnanendra Nath Som	Scientist F	OLP0008
Dr Ashok Kumar	Scientist F	OLP0009
Dr Rakesh Kumar Garg	Scientist F	OLP0004
Sh Omkar Sharma	Scientist F	OLP0007
Sh Mati Lal Das	Scientist EII	OLP0001
Sh Ganga Prasad	Scientist EII	OLP0001
Dr V G Kulkarni	Scientist EII	OLP0002
Sh K P Chaudhary	Scientist EII	OLP0002
Dr Yesh Pal Singh	Scientist EII	OLP0003
Sh Navin Kumar Srivastava	Scientist EII	OLP0003
Dr Devinder Gupta	Scientist EII	OLP0004
Dr Miss Ranjana Mehrotra	Scientist EII	OLP0004
Sh Jagdish Kumar Dhawan	Scientist EII	OLP0005

Name	Designation	Decision Package
Sh Anil Kumar	Scientist EII	OLP0005
Sh Raj Singh	Scientist EII	OLP0008
Sh Mukesh Chandra	Scientist EII	OLP0009
Sh Subodh Kumar Singhal	Scientist EII	OLP0011
Dr Sanjeev Sinha	Scientist EI	OLP0001
Sh Mrityunjay Karfa	Scientist EI	OLP0002
Dr (Mrs) Rina Sharma	Scientist C	OLP0002
Dr S Seela Kumar Titus	Scientist C	OLP0005
Sh D Arun Vijayakumar	Scientist C	OLP0006
Dr (Miss) Nita Dilawar	Scientist C	OLP0006
Dr Sanjay Yadav	Scientist C	OLP0006
Dr Mahavir Singh	Scientist C	OLP0007
Sh Rajesh Kumar	Scientist C	OLP0005
Sh Gautam Mandal	Scientist B	OLP0001
Sh Virendra Babu	Tech Ofcr (EII)	OLP0008
Mrs Veena Roonwal	Tech Ofcr (EI)	OLP0002
Sh N K Aggarwal	Tech Ofcr (EI)	OLP0002
Sh B K Roy	Tech Ofcr (EI)	OLP0002
Sh Satish Kumar Nijhawan	Tech Ofcr (EI)	OLP0003
Sh Ravi Khanna	Tech Ofcr (C)	OLP0002
Sh S L Thind	Tech Ofcr (C)	OLP0002
Sh Jagdish Kumar Gupta	Tech Ofcr (C)	OLP0003
Sh Jai Bhagwan	Tech Ofcr (C)	OLP0004
Sh T K Parameshwaran	Tech Ofcr (B)	OLP0001
Sh V K Ojha	Tech Ofcr (B)	OLP0007
Mrs Reeta Gupta	Tech Ofcr (B)	OLP0009
Dr Yudhisther Kumar Yadav	Tech Ofcr (B)	OLP0009
Sh Gurcharanjit Singh	Tech Ofcr (A)	OLP0003
Sh Gurbir Singh	Tech Ofcr (A)	OLP0007
Sh Ishwar Singh Taak	Tech Ofcr (A)	OLP0008
Sh Gurdeep Singh Lamba	Tech Ofcr (A)	OLP0011
Sh Bhikham Singh	Tech Ofcr (A)	OLP0010

Name	Designation	Decision Package
	Electrical & Electronic Standards	
	Head : Dr Prafulla Chandra Kothari	
Dr Prafulla Chandra Kothari	Scientist G	OLP0021
Dr P Banerjee	Scientist G	OLP0012
Dr Ved Ram Singh	Scientist G	OLP0023
Dr V T Chitnis	Scientist G	OLP0024
Dr Amitava Sengupta	Scientist F	OLP0012
Dr G M Saxena	Scientist F	OLP0012
Dr Ashok Kumar Hanjura	Scientist F	OLP0012
Dr Vijay Narain Ojha	Scientist F	OLP0015
Sh Mukesh Kumar Mittal	Scientist F	OLP0016
Dr Sita Ram Gupta	Scientist F	OLP0017
Dr Omkar Nath	Scientist F	OLP0018
Sh Vijay Kumar Rustagi	Scientist F	OLP0019
Sh Anil Kumar Govil	Scientist F	OLP0019
Dr Ram Swarup	Scientist F	OLP0020
Dr Surender Kumar Mahajan	Scientist F	OLP0022
Dr N D Kataria	Scientist F	OLP0014
(Mrs) Arundhati Chatterjee	Scientist EII	OLP0012
Sh Vijay Kumar	Scientist EII	OLP0013
Sh Anil Kishore Saxena	Scientist EII	OLP0018
Sh Ritander Aggarwal	Scientist EII	OLP0019
Sh Pramendra Singh Negi	Scientist EII	OLP0020
Dr R K Kotnala	Scientist EII	OLP0021
Dr Ramesh Babu Tripathi	Scientist EII	OLP0023
Sh Mitthan Lal	Scientist EII	OLP0024
Dr Neeraj Khare	Scientist EII	OLP0013
Dr (Mrs) Santa Chawla	Scientist EI	OLP0012
Sh Ajeet Singh	Scientist EI	OLP0015
Sh Naib Singh	Scientist EI	OLP0018

