वार्षिक प्रतिवेदन
ANNUAL REPORT
1994 - 95

राष्ट्रीय भौतिक प्रयोगशाला
National Physical Laboratory
New Delhi

CONTENTS

Director's Report

We feel pleasure in presenting through this Annual Report for the year 1994-95, the achievements and progress made by NPL in basic research, development of technologies and other activities.

In addition to the useful calibration work in the area of standards, improvements were made in the measurement systems as well as techniques. For example, a compact and integrated electronic servo control system is designed for reliable frequency stabilized He-Ne/I_2 laser. In the field of force measurements the 6 MN hydraulic multiplication machine was installed and an old U.T.M. has been suitably converted into a force calibration machine of 50 KN capacity. Similarly, photometric and radiometric calibration activities were also up graded. In the electrical measurements area NPL has developed in principle a peak voltmeter. A low cost ultrasonic power meter, based on measurements of radiation pressure has been designed and fabricated. The standard time & frequency service broadcast was continued and several user applications of STFS were carried out. AIR started using STFS for generation and synchronisation of the hourly pips. The Rubidium isotopic filter cells and lamp bulbs were developed.

Research and development work in the field of materials development was continued which included the work on silicon devices, interface micro-structure devices, Display Devices, liquid crystals, sol-gel processed materials, Bio-sensors, conducting polymers, carbon products, thin film systems,metals & alloys. In the field of gas sensing devices metal-oxide based thin film catalytic combustion sensors have been developed. Another exciting development in this area is the fabrication of polymeric semiconductive thin films for carbon monoxide gas sensing with increased sensitivity.

Substantial progress has been made in the development of solid state electrochromic devices (ECD) for display applications. Further the photoreceptor plates developed at NPL have been tested on the mamography machine in a Delhi Hospital. The results are very encouraging. Conducting polymeric filters have been developed and are under testing at AIIMS New Delhi for monitoring of viruses in water.

The work on characterisation of different kinds of materials was continued. Characterisation of materials play a major role in evaluating their usefulness in scientific and technological applications. Various techniques have been applied for this purpose in NPL for evaluating composition, purity, structure, and perfection in organometallic compounds, carbon fibres and electronic materials. Techniques including chemical methods, FTIR spectroscopy, EPR spectroscopy, x-ray diffraction techniques and electron microscopy etc. were used. Different kinds of crystals were grown and studied for their characteristics. A five-crystal x-ray diffractometer, designed and developed at NPL, has been used for study of crystalline perfection. Also, preparation of Indian Reference materials was continued and two new reference materials viz nickel and fluoride in high purity water have been prepared. Radio-science is yet another major field in which the laboratory continued the work. The activities in this area include International

Geosphere Biosphere Programme, MST Radar, Microbarograph, Satellite Radio Beacon studies, Indian Antarctic Research Programme, Sross Aeronomy measurement & Radio communications. RWC (New Delhi) continued to cater to the needs of a large number of users. Three microbarograph units were fabricated. An aeronomy experiment was also continued in space, SROSS-C2, a 114 Kg satellite was launched from SHAR range of ISRO by the ASLV-D4 satellite. This experiment was successfully performed on 4th May 1994.

NPL continued R & D work in low temperature physics too. Superconductivity has been an integral constituent of this area. Superconducting magnet and a Liquid Helium Dewar was developed at NPL for a 100 MHZ NMR spectrometer. Consultancy was provided by NPL to a prototype 200 KVA superconducting generator.

NPL continued active collaboration with research organisations, educational institutions, industries, Public sectors and various governmental organisations. Several projects were under taken during the year under sponsorship from DST, CEERI, Indo-French, DRDO, DBT, NRDC, MNES and DOE etc.

A number of processes were released to industry for commercial exploitation including Blood Glucose sensors, Activated carbon fibre cloth, Graphite tapes and Sheets and piston Gauge pressure standards etc.

In the academic field, fifteen candidates were awarded Ph.D. and one M.S. Degree for their work done in NPL. About a dozen candidates from different organisations were trained in different fields of science. NPL scientists published more than one hundred and fifty papers and about one dozen research reports in leading national and international journals. Several distinguished visitors from Scientific Community delivered lectures at NPL.

I have a great pleasure in congratulating some of our scientists for their outstanding work in science for which they have been honoured. Dr. A.V. Narlikar was awarded "Khosla National Award-1994", of the university of Roorkee, Dr. K.K. Mahajan won "Shri Om Prakash Bhasin Award", Dr. S.K. Sharma was elected as the president of Electron microscope society of India, Dr. Ved Ram Singh was elected as a Fellow of the "Indian College of Medical Ultrasound". Dr Harish Bahadur received the "National unity Award for Excellence" and Sh. S.U.M. Rao got 'Phillips Award' for the best electron micrograph.

This year as a whole was successful with major achievements in the field of Science and technology which has encouraged us. Redeployment of scientific and technical staff was meaningfully done for their maximum utilisation to serve the industries, laboratories and hence the nation to the utmost utility.

Hoping for a fruitful future.

E R Gopal

(E.S.R. Gopal)

निदेशकीय प्रतिवेदन

1994-95 के इस वार्षिक प्रतिवेदन द्वारा राष्ट्रीय भौतिक प्रयोगशाला में मूल अनुसंधान, प्रौद्योगिकी विकास तथा अन्य गतिविधियों में प्रयोगशाला की उपलब्धियों और तथा प्रगति का ब्यौरा देते हुए हमें बहुत प्रसन्नता का अनुभव हो रहा है।