Name	Designation	Decision Package
Dr Ranjit Singh	Scientist EI	OLP0020
Dr Mansha Ram	Scientist EI	OLP0024
Sh Joges Chandra Biswas	Scientist EI	OLP0016
Dr Harikrishna Singh	Scientist C	OLP0014
Sh Man Mohan Krishna	Scientist C	OLP0013
Sh Chockalingam Sreekumar	Scientist B	OLP0012
Dr Ashish Agarwal	Scientist B	OLP0012
Sh Shiv Kumar Jaiswal	Scientist B	OLP0017
Sh Anil Kumar Suri	Tech Ofcr (C)	OLP0012
Mrs Asha Rani Kaushik	Tech Ofcr (C)	OLP0018
Sh Mohammad Saleem	Tech Ofcr (B)	OLP0018
Sh Kul Bhushan Ravat	Tech Ofcr (B)	OLP0022
Sh G K Kapoor	Tech Ofcr (B)	OLP0024
Sh S K Rastogi	Tech Ofcr (B)	OLP0024
Sh Avdhesh Kumar Goel	Tech Ofcr (A)	OLP0018
Sh Jagan Nath Prasad	Tech Ofcr (A)	OLP0024
Mrs Shashi Lekha Bhatnagar	Tech Ofcr (A)	OLP0024

Engineering Materials

Head : Dr Anil Kumar Gupta

Dr Anil Kumar Gupta	Scientist G	OLP0025
Dr Sukhwant Singh Bawa	Scientist G	OLP0028
Dr Sukhmal Chand Jain	Scientist G	OLP0029
Dr Gopal Bhatia	Scientist F	OLP0026
Dr Rakesh Behari Mathur	Scientist F	OLP0026
Dr R K Aggarwal	Scientist F	OLP0026
Dr Tarsem Lal Dhami	Scientist F	OLP0026
Dr (Mrs) Vasantha Raman	Scientist F	OLP0026
Dr Bhanu Pratap Singh	Scientist F	OLP0025
Dr M N Kamalasanan	Scientist F	OLP0028
Dr Satish Chandra Kant Mishra	Scientist F	OLP0028

Name	Designation	Decision Package
Dr Ashok Manikrao Biradar	Scientist F	OLP0028
Dr Chhatra Pal Sharma	Scientist F	OLP0028
Dr Suresh Chand	Scientist F	OLP0028
Sh Subhash Chandra Gera	Scientist F	OLP0052
Dr Bansi Dhar Malhotra	Scientist F	OLP0028
Sh Surendra Singh Verma	Scientist F	OLP0052
Sh Ramesh Chandra Anandani	Scientist EII	OLP0025
Dr Rajeev Chopra	Scientist EII	OLP0025
Dr Ajay Dhar	Scientist EII	OLP0025
Dr Chhotey Lal	Scientist EII	OLP0026
Dr Sunil Kumar Singhal	Scientist EII	OLP0025
Dr Krishan Kumar Saini	Scientist EII	OLP0028
Dr R K Sharma	Scientist EII	OLP0028
Dr S K Dhawan	Scientist EII	OLP0028
Dr Tushya Kumar Saxena	Scientist EI	OLP0028
Sh Sudhanshu Dwivedi	Scientist EI	OLP0028
Sh Sanjay Rangnate Dhakate	Scientist EI	OLP0026
Dr R G Mathur	Scientist B	OLP0025
Sh Ashok Kumar	Scientist B	OLP0052
Sh Islamuddin Anwar Malik	Tech Ofcr (EI)	OLP0025
Sh Rajiv Sikand	Tech Ofcr (C)	OLP0025
Sh K D Sharda	Tech Ofcr (C)	
Sh Rakesh Khanna	Tech Ofcr (B)	OLP0025
Sh Pinaki Ranjan Sengupta	Tech Ofcr (B)	OLP0026
Sh Gauri Datt Sharma	Tech Ofcr (B)	OLP0028
Sh Chander Kant	Tech Ofcr (B)	OLP0028
Sh Mohan Chandra Singh	Tech Ofcr (A)	OLP0052

Electronic Materials

Head : Dr Shiv Nath Singh

Dr Shiv Nath Singh	Scientist F	OLP0032
Dr Janardan Singh	Scientist F	OLP0034

Name	Designation	Decision Package
Dr Virendra Shanker	Scientist F	OLP0030
Dr Harish Chander	Scientist F	OLP0030
Dr Prakash Narain Dixit	Scientist F	OLP0031
Dr Amitabha Basu	Scientist F	OLP0033
Dr Mohan Lal	Scientist F	OLP0032
Dr S T Lakshmikumar	Scientist F	OLP0033
Dr Srikant N Ekbote	Scientist F	OLP0034
Dr (Mrs) S A Agnihotry	Scientist F	OLP0033
Dr Ramadhar Singh	Scientist F	OLP0033
Dr Bidhan Chandra Chakravarty	Scientist F	OLP0032
Dr Parakram Kumar Singh	Scientist F	OLP0032
Dr S M Shivaprasad	Scientist EII	OLP0043
Sh Sher Singh Rajput	Scientist EII	OLP0031
Dr Omvir Singh Panwar	Scientist EII	OLP0031
Dr (Mrs) Meenakshi Kar	Scientist EII	OLP0033
Dr (Mrs) Kiran Jain	Scientist EII	OLP0033
Dr K M K Srivatsa	Scientist EI	OLP0031
Dr Narinder Kumar Arora	Scientist EI	OLP0034
Sh C M S Rauthan	Scientist EI	OLP0031
(Mrs) Santosh Singh	Scientist C	OLP0033
Dr V K Sankaranarayanan	Scientist C	OLP0033
Dr T D Senguttuvan	Scientist C	OLP0034
Dr Amish G Joshi	Scientist C	OLP0043
Dr Divi Haranath	Scientist B	OLP0030
Dr Sushil Kumar	Scientist B	OLP0031
Dr Shailesh Narayan Sharma	Scientist B	OLP0033
Dr (Ms) Gurusharan Kaur Padam	Scientist B	OLP0034
Sh Ravi Kumar	Tech Ofcr (C)	OLP0032
Sh M K Banerjee	Tech Ofcr (C)	OLP0034
Sh N C Soni	Tech Ofcr (B)	OLP0034

Name	Designation	Decision Package
Sh Tarun Kumar Chakraborty	Tech Ofcr (B)	OLP0033
Sh T K Bhattacharya	Tech Ofcr (B)	OLP0033
Sh Mukul Sharma	Tech Ofcr (B)	OLP0034
Sh Vipin Kumar Singhal	Tech Ofcr (A)	OLP0033
Sh Murari Lal Sharma	Tech Ofcr (A)	OLP0033

Materials Characterization

Head : Dr S. K. Gupta

Dr S K Gupta	Scientist F	OLP0038
Dr R V Anantha Murthy	Scientist F	OLP0042
Dr Sujit Kumar Halder	Scientist F	OLP0042
Dr Godavarthi Bhagavannarayana	Scientist F	OLP0042
Sh Har Prakash Narang	Scientist F	OLP0044
Dr Ram Kishore	Scientist F	OLP0040
Dr Arun Kumar Agrawal	Scientist F	OLP0041
Sh Prabhat Kumar Gupta	Scientist EII	OLP0037
Dr (Miss) Rashmi	Scientist EII	OLP0039
Sh Kasturi Lal	Scientist EII	OLP0040
Dr Rajendra Prasad Pant	Scientist EI	OLP0039
Dr (Mrs) S Niranjana Goswami	Scientist EI	OLP0042
Sh Sukhvir Singh	Scientist EI	OLP0040
Dr Avanish K Srivastava	Scientist C	OLP0040
Dr Nahar Singh	Scientist B	OLP0037
(Mrs) Prabha Johri	Scientist B	OLP0037
Dr Kamlesh Kumar Maurya	Scientist B	OLP0042
Sh Niranjan Singh	Tech Ofcr (B)	OLP0037
Sh M K Dasgupta	Tech Ofcr (B)	OLP0037
Dr (Miss) Manju Arora	Tech Ofcr (B)	OLP0038
Dr Dharam Pal Singh	Tech Ofcr (B)	OLP0039
Sh Kedar Nath Sood	Tech Ofcr (B)	OLP0040