मानकों के क्षेत्र में उपयोगी सहयोगात्मक कार्य के अतिरिक्त मापन निकायों के साथ-साथ तकनीकों भी सुधार किए गए। उदाहरण के लिए भरोसेमंद आवृत्ति स्थाईकृत He-Ne/I_2 लेज़र के लिए एक कॉम्पेक्ट तथा एकीकृत इलैक्ट्रॉनिक सर्वो नियंत्रित सिस्टम का डिज़ाइन तैयार किया गया है। बल मापन के क्षेत्र में 6 MN की एक हाइड्रालिक मल्टीप्लिकेशन मशीन की स्थापना की गई तथा एक पुरानी UTM को उपयुक्त रूप से 50 KN क्षमता वाली बल अंशांकन मशीन के रूप में परिवर्तित कर लिया गया। इसी प्रकार प्रकाशमितीय और विकिरणमितीय अंशांकन गतिविधियों को भी अपग्रेड किया गया। विद्युत मापों के क्षेत्र में प्रयोगशाला ने सिद्धांत रूप में एक पीक वोल्टमीटर का विकास किया है। विकिरण दाब के माप पर आधारित एक कम दाब वाले पराश्रव्य पावर मीटर का डिज़ाइन और निर्माण भी किया गया। ऑल इंडिया रेडियो ने हर घंटे पर प्रसारित होने वाली पिप ध्वनि करने और उसके तुल्यकालन के लिए STFS का इस्तेमाल आरम्भ कर दिया। रुबीडियम आइसोटोपीय फिल्टर सैलों तथा लैम्प बल्बों का विकास किया गया।

पदार्थों के विकास के क्षेत्र में अनुसंधान एवं विकास का कार्य जारी रहा जिसमें सिलिकॉन साधनों, इंटरफेस माइक्रोस्ट्रक्चर साधनों पर कार्य सम्मिलित है। इस दिशा में एक अन्य विचारोततेजक क्षेत्र पॉलिमर अर्धचालकीय तनुपरतों का है जिनका उपयोग कार्बन मोनॉक्साइड गैस का बहुत सुग्राहितापूर्वक पता लगाने में किया जा सकता है।

प्रदर्श साधनों में इस्तेमाल के लिए सॉलिड स्टेट इलैक्ट्रोक्रोमिक साधनों के क्षेत्र में भी काफी प्रगति हुई है। इसके अतिरिक्त प्रयोगशाला में विकसित फोटोरिसेप्टर प्लेटों पर दिल्ली के एक अस्पताल में मैमोग्राफी मशीन पर परीक्षण किया गया। पानी में वायरसों की उपस्थिति का पता लगाने के लिए चालक पॉलिमर फिल्टरों का विकास किया गया है। इनके परीक्षण का कार्य भारतीय आयुर्विज्ञान संस्थान नई दिल्ली में चल रहा है।

विभिन्न प्रकार के पदार्थों के अभिलक्षणन का कार्य जारी रहा। वैज्ञानिक तथा औद्योगिक इस्तेमाल के लिए पदार्थों की उपयोगिता का मूल्यांकन करने में पदार्थों के अभिलक्षणन का कार्य महत्वपूर्ण भूमिका निभाता है। राष्ट्रीय प्रयोगशाला में ऑर्गेनोमेटैलिक यौगिकों, कार्बन रेशों और इलैक्ट्रॉनिक पदार्थों की संरचना, शुद्धता, संयोजन तथा दोषहीनता का मूल्यांकन करने के लिए अनेक तकनीकों का इस्तेमाल किया गया है। रासायनिक विधियों, एफ.टी.आई.आर. स्पेक्ट्रमिकी ई.पी.आर. स्पेक्ट्रमिकी, एक्स किरण विवर्तन तकनीक तथा इलैक्ट्रॉन सूक्ष्मदर्शिकी आदि तकनीकों का इस्तेमाल किया गया। विभिन्न प्रकार के क्रिस्टलों का वर्धन करके उनके अभिलक्षणों का अध्ययन किया गया। राष्ट्रीय भौतिक प्रयोगशाला में ही डिज़ाइन तथा विकसित किए गए एक पंच क्रिस्टल एक्स किरण विवर्तन मापी का इस्तेमाल करके क्रिस्टलीय दोषहीनता का अध्ययन किया गया। भारतीय निर्देशक द्रव्यों को तैयार करने का कार्य जारी रहा और दो नए निर्देशक द्रव्यों अर्थात निकेल तथा फलोराइड को अति शुद्ध पानी में तैयार किया गया। रेडियो विज्ञान विभाग एक अन्य ऐसा क्षेत्र है जिसमें प्रयोगशाला ने कार्य

जारी रखा। इस क्षेत्र में सम्मिलित गतिविधियॉ इस प्रकार हैं: अंतर्राष्ट्रीय भूमंडल जीवमंडल कार्यक्रम, एम एस टी रेडार, सूक्ष्म दाब लेखी उपग्रह रेडियो बीकन अध्ययन, भारतीय एंटार्कटिक अनुसंधान कार्यक्रम, स्रौस बायविकी मापन तथा रेडियो संचार। आर डब्लू सी नई दिल्ली अनेक उपयोक्ताओं की जरूरतों को पूरा करने का कार्य करता रहा। अंतरिक्ष में एक वायविकी प्रयोग भी किया गया। ASLV-D4 उपग्रह द्वारा ISRO के SHAR क्षेत्र से SROSS-C2, एक 114 किलोग्राम का उपग्रह भी छोड़ा गया। यह प्रयोग सफलतापूर्वक सम्पन्न हुआ।

राष्ट्रीय भौतिक प्रयोगशाला ने निम्न ताप भौतिकी के क्षेत्र में भी कार्य जारी रखा। अतिचालकता इस क्षेत्र का एक अभिन्न अंग है। 110 मैगा हर्ट्ज के NMR स्पैक्ट्रममापी के लिए अतिचालक चुम्बक तथा द्रव देवार का राष्ट्रीय भौतिक प्रयोगशाला में विकास किया गया। प्रयोगशाला द्वारा 220 kVA के एक अतिचालक जनित्र के आदीप्ररुप के लिए सलाहकार सेवा भी दी गई ।

इस प्रयोगशाला ने अनुसंधान संगठनों, शैक्षिक संस्थाओं, उद्योगों, तथा सार्वजनिक और सरकारी क्षेत्र की अनेक संस्थाओ से सक्रिय सहयोग बनाए रखा। DST, CEERI, भारत-फ्रेंच, DRDO, DBT, NRDC, MNES, तथा DOE से प्रायोजित कई परियोजनाएं भी इस वर्ष ली गई।