Name	Designation	Decision Package
Sh Rajiv Kumar Saxena	Tech Ofcr (B)	OLP0041
Sh V K Hans	Tech Ofcr (B)	OLP0043
Mrs Abha Bhatnagar	Tech Ofcr (A)	OLP0041

Radio & Atmospheric Sciences

Head : Dr M. K. Tiwari

Dr M K Tiwari	Scientist F	OLP0046
Sh Satish Chand Garg	Scientist G	OLP0047
Dr Sohan Lal Jain	Scientist F	OLP0046
Dr P K Banerjee	Scientist F	OLP0047
Dr P N Vijayakumar	Scientist F	OLP0047
Dr Lakha Singh	Scientist F	OLP0045
Dr Swapan Kumar Sarkar	Scientist F	OLP0045
Dr Raj Singh Dabas	Scientist F	OLP0045
Dr Mahendra Kumar Goel	Scientist F	OLP0045
Dr Hirday Nath Dutta	Scientist F	OLP0046
Dr Pradeep Kumar Pasricha	Scientist F	OLP0046
Dr Kanwar Sushil Zalpuri	Scientist F	OLP0048
Dr S D Sharma	Scientist F	OLP0047
Dr M S V N Prasad	Scientist F	OLP0045
Dr Bhuwan Chandra Arya	Scientist F	OLP0046
Dr Harish Bahadur	Scientist EII	OLP0046
(Mrs) Madhu Bahl	Scientist EII	OLP0047
Sh H K Maini	Scientist EII	OLP0047
Sh Thomas John	Scientist EII	OLP0047
Sh Vijay Kumar Vohra	Scientist EII	OLP0047
Sh Pattamatta Subrahmanyam	Scientist EII	OLP0045
Sh Narendra Kumar Sethi	Scientist EII	OLP0045
Dr Vijay Kumar Pandey	Scientist EII	OLP0045
(Mrs) Parvati Chopra	Scientist EII	OLP0045

Name	Designation	Decision Package
Sh Deo Raj Nakra	Scientist EII	OLP0046
Dr Mahendra Mohan	Scientist EII	OLP0046
Dr Radhe Shyam Arora	Scientist EII	OLP0046
Dr Risal Singh	Scientist EII	OLP0046
Sh C B Tandel	Scientist EI	OLP0047
Dr Jayanta Kar	Scientist EI	OLP0046
Dr (Mrs) Meena Jain	Scientist EI	OLP0046
Sh Randhir Singh Tanwar	Scientist EI	OLP0046
Dr Sachidanand Singh	Scientist C	OLP0047
Dr Tuhin Mandal	Scientist C	OLP0046
Sh Sher Singh	Scientist B	OLP0047
Sh K G M Pillai	Tech Ofcr (C)	OLP0047
Sh Iqbal Ahmed	Tech Ofcr (C)	OLP0047
Sh Vishram Singh Yadav	Tech Ofcr (B)	OLP0047
Sh Ramesh Kohli	Tech Ofcr (B)	OLP0047
Sh Dhan Singh Chaunal	Tech Ofcr (B)	OLP0047
Sh Dharam Bir Sharma	Tech Ofcr (B)	OLP0045
Mrs Shiv Kumari Bhatia	Tech Ofcr (B)	OLP0045
Sh Arun Kumar Ghoghar	Tech Ofcr (B)	OLP0046
Sh Shambhu Nath	Tech Ofcr (B)	OLP0046
(Mrs) Beena Gupta	Tech Ofcr (A)	OLP0047
Sh Man Mohan Gupta	Tech Ofcr (A)	OLP0047

Superconductivity & Cryogenics

Head : Dr Hari Kishan

Dr Hari Kishan	Scientist F	OLP0049
Sh Rajan Babu Saxena	Scientist F	OLP0051
Sh B V Kumaraswamy	Scientist F	OLP0049
Sh Pratim K Dutta	Scientist EII	OLP0049
Dr S K Agarwal	Scientist EII	OLP0049

Name	Designation	Decision Package
Dr (Miss) P L Upadhyay	Scientist EII	OLP0049
Dr Ratan Lal	Scientist EII	OLP0049
Sh Umesh Chandra Upreti	Scientist EII	OLP0049
Dr B V Reddi	Scientist EII	OLP0049
Dr Veerpal Singh Awana	Scientist C	OLP0049
Sh M A Ansari	Scientist C	OLP0051
Dr Anurag Gupta	Scientist C	OLP0049
Sh S B Samanta	Tech Ofcr (C)	OLP0049

Director's Office

Head : Dr Vikram Kumar

Dr Vikram Kumar	Director	Infrastructure
Dr (FNA) Krishan Lal	Sci (Dir Grd)	OLP0042
Sh Rama Shankar Singh	Tech Ofcr (EI)	Infrastructure

Library

Head : Dr S M Dhawan

Dr S M Dhawan	Scientist F	STS0001
Sh Deepak Kumar Tewari	Scientist EII	STS0001
Sh N K Wadhwa	Scientist C	STS0001
Sh Hasan Haider	Tech Ofcr (C)	STS0001
Sh Jagdish Prasad	Tech Ofcr (B)	STS0001

Scientific Support Services

Head : Sh. C S Prasannakumar

Sh C S Prasannakumar	Scientist G	STS0004
Dr P K Ashwinikumar	Scientist F	STS0004
Sh S K Chakladar	Scientist F	STS0008
(Mrs) Indra Tiwari	Scientist EII	OLP0024
(Mrs) Shikha Mandal	Scientist EII	STS0008

Name	Designation	Decision Package
Sh Narinder Kumar Babbar	Scientist EII	STS0005
Dr D P Bhatt	Scientist EII	STS0004
Dr (Miss) Jyoti Lata Pandey	Scientist EII	STS0005
Sh Sushil Kumar Sharma	Scientist EII	STS0009
Sh Tushar Kanti Chakravarty	Scientist EI	STS0004
Sh Mohinder Kumar Chhibber	Tech Ofcr (C)	STS0005
Sh V D Arora	Tech Ofcr (B)	STS0004
Sh Ashwani Kumar Suri	Tech Ofcr (B)	STS0009
Sh Vinod Kumar Sharma	Tech Ofcr (A)	STS0008

Technical Support Services

Head : Dr Jagdish Chandra Sharma

Sh Jagdish Chandra Sharma	Scientist EII	STS0010
Sh I P Singh	Exe. Engg.	STS0013
Sh Subhash Chandra	Tech Ofcr	STS0015
Sh Dharamjit Singh	Asst. Exe. Engnr.	STS0013
Sh V K Singh	Asst. Exe. Engnr.(Civil)	STS0013
Sh Deepak Bansal	Tech Ofcr (B)	STS0010
Sh Prabhu Shankar Tripathi	Tech Ofcr (A)	STS0010

Workshop & GTU

Head : Sh. H N P Poddar

Sh H N P Poddar	Scientist F	STS0016
Sh Ram Sarup	Tech Ofcr (C)	STS0016

Central Computer Facility

Head : Dr Ravi Mehrotra

Dr Ravi Mehrotra	Scientist F	STS0018
(Ms) Deepti Chaddha	Scientist B	STS0018
Sh Kanwaljit Singh	Tech Ofcr (B)	STS0018
Sh Vijay Sharma	Tech Ofcr (A)	STS0018
Sh Ashok Kumar	Tech Ofcr (A)	STS0018

Name	Designation	Decision Package
Not Reporting		
Sh V K Gogia	Scientist C	
Sh S K Gupta	Scientist C	

Administration & House Keeping

Head : Sh. R. P. Sharma

Administration, Accounts, Stores & Purchase

Sh R P Sharma	COA	Infrastructure
Sh B S Rawat	Dy Fin. Advicer	Infrastructure
(Mrs) Saroj Dhingra	Sr F & AO	Infrastructure
Sh Brijesh Sharma	SPO Gr. I	Infrastructure
Sh Lila Dhar	Admn. Ofcr	Infrastructure
Dr (Mrs) Shakuntala Sharma	Sr Hindi Officer	Infrastructure
Sh Lakhpat Singh	Sr Security Ofcr	Infrastructure
Sh Vijay Kumar	Sr Security Ofcr	Infrastructure
Sh Kuldeep Kaushik	Dy Str & Pur Ofcr	Infrastructure
Sh S N Gupta	Dy Str & Pur Ofcr	Infrastructure
Sh S Seelan	SO (F&A)	Infrastructure
Sh Hankolin Chongloi	SO (F&A)	Infrastructure
Sh Satish Kumar	SO (F&A)	Infrastructure
Sh R K Gaur	SO (F&A)	Infrastructure
Sh Subhash Chander	SO(G)	Infrastructure
Sh Bal Krishna	SO(G)	Infrastructure
Sh D K Salone	SO(G)	Infrastructure
(Mrs) Vandana Digvijaya Singh	SO(G)	Infrastructure
Sh B K Singh	SO(G)	Infrastructure
Sh Chhering Tobden	SO(G)	Infrastructure
(Ms) Beena Anupa Kullu	SO(G)	Infrastructure
(Mrs) Paramjit Kaur	PS	OLP0002
(Mrs) Santosh Khanna	PS	OLP0009
Sh R K Bhasin	PS	OLP0046
Sh Mange Ram	PS	OLP0051
Sh Shish Ram	PS	Infrastructure