अनेक प्रक्रियाएं, व्यापारिक रुप से इस्तेमाल के लिए उद्योगों को दी गई जिनमें रक्त ग्लूकोज सेसंर, सक्रियित कार्बन रेशों से बने कपडे, ग्रेफाइट के फीते तथा चादरें तथा पिस्टन गेज दाब मानक आदि सम्मिलित है।

शैक्षिक क्षेत्र में, इस प्रयोगशाला में गत वर्ष के कार्य के आधार पर 15 अभयर्थियों को पी. एचडी. तथा एक को एम.एस. की उपाधि दी गई। विभिन्न संगठनों के एक दर्जन अभ्यर्थियों को विज्ञान के विभिन्न क्षेत्रों में प्रशिक्षित किया गया। प्रयोगशाला के वैज्ञानिकों ने देश विदेश के प्रतिष्ठित जर्नलों में एक सौ पचास से अधिक पत्र तथा लगभग एक दर्जन अनुसंधान पत्र प्रकाशित किए।

वैज्ञानिक समुदाय के अनेक विशिष्ट आगंतुकों ने राष्ट्रीय भौतिक प्रयोगशाला में व्याख्यान दिए।

विज्ञान के क्षेत्र में विशिष्ट योगदान के लिए प्रयोगशाला के कुछ वैज्ञानिकों का मैं हार्दिक अभिनंदन करता हूँ। इनमें डा. ए. वी. नार्लीकर को रुड़की का "खोसला नेशनल अवार्ड - 1994" प्रदान किया गया, डा. के. के. महाजन ने "श्री ओम प्रकाश भसीन" पुरस्कार जीता, डा. एस. के. शर्मा को इल्कैट्रॉन माइक्रोस्कोपी सोसाइटी ऑफ़ इंडिया का अध्यक्ष चुना गया, डा. वेद राम सिंह को फॅलो ऑफ इंडियन कॉलेज ऑफ़ अल्ट्रासांउड चुना गया, डा. हरीश बहादुर को "नेशनल यूनिटी अवार्ड फॉर एक्सीलेंस" तथा श्री एस. यू. एम. राव ने सर्वश्रेष्ठ इलैक्ट्रॉन माइक्रोग्राफ के लिए "फिलिप्स अवार्ड" प्राप्त किया।

कुल मिला कर यह वर्ष सफल रहा जिसमें विज्ञान तथा प्रौद्योगर्की के क्षेत्र में बहुत सी उपलब्धियों मिलीं जिनसे हमारा उत्साह बढ़ा है। वैज्ञानिक तथा तकनीकी कर्मचारियों को नए-नए कार्यो पर लगाया गया जिससे उनकी क्षमताओं का पूरा उपयोग करके उद्योगों, प्रयोगशालाओं तथा देश की भरपूर सेवा की जा सके।

सफल भविष्य की आशाओं सहित।

ई एस राजा गोपाल

(ई एस आर गोपाल)

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

1. Length

A compact and integrated electronic servo control system is designed for reliable frequency stabilized He-Ne/I_2 laser. The system includes the servo control electronic power supplies, saw tooth generator and storage oscilloscope. The laser-rod cavity structure of the He-Ne/I_2 laser has been redesigned and improved to make a very stable system. The computer was interfaced with the He-Ne laser system and the cavity was scanned using saw tooth from the computer. The photoelectronic output was converted into digital signals by A/D cards and the laser gain curve was observed for the first time on the computer video display unit. The gain curve recorded on the computer screen is used to compute an inverted gain curve and the intersection point for locking. The difference between the gain curve and its inversion is used for frequency stabilisation at the point of intersection of the two gain curve. Stability of 3×10^{-9} is demonstrated.

The conventional mask aligner is modified using PZT controllers and alignment optics and the lithography is performed using the technique developed by us. A new method for automatic alignment starting from placement accuracy to submicron accuracy have been demonstrated. The coarse alignment is obtained by a coarse pitch grating and the final submicron alignment is obtained by fine pitch (25 um) gratings. Optoelectronic noncontact gap sensor was demonstrated by using just one grating and a reflecting surface and obtaining gap sensitive moire signal.

Laser Doppler velocity meter feasibility experiment was set up with Ar laser and a rotating disc. The HP laser interferometer is hooked up with computer and the length measurement data acquisition as well as data processing is done automatically with the help of a suitable software package. The system can be very conveniently used at site with the help of a notebook computer.

2. Dimensional Metrology

About 813 calibration certificates were issued to different organisations and efforts are being made to modernize the calibration facility in accordance with the latest State-of-Art and to meet the requirements of industry in view of the enforcement of ISO : 9000 Quality Systems. The following steps were initiated in this direction :-

- Installed computerized Gauge Block Testing unit 826 E
- Acquired compatible sets of reference grade gauge block sets for direct comparision of gauge blocks in range of 0.5 to 100 mm. and 0.05 to 4 inch and length bars in range of 200 to 1000 mm.

  This reduced the time of calibration of gauge blocks and improved the measurement uncertainty.
- Initiated renovation of calibration laboratory to maintain the requisite environmental conditions and thus high quality of measurement.

1,3,8,40 and 100 mm gauge blocks were measured interferometrically by 10 standards laboratories in the world. The results reported by NPL, were within 30 nm for gauge upto 40 mm and 80 nm for 100 mm gauge which was within half the tolerance limits specified in ISO : 3650.

MASS

An automatic computer controlled set-up for solid standard density measurement has been set up. Primary solid density standard was obtained from P.T.B. Germany. Transfer solid density standard is being generated in N.P.L. for various applications. Relative standard deviation in density measurement of 3 ppm has been obtained.

FORCE

A 6MN (Compression) cum 3MN (Tension and Compression) Hydraulic Multiplication System for the calibration of Force Proving Devices has been received from PTB, Germany. The installation of the loading frame of 6 MN machine has been completed. An old U.T.M. has been suitably converted into a force calibration machine of 50 KN Capacity by using a high sensitive strain gauge type load cell as a transfer standard.