RETIRED PERSONS

Mrs Shashi Kala Suresh Shastri, Tech Ofcr (EI)
Sh J M Jolly, Dy Str & Pur Ofcr
Mrs Priyadarshini, Workshop Asstt II
Sh Biram Singh, Jr Sec Grd (ACP)
Sh Ravi Mohan Khanna, Scientist F
Sh Gurdial Singh, Tech Ofcr (B)
Sh Nathu Singh, Workshop Asstt VII
Sh F C Khullar, Scientist F
Dr Raghunath Bhattacharyya, Scientist G
Sh Surjit Singh, Sr Mech Asstt
Sh M M Tara, Technician VIII
Sh Pooran Singh, Technician VIII
Sh Sukhpal Singh, Workshop Asstt VII
Dr Ajit Kumar Sarkar, Scientist F
Sh Sham Lal Sharma, Tech Ofcr (C)
Sh Karnail Singh, Tech Ofcr (C)
Dr Ashok Kumar Gupta, Scientist G
Sh Ram Lal Mishra, Sr Mech Asstt
Mrs S A Joseph, PS
Sh Bhupinder Singh, Techanician VIII
Mrs Mithlesh Saxena, Scientist EII
Sh Jaspal Singh, Sr Mech Asstt
Sh Jagdev Singh, Workshop Asstt VII
Sh Manohar Lal, Sr Mech Asstt
Sh Om Prakash Arora, Sr Mech Asstt

OBITUARIES

Sh Raj Bahadur Dhuria, Technician VII
Sh Raj Singh, Technician VIII
Dr D K Suri, Scientist F
Dr Asit Baran Ghosh, Scientist F
Sh Ramesh Ram, Technician VII
Sh Dev Dutt Sharma, Security Guard
Sh Vinod Kumar Rajpal, UDC (ACP)
Sh Satpal Singh, Technician VII

SCIENTIST FELLOW & EMERITUS SCIENTISTS

Dr A P Mitra, Hony Scientist of Eminence
Dr A V Narlikar, Emer. Scientist
Dr B S Mathur, Emer. Scientist
Dr K K Mahajan, Emer. Scientist
Dr O P Bahl, Emer. Scientist
Dr P K Ghosh, Emer. Scientist
Dr Subhas Chandra, Emer. Scientist
Dr Vikram Soni, UGC Res. Scientist
Dr Govind, Res. Scientist

RESEARCH ASSOCIATES

Sh Neeraj Panwar, JRF
Km Kavita Arora, JRF (CSIR)
Km Monika Gupta, JRF (CSIR)
Km Sarabjeet Kaur, JRF (CSIR)
Sh Vikram Sen, JRF (CSIR)
Sh Bhupendra Singh, JRF (CSIR)
Sh DwiJendra Pratap Singh, SRF (CSIR)
Sh Jitendra Kumar, JRF (CSIR)
Sh Praveen Kumar Singh, JRF (CSIR)
Kumari Priyanka, JRF, PhD
Sh Rajeev Kumar Singh, JRF, PhD
Dr Y Aparna, P.I.
Sh Rahul Singhal, Prov.Res.Assoc.
Dr Daya Soni, RA
Dr Mitali Shah, RA
Dr S P Singh, RA
Dr Sippy Calra Chauhan, RA
Dr Suman Anand, RA
Dr. Nirmalaya Karar, RA
Sh Anand Kumar Dwivedi, RA
Sh Raj Kishore Sharma, RA
Sh Ravinder Pratap Singh, RA
Dr Umendra Kumar, RA
Km Meena Jain, Res. Intern
Km Rashmi Arora, Res. Intern
Km Rashmi Nigam, Res. Intern
Km Sushri Parul, Res. Intern
Sh Jitendra Kumar, Res. Intern
Sh Manish Sharma, Res. Intern
Sh Nitesh, Res. Intern
Sh Nitin Sharma, Res. Intern
Sh Prasun Ganguli, Res. Intern
Sh Radhish Kumar, Res. Intern