PRESSURE AND VACUUM

1. Pressure

The piston gauge pressure standard is designed and fabricated to measure hydraulic pressure upto 80 MPa. The complete indigenous has several unique features like the pressure is generated by ram screw without any priming pump, the hanging weight carrier provides long floating time and to shut off the input and output pressure by the two independent isolation valves. The standard can measure the pressure with an accuarcy of better than 0.03 MPa to 80 MPa. This can serve as reference pressure standard in the quality control laboratory of industrial organizations.

Detailed dielectric dispersion studies of Bismuth Germanium oxide at different temperatures ranging from 290-310 K and applied hydrostatic pressures upto 550 MPa gives the low temperature (60 ppm/K) and high pressure (100 ppm/Pa) coefficient of permitivity. These values are far superior over the values typically 260 ppm/K and 35 ppm/Pa observed in case of Ca F2.

2. Vacuum

The SRG denoted by NPL-I which had been calibrated in Jan/Feb. 1994 at NPL was taken to IMGC, Torino and was calibrated on the dynamic expansion system for two different gases, argon and helium. The measurements with this gauge have been found to be in close agreement with the measurements performed in 1987 both at IMGC, and NPL. This exercise has been useful to arrive at the long term performance of this transfer standard.

A high vacuum system based on a diffusion pump-rotary pump combination with a liquid nitrogen trap has been designed and set up. The system has been equipped with a SRG, and a CDG both of them calibrated aganist the primary standards of the Group. The system thus set up will be helpful in performing faster calibrations of the user gauges.

3. Surface Physics

Auger Electron Spectroscopy (AES) and Electron Loss Spectroscopic (ELS) techniques were used to observe valence-band features of molybdenum in its pure state and its oxidation and silicidation. The auto-ionization process is exploited in probing the d-band occupancy manifested in t ıe AES α ELS spectra. The change in the valence band related transitions, like the auto-ionization feature, the MNN Auger transition and the p-d quasi atomic transition in the ELS are used to explain the charge transfer in the ionically bonded oxide and the dominantly covalent silicide. Angle dependent X-ray photoelectron Spectroscopy (ADXPS) was used to study the growth mode of thermally evaporated Ag on Si (001) surface from fractions of monolayer

to several monolayers. Anisotropy of photoelectron emission due to X-ray photoelectron diffraction (forward scattering effect) shows structural modifications induced by Ag adsorption. The data suggests that annealing upto about 860 K induces agglomeration of Ag into large Islands and an irreversible redistribution of Ag on Si atoms at higher temperatures.

Secondary Ion Mass Spectrometry (SIMS) was used to study stainless steel (SS) samples used as anode in the sputter ion pumps (SIP). Four SS anode samples (supplied by M/s Varian, Torino, Italy) operated at different conditions of pressure α anode-cathode potentials were studied. The depth profilings show a very thin film of same thickness deposited on the two samples operated at 10^{-9} mbar N_2 Pressure at 3KV α 7KV, while the thickness of the film deposited on a samples operated at 10^{-7} mbar pressure at 7KV is approximately twice than that obtained at 3KV for the same pressure. This study may help to define the working parameters for sputter ion pumps.

TEMPERATURE

Work on Aluminium fixed point was initiated, and after several Experimental runs. Aluminium Temperature Standard has been established at NPL.

Further improvements were made in Tin Point Furance, resulting in stable and long duration plateaus.

One standard platinum resistance thermometer, range O-630° C, supplied to M/s BHEL, Madras. Also one triple point of water cell was made.

Two more heat pipe extension baths were fabricated to improve stability of low temperature automated baths, range - 80° C to 95° C.

Calibration work of glass thermometer, thermocouples, optical pyrometers, SPRTs, RID's and other digital temperature measuring instruments was undertaken. As many as 689 test reports were issued to industry. This has sufficiently increased the revenue earning.

OPTICAL RADIATION

This is a continuing project of the laboratory. During the year the facilities of photometric and radiometric measurements have been upgraded through PTB assistance. The entire set of working standards for luminous flux have been recalibrated using goniophotometric technique. The newly set up facilities for spectral irradiance calibration have been used by space research organization for calibration of their spectroradiometers and sources.

Work on basic research relevant to optical measurement is being continued.

INFRARED RADIATION

A variable angle transmittance accessory to match the optics of the spectrophotometer was designed and got fabricated. Preliminary measurements on the spectral transmittance of the reflectance standards at normal as well as oblique angle of incidence were taken and the experimentally determined transmittance values were compared with those derived from their reflectance values both at normal and oblique angle (10° to 70°) of incidence. Thus, the performance of the fabricated variable angle transmittance accessory was ascertained and the spectral transmittance values measured with the accessory were assured for their correctness. These standards were evaluated for their reproducibility and probable uncertainties by studying the effect of environmental variations and aging.

Four infrared scanners of different types from industries were calibrated for their responsivity. The testing and evaluation of

"filters for watching total solar eclipse" were carried out in 2.5 to 25 μm spectral region. The data thus obtained were analyzed to ascertain the performance of the filter and the correct thickness of the metalization for the filter to be harmless.

ULTRAVIOLET RADIATION

There is a great demand of accurate measurement of ultraviolet radiation emitted from artificial sources such as high pressure xenon lamps, high pressure mercury lamps, electric and welding arcs,uv lasers etc. in the industrial environment and work place. In this direction experimental facilities have been created for the relative measurement of spectral energy distribution of radiation sources transmission measurement of uv filters and welding glasses and solar eclipse shades and spectral response measurement of uv detectors in 200 - 400 nm spectral regions. These facilities have been extended to industries and academic institutions to solve their uv measurement problems. We are in the process of creating the quantitative measurement facilities for the above parameters for uv sources, detectors and filters and also setting up the uv radiometric scale at selected wavelengths.

Two numbers of calibrated uv radiation source system have been initiated to be supplied to user institutions.

ACOUSTICS

Study was carried out in respect of auditorium chair sound absorption under reverberant conditions. The chairs were arranged under different configuration in order to find out the effect of their placement on the measured RT values in the chamber.

Light weight Autoclaved Aerated Concrete (ACC) bricks of varying thickness were evaluated for their sound insulation properties as per Indian Standard Specifications. In order to obtain better TL values, they

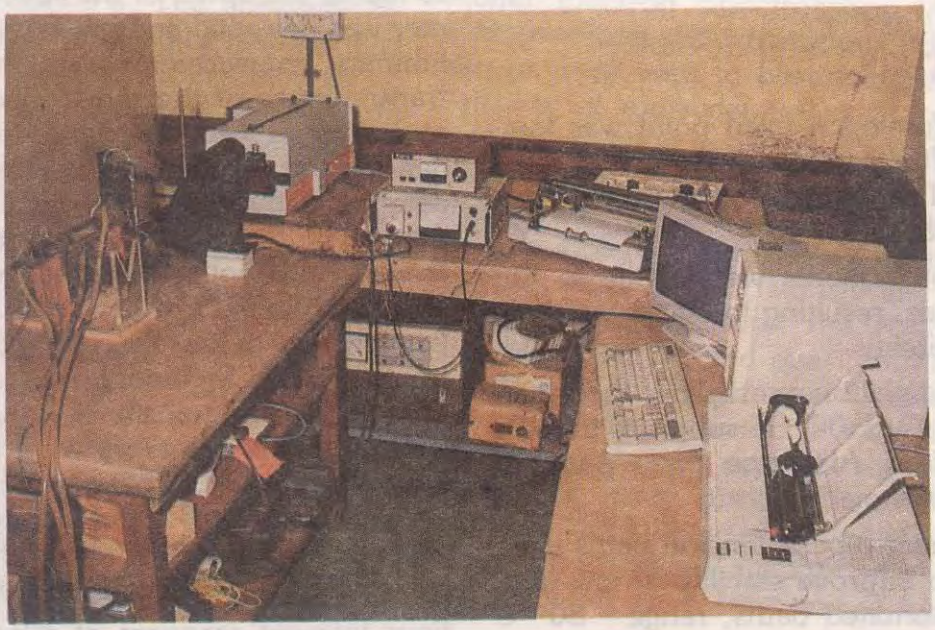

Fig. 1 Experimental setup for the relative measurement of uv radiation

were to be tested under double-leaf mounting conditions. Initial results were encouraging and more than 5 dB TL was obtained for the double-leaf construction. Acoustic Evaluation of Built-up Areas was done in respect of :

IG Indoor Stadium to check the suitability of conducting a European Concert for M/s. Delhi Symphony Society.

Rashtrapati Bhavan to check the noise and vibration levels due to a newly installed A/C System in the basement from human comfort and structural safety point of view.

Sodar Studies

(a) A 32-element acoustic array antenna was designed and evaluated to deter mine optimum frequencies of operation of a Doppler Mini Sodar.

(b) Work on development of software for Dispersion Modelling for air pollution using Sodar data and creation of data bank of sodar data of various stations throughout the country were initiated.

Also field performance of 4 ft x 2 ft. parabolic with dish antenna was made for possible use in Doppler Mini Sodar at centre frequencies of 2.2 kHz, 3.5 kHz, 4.5 kHz and 6 kHz.

(c) PCB miniaturisation of tone burst and receiver cicuits were made and its field performance was carried out for PC based sodar system. Also an additional satge with 6 dB gain was added in the receiving stage to obtain improved S/N ratio.

(d) The following sub-systems were also developed in respect of Doppler Mini Sodar:

(i) Preamplifier and receiver filters to obtain band width of 250 Hz and 400 Hz respectively.

(e) PC based sodar systems were installed at Durgapur (Bihar) for SAIL and Nagothane (Bombay) for IPCL to study atmospheric boundary layer for air quality assessment. Evaluation and testing of electro-acoustic equipments and acoustic products manufactured indigeneously were undertaken. About 142 calibration/Test Certificates were issued to various regional laboratories α Industrial units. The calibration range for noncontact tachometers was raised to 25,000 r.p.m.

ULTRASONICS

Ultrasonic transducers have been designed and fabricated for applications in mechanical sector scanner as medical diagonstic equipment. Its peak positive pressure is 6 MPa, pulse duration is 400 ns, beam width 2mm, receiving sensitivity 6 uV/Pa and focal range 40-90mm.

The frequency range for the calibration of bilaminar PVDF membrane hydrophone has been increased from 0.54 MHz to 1.5 MHz. The uncertainty in measurement is 1.1 db.

A 16 element transducer having centre frequency of 20kHz and bandwidth of 4kHz, size 17cmx17cm and a source level of 202 dB re/uPa at 1m has been constructed for use as a preliminary source for parametric sounding.

The suitable tubular transducer element of the dimension 0D.27.00mm, ID.21.mm and length l0mm and solid cylindrical transducer elements diameter 6.00mm, length 8mm have been fabricated as per requirement of transducer devices needed for NSTL and KDMIPE (ONGC) respectively.

Basic Investigations

A Piezoelectric tubular transducer immersed in liquid exhibitis the cavity resonance phenomenon due to the radial motion of transducer element. The study of cavity

resonance has been carried out to evaluate the velocity of ultrasonic wave in the enclosed liquid medium. The results are reported for the ultrasonic velocity in the methanol at varying hydrostatic pressure upto 10,000 psi. The measurements of ultrasonic velocity in the temperature range 10-50° C have also been carried out. The present method is simple and permits the measurements of ultrasonic velocity of liquids at low frequencies as well as at high hydrostatic pressures.

The vector impedance spectroscopic studies have been undertaken inorder to characterise the various fundamental modes of vibration alongwith its overtones present in tubular transducer elements. The Frequency spectra of impedance /Z/ and phase angle (θ) of various dimensions of tubular transducer elements have been recorded in the frequency range 1KHz to 10MHz. The frequency spectra of /Z/ and provide quite vivid and distinct indications of the different fundamental as well as its overtones for the tubular transducer elements of the dimension i.e. outer diameter (O.D.) greater than 20 mm with relatively thinner wall thickness. The complexity in the frequency spectra have been observed in a relatively smaller tubular transducer elements with O.D. 10mm. It has been observed that the more pronounced vibration of a particular mode may be obtained by selecting a proper ratio of outer diameter, length and wall thickness, which can be better exploited for specific transducer devices.