Sh Raghav Gandotra, Res. Intern
Sh Rohit Rathore, Res. Intern
Sh Rupesh M Das, Res. Intern
Sh Vishesh Kaul, Res. Intern
Dr Govind, Research Sci
Mohd. Dilshad, Research Sci
Dr B. Vinadhari, SRA (Pool)
Kumari Amita Varma, SRF
Kumari Pooja Sharma, SRF
Kumari Shampa Chaudhari, SRF
Sh Amit, SRF
Sh Bhaskar Gahtori, SRF
Sh P Tyagrajan, SRF
Sh R Nagrajan, SRF
Sh Radhey Shyam Rai, SRF
Sh Ravinder Singh Parmar, SRF
Sh Anil Kumar Thakur, SRF (CSIR)

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APPENDIX – 17

RESEARCH COUNCIL AND MANAGEMENT COUNCIL OF NPL

RESEARCH COUNCIL

(01.04.2003 - 31.12.2003)

Name	Status
Prof V S Ramamurthy Secretary, Department of Science & Technology, Technology Bhawan, New Mehrauli Road, **NEW DELHI - 110 016**	**Chairperson**
Dr. Girish S Agarwal Director Physical Research Laboratory **AHMEDABAD – 380 009.**	**Member**
Dr. D.D.Bhawalkar Director Centre for Advanced Technology **INDORE – 452 013 (M.P.)**	**Member**
Prof S Dattagupta, FNA, FA Sc, FNA Sc Director, S N Bose National Centre for Basic Sciences, Block - JD, Sector III, Salt Lake, **KOLKATA - 700 098** (WB)	**Member**
Dr. S K Sikka Scientific Secretarty Office of the Principal Scientific Adviser to the Govt. of India Vigyan Bhavan Annexe Maulana Azad Road **New Delhi – 110 011.**	**Member**

Name	Status
Dr. S. M. Chitre Dept. of Astronomy and Astrophysics Tata Institute of Fundamental Research **MUMBAI – 400 005.**	**Member**
Sh. Nirmal Singh, IAS Director General Bureau of Indian Standards Manak Bhawan **NEW DELHI – 110 002.**	**Member**
Dr. O. P. Agarwal Head Research Planning & Business Development (RPBD) Council of Scientific & Industrial Research Anusandhan Bhawan 2 Rafi Marg **NEW DELHI – 110 001.**	**Member** DG's Nominee
Dr. S Ahmad Director Central Electronics Engineering Research Institute **PILANI – 333 031 (Rajasthan)**	**Member** Sister Lab
Dr. Krishan Lal (Dr Vikram Kumar) Director, National Physical Laboratory, Dr K S Krishnan Marg, **NEW DELHI - 110 012**	**Member**
Dr. V T Chitnis Scientist-in-Charge Planning, Monitoring & Evaluation Group National Physical Laboratory, Dr K S Krishnan Marg, **NEW DELHI - 110 012**	Non-Member Secretary

RESEARCH COUNCIL AND MANAGEMENT COUNCIL OF NPL

RESEARCH COUNCIL

(01.01.2004 - 31.03.2006)

Name	Status
Prof V S Ramamurthy Secretary, Department of Science & Technology, Technology Bhawan, New Mehrauli Road, **NEW DELHI - 110 016**	**Chairman**
Prof Ajay Kumar Sood, FNA, FASc, FTWAS Division of Physical and Mathematical Sciences, Dept of Physics, Indian Institute of Science, **BANGALORE - 560 012**	**Member**
Prof G K Mehta Vice Chancellor, University of Allahabad, Senate House, **ALLAHABAD - 211 002**	**Member**
Prof S Dattagupta, FNA, FA Sc, FNA Sc Director, S N Bose National Centre for Basic Sciences Block - JD, Sector III, Salt Lake, **KOLKATA - 700 098** (WB)	**Member**
Dr M J Zarabi Chairman & M D, Semiconductor Complex Ltd., Sector 72, Near Chandigarh **S A S Nagar – 160 071** (Punjab)	**Member**
Dr Satish Kaura Chairman & Managing Director, SAMTEL Colour Ltd., 52, Community Centre, New Friends Colony, **NEW DELHI - 110 065**	**Member**