FLUID FLOW MEASUREMENT

The following Civil Works planned and awarded in 1993-1994 have been executed during 1994-1995 :

- Constant Leve! Over Head Tank (Cap.17 m^3),
- Sump Tank (Cap. 185 m^3)
- Pump Room, Control Room, Instrument Room,
- Misc. Civil Works (Drainage, Connect ing Channel, Development of Outside area, etc.)

Four window type air conditioners procured for control and instrument room. Standard weights of 500 Kg (20 Nos.) designed and fabricated for calibration of load cells of the weight tank (10t & 1t).

- Various precision equipments and accessories worth DM-1.5M, received from PTB, Germany for installation.- Procurement and storage of these (Customs clearance, unloading, Proper preservation) done.

ELECTRICAL STANDARDS

TIME AND FREQUENCY

During the year several user applications of STFS were carried out. Titan Watch Industries started using STFS for calibration of their watches All India Radio (AIR) started using STFS for generation and synchronisation of the hourly Pips. AIR also started its shortwave Vividh Bharti Broadcast from Delhi, Bombay, Madras and Gauhati by frequency synchronising their carriers using STFS. Two centres, at DVC, Maithon and Power Grid, Durgapur have started using STFS for time synch of the SCADA.

STFS knowhow has been transferred to another firm "Punjab Digital Industries Systems", Chandigarh.

The H-Maser become fully operational during this period. Further work on temp. stabilization is in progress.

The Rubidium isotopic filter cells and lamp bulbs were developed. Their long term performance is being evaluated before integrating them to the Physics package of the Rb Standards. The miniatured synthesizer circuit using sample held technique was developed for the Rb standard.

JOSEPHSON VOLTAGE STANDARD

A standard for dc voltage at 1 volt level based on series array of Josephson junctions has been installed. Several Josephson junction arrays have been tested for their dc and *rf* characteristics at liquid helium temperature. The arrays, when irradiated with microwaves of 70 GHz frequency, show constant voltage steps upto ±2 volts. The stability and noise aspects of the steps are being improved before these can be used for calibration purpose.

Work has been initiated on fabrication of thin film Nb/$A1_2$ O_3/Nb Josephson junctions. The ultra High vacuum system for fabrication of junctions has been upgraded by installing a load-lock chamber through which the samples can be transferred to the fabrication chamber without breaking its vacuum.

SUPERCONDUCTING THIN FILMS AND DEVICES

Superconducting Thin Films

Superconducting thin films of $YBa_2Cu_3O_{7-x}$ have been deposited insitu on various single crystal substrates by dc magnetron sputtering technique. The role of surface smoothness of the single crystal substrates on J_c of the thin film deposited on them has been investigated by Atomic Force Microscopy. Some of the commercially available single crystal substrates have shown sharp needle like structure of height ≈ 200A on its surface. The epitaxial film grown on such surfaces form high angle grain boundary Josephson weaklinks which result in a decrease in J_c of the thin film. The larger the density of these needle like structures, the lower the J_c of the films. The $YBa_2Cu_3O_{7-x}$ thin films deposited on $SrTiO_3$ substrates with smooth surface showed highest J_c ≈$2x10^6$ A/cm^2 at 77K and ambient magnetic field.

Detailed microstructural studies of $YBa_2Cu_3O_{7-x}$ thin films deposited insitu on (100) MgO and (1102) α-$A1_2O_3$ with Mgo buffer layer substrates have revealed that three-dimensional alignment of thin film and substrate lattice vectors are essential to obtain high J_c in thin films. The critical current density J_c of the film deposited on (100) MgO, which were c-axis oriented and also had in-plane alignment was $1x10^6$ A/

cm^2 at 77K while J_c of the films deposited on α-$A1_2O_3$ with MgO buffer layer substrate, which had same T_c and c-axis orientation but did not had in-plane alignment was found to be only $2x10^4$ A/cm^2 at 77K.

High-T_c RF-Squids

Under the sponsored project by the DST several high-T_c rf-SQUID sensors have been fabricated and characterized. Preliminary studies on passivation of high-T_c YBCO and BSCCO rf-SQUID sensors have been carried out and the effect of thermal cycles between room temperature and liquid nitrogen temperature has been studied on the SQUID characteristics over a period of several months.The characteristics of the passivated SQUIDs was found to be more stable than that of unpassivated SQUIDs. A SQUID probe incorporating passivated rf-SQUID sensor has been fabricated and given to CEERI Pilani for day to day testing of rf-SQUID electronics being developed by them. RF-SQUID behaviour has been studied in Ti-Ca-Ba-Cu-O thin film prepared by spray pyrolysis technique. The SQUID behaviour has been observed up to 101K.

RF-SQUID behaviour due to grain boundary weaklinks has been observed for the first time in electron-doped NdCeCuO superconductor. It is generally believed that the grain boundaries in hole-doped cuprates (e.g. YBCO, BSCCO etc.) behaves like Josephson weaklinks, mainly due to extremely short coherence length (3-20A) in these cuprates. In spite of relatively larger in-plane coherence length(≈70A) in electron-doped NdCeCuO superconductor, the grain boundaries observed.

Microwave Superconductivity

A modified cavity and plate replacement technique has been developed to measure microwave surface resistance of small area samples at 10 GHz. Using this technique one could measure surface resistance of samples of smaller area (≈1 cm^2).

Magnetic penetration depth λ (O) of high T_c YBCO polycrystalline samples of different density was measured by the cavity resonant frequency shift method at 10,16.65 and 22.3 GHz frequencies. The value of λ (O) remains fairly constant for all the samples in the frequency range 10-22.3 GHz. However, the value of λ (O) at a particular frequency (10 GHz) is found to decrease from 5850A to 2550A as the density of the sample increases from 4.4 to 5.3 g/cm3.

HIGH VOLTAGE STANDARDS

NPL is going to specialize in design and fabrication of standard components or equipment to establish high voltage measuring standards.

NPL has developed in principle a peak voltmeter. In operation it has been used with compressed gas standard capacitor to measure ac high voltage upto 60 kV. The capacitor in question can go upto 100kV but necessary clearance for such High voltage is not available in the present laboratory. Low voltage arm has been provided using a high value capacitor.

HF & MW VOLTAGE, CURRENT, POWER, FREQUENCY AND NOISE

Four Resonant Networks at four frequencies 10 MHz, 20 MHz, 30 MHz and 50 MHz have been designed and fabricated in collaboration with PTB, Germany for calibration work at high voltages (greater than 5 volts). These networks have 50ohm input impedance to match the source and very high impedance at the output port and are able to drive the high voltage thermal voltage convertors which have very high input impedance. The advantage of these networks is (1) That these circuits have very high Q and thus suppress all other harmonics which may be present with input signal.

So overall accuracy of measurement is improved. (2) That the expensive high voltage sources/highvoltage amplifiers are no more required.

LF & HF IMPEDANCE STANDARDS

International intercomparison of capacitance standards (10 pF, 100 pF and 1000pF) was carried out under APMP (Asia Pascific Metrology Programme) in which 12 countries participated. The intercomparison was done with an uncertainty of better than 0.2 ppm, which is at per with the other countries participating in this programme. Facility has been set up for calibration of Inductive voltage dividers with an accuracy of better than 0.1ppm. Facility has also been set up for calibration of transformer ratio and ratio standards with an uncertainty of o.o.5 ppm.

MAGNETIC STANDARDS

A substantial grant has been provided for this new activity under grant-in-aid schemes, NPL-PTB phase 1994-97, keeping in view the growing demands of Indian industries. Some of the facilities alongwith major equipments, which would be made available at NPL are: Calibration of H-Sensors using NMR measuring set up; AC & DC measurements on soft magnetic materials using Epstein frame, Permeameter and single sheet tester; Measurements on permanent magnetic materials using sensor system and Ni reference samples; Measurements on feebly magnetic materials using fluxmeter and precision solenoid.

As a first step towards setting up of magnetic standards laboratory, one of the NPL's search coil has been calibrated at PTB, Germany. The effective area of the search coil was found to be (549.3±0.5)cm² at 70 Hz and at a temperature of (23±0.5)°C.A great part of the components for the electronic circuits and instruments to be built at PTB for NPL's magnetic standards laboratory have been ordered. Practical work on the hardware has been started at PTB from January 1995.

At NPL, flux density measurements have been conducted on the Helmholtz coil at 20 Hz. The flux density variation with current has been found to be 1.10 mT/Ampere. Uniformity of flux-density at the centre of coil in 50 mm diameter area came out to be within ±0.4%. For the generation of low uniform magnetic field a dc solenoid is being designed and fabricated in NPL workshop. The maximum field strength to be achieved is 200 A/cm. Magnetic measurements have been conducted for other groups of NPL (X-ray Section, Workshop, JVS and SQUID group) in connection with their R&D work.

13 calibration certificates have been issued during the year with the limited facilities available with us.

SILICON DEVICES

1. Crystalline Silicon Solar Cells

During the year we have realised a Electrophotovoltaic (EPV) cell based on silicon. It is composed of a combination of n^+-p-n^+ and p^+-n-p^+ structure. The n^+-p junction is common to both structures. This cell has distinction of having its I-V characteristic in I-V quadrant both under dark and illumination conditions. The cell acts (i) as an Electrovoltaic (EV) cell under dark when the back n^+-p junction is forward biased, (ii) as a photovoltaic (PV) cell under illumination when the back n^+-p junction is open and (iii) as Electrophotovoltaic cell under illumination when the back n^+-p junction is forward biased. The I-V characteristics of an EPV cell are shown in Fig. 1. New devices can be made based on EV effect or using the EV effect in combination with other effects. For examples, as has been proposed by Singh, a n-p-n-...p...n-p-n structure based EV cell (where n(n) refers to partially (fully) depleted n-regions) can provide a d.c. voltage step up device.

The work on development of 15% efficiency silicon solar cells using 100mm dia and 100mm x 100mm silicon solar cells continued. Single crystalline cells of efficiency up to 12.6% were fabricated. A set up for spray deposition of TiO_x films was made and 100mm dia silicon solar cells were AR coated using this set up. An enhancement of more than 24% was observed using sprayed TiOx AR coating. Process of coating 100mm x 100mm dia silicon solar cells with a TiO_2 antireflection (AR) films using screen printed process was developed. A maximum of 27% improvement in short circuit (IS_c) was realised as a result of this AR coating on n^+-p cells made on chemically polished wafers.

Investigations were also done to develope a convenient method of measurement of contact resistance of front contact of silicon solar cells and create a set up for measurement of minority carrier mobility in silicon using a Shockley Haynes kind of method. The effect of shadowing on large area silicon solar cells was investigated and a new model was proposed to describe the I-V characteristic of cells adequately under conditions of full and partial illumination. Our group participated in round robin testing of silicon and GaAs cells received from foreign manufacturers for international intercomparison.

2. Silicon Processing for VLSI

Validation of I-D STEP VLSI Process simulator for impurity diffusion into silicon during silicon processing was done and the impurity profiles generated with it was found to be comparable to those obtained with SUPREM III process simulator package. A software package for 2-D diffusion modeling under neutral ambient was completed by developing a partial differential equation solver for diffusion equation in two dimensions and 2-D impurity profiles were generated.

A MOS capacitor using the $TiSi_2$ / SiO_2 / Si structure was fabricated using the e-beam evaporation and annealing and dry thermal oxidation. The capacitor was irradiated by 60 MeV boron beam at Nuclear Science Centre. From the study of I-V and C-V characteristics before and after

irradiation, the electrical properties were found to be degraded after irradiation. Sheet resistance of the silicide layer also decreased with irradiation.