Name	Status
Prof S Bhattacharya Director, Tata Institute of Fundamental Research, (TIFR) Homi Bhabha Road, Colaba, **MUMBAI - 400 005**	**Member**
Prof N Kumar Director & Professor of Physics, Raman Research Institute, C V Raman Avenue, Sadashivanagar, **BANGALORE - 560 080**	**Member**
Sh B A Mylar Rao Chairman-Cum-Managing Director, Central Electronics Ltd., 4, Industrial Area, **SAHIBABAD - 201 010**	**Member**
Dr H S Maiti Director, Central Glass & Ceramic Research Institute, 196 Raja S C Mullick Road, **KOLKATA - 700 032**	**Member** Sister Lab
Dr O. P. Agarwal Head, RPBD, Council of Scientific & Industrial Research, Anusandhan Bhawan, 2 Rafi Marg, **NEW DELHI - 110 001**	**Member** DG's Nominee
Dr Vikram Kumar Director, National Physical Laboratory, Dr K S Krishnan Marg, **NEW DELHI - 110 012**	**Member**
Sh C. S. Prasanna Kumar Scientist 'G' & Head, Scientific Support Services & PME National Physical Laboratory, Dr K S Krishnan Marg, **NEW DELHI - 110 012**	**Secretary**

Management Council

(01.04.2003 - 30.06.2003)

Name of the Member	Status
Dr. Krishan Lal (Dr Vikram Kumar) Director NPL	Chairman
Dr, S. C. Garg Scientist G NPL	Member
Dr. Mahavir Singh Scientist C NPL	Member
Dr R. P. Pant Scientist EI NPL	Member
Dr. (Ms.) Ranjana Mehrotra Scientist EII NPL	Member
Dr. S. B. Samanta TO-C NPL	Member
Dr. S. N. Joshi Scientist G CEERI, Pilani	Member
Dr. T. K.Chakraborty Scientist EI NPL	Member
Sr. F. & A. O. (SG)/Sr. F. & A. O./F. & A. O. NPL	Member
Sr. C. O. A./C. O. A./A. O. NPL NPL	Member-Secretary

Management Council

(01.07.2003 - 31.03.2004)

Name of the Member	Status
Dr. Vikram Kumar Director NPL	Chairman
Dr Anil Kumar Gupta Scientist G NPL	Member
Dr M K Tiwari Scientist F NPL	Member
Dr V N Ojha Scientist F NPL	Member
Dr (Ms) Nita Dilawar Scientist C NPL	Member
Ms Deepti Chadha Scientist C NPL	Member
Sh K G M Pillai Tech Ofcr 'C' NPL	Member
Sh C S Prasanna Kumar Sc G, Head, PME NPL	Member
Sr. F. & A. O. (SG)/Sr. F. & A. O./F. & A. O. NPL	Member
Sr. C. O. A./C. O. A./A. O. NPL NPL	Member-Secretary

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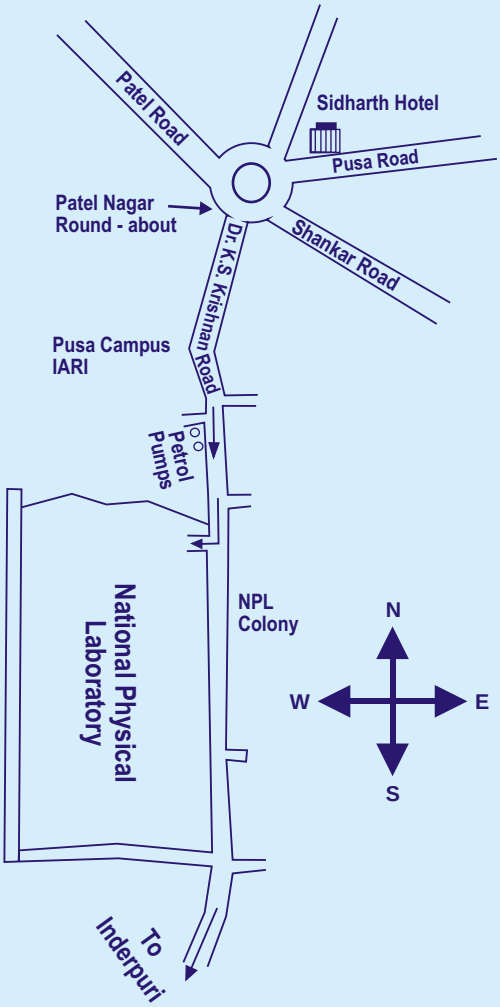
Important nearby landmarks

- *Sidharth Hotel*
- *Pusa Campus*



Distances from NPL

New Delhi Railway Station	:	06 km
Delhi Railway Station	:	09 km
Indira Gandhi International Airport :		
Domestic (Terminal I)	:	11 km
International (Terminal II)	:	19 km
I.S.B.T.	:	08 km
Connaught Place	:	05 km

Director :

Dr Vikram Kumar

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Monday to Friday
Working Hours
9.00 a.m. to 5.30 p.m.

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NATIONAL PHYSICAL LABORATORY, NEW DELHI

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