3. High Temperature Superconducting Wires/Tapes

For fabrication of long length silver clad BSCCO tapes, the main route followed was the powder-in-tube method, which involed synthesis of BSCCO powder, filling of a silver tube with the powder and subjecting the powder filled silver tube to a series of thermomechanical treatments. BPSCCO powder was prepared by spray drying technique in batch sizes of 300 gms. 6 batches were prepared during the year.Tc of the powder was standardized to be 110 K as measured on sintered compacts using R-T and X-T. Due to non-availability of seam less silver tubes from the market, these tubes of 8 mm OD, 5 mm ID and 200 mm length were fabricated from silver ingots using the cold extrusion facility at NPL. Thickness was reduced first in form of wire and then the resultant wire was rolled in tape form in several (10-20) reduction steps with an intermittent anneal after each step. Finally the tape was alternately rolled to reduce thickness and sintered at 800-850°C for 100-300 hrs. Continuity of the ceramic filament was checked out to thickness up to 70 μm. Reduction stages and heat treatment sequence is under optimization.

4. Porous Ceramic Materials

A process to fabricate porous sponge ceramics for use as particulate filter at high temperatures was developed. Sponge cordierite ceramics with density of 0.4-0.6 g/cc, porosity >80% and cold crushing strength of 3 MPa were prepared. Several prototypes of particulate filters for the exhaust of a two wheeler were evolved for effective filteration using the sponge ceramics made at NPL. These apparently reduced the particulate emission of the two wheelers.

5. Magnetic Materials

A project to increase the silicon content of silicon steel to 6 wt% Si by CVD process and optimise its magnetic properties was negotiated with Tata Iron and Steel Co. (TISCO) and the funding for the project was provided by TISCO in February 1995. Preliminary work on CVD deposition of silicon starting from $SiCl_4$ as precursor material was carried out and the furnaces to carry out the CVD deposition and post deposition annealing were assembled.

6. Interface and Microstructure Devices

Polycrystalline thin film CdTe and $CuInSe_2$ (CIS) solar cells are being developed. Under the sponsorship of MNSE a project to demonstrate high efficiency CdTe solar cell by electrodepositon technology has been taken up. Electrochemical technique for depositon of semiconductor layers used in solar cell based on acidic aqueous and organic electrolytes has been developed. Solar cell fabrication steps involving junction optimization and pseudo-Ohmic contacts to solar cells are being developed. Alternate process technique for CdTe formation by closed space sublimation has been set-up. A joint research project sponsored by a private industry, M/s Eco Solar Systems India at Pune has been initiated. Process technology for electrical contacts to CdTe solar cells has been developed for them and is being tried at manufacturing level. General consultancy is also being provided to Eco Solar Systems in cell fabrication in a 700 KW/yr pilot production line.

Current emphasis for CIS solar cells is on materials development. Se vapour selenization approach to CIS formation is being developed. Phase evolution during

Se vapour selenization of evaporated Cu/In bilayer metal precursors has been extensively investigated and it has been established that pressure is a critical process parameter. At low pressures, the relative kinetics of selenization of Cu and In are changed resulting in the formation of single phase CIS even at very low temperatures (260° C). At higher pressures simultaneous formation of the equilibrium binaries, CuSe and In_2Se_3 at low temperatures leads to the formation of CIS through a diffusion limited reaction of the binaries at higher temperatures. Modeling of the gas dynamics in the reactor shows that the availability of Se reacting species varies significantly in this pressure regime. Formation of In doped ZnSe films by the selenization of In/Zn (In) metal precursors is being investigated as an alternative heterojunction layer for CIS cells.

Work on the metal/extrinsic dielectric/Silicon structures was extended to ferroelectric PZT films as part of the programme on development of high density MOS and nonvolatile memory devices. A relationship between the electronic properties and the stoichiometry and microstructure of electron beam evaporated PZT thin films is being investigated.

Ion beam techniques for thin film processing, for surface treatments, for sputter deposition and microetching are being developed. Various types of ion gun sources with energies of 500 eV to 6 KeV have been designed and developed. A system has been fabricated for micromilling of materials for the preparation of samples for TEM investigations.

Work on the YIG films formed by an MOCVD process has been extended. Detailed investigation of Ce and Co doping has been undertaken to understand the interrelationship of the microstructure and magnetic properties and their dependence on the stoichiometry, deposition conditions and annealing. These studies are aimed for development of magneto-optic and magnetic storage media.

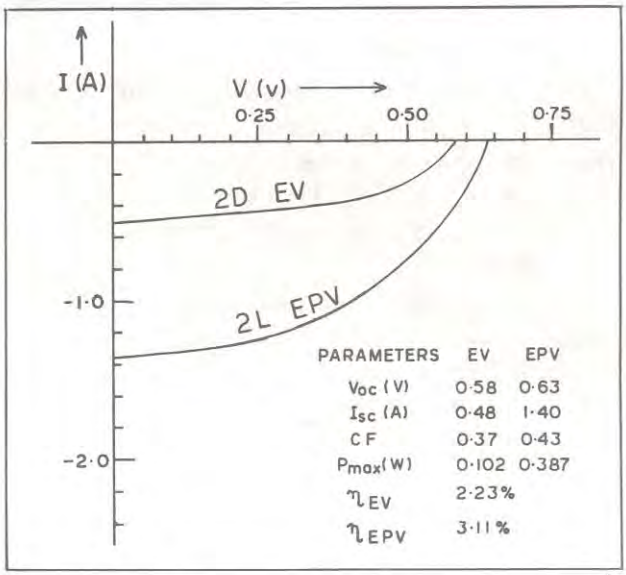

Fig. 1 I-V Characteristics of electrovoltaic (EV) and electrophotovoltaic (EPV) cells.

LUMINESCENT MATERIALS

Work on electroluminescent backlighting panels was continued further with the aim of studying field performance and commercial utilization. A number of firms showed interest for developing different kinds of advertisement displays. To achieve the objectives a number of experiments to improve the phosphor and EL device were carried out. Size of device has been increased from 7.5 x 2.5 cm to 15.0 x 7.5 cm and typical ad logos have been provided on the devices developed. Based on the above work detail for six patents have been worked out. We were approached by D.L. Jodhpur project to develop long persistence phosphor and plastic tapes there from. These are to be used for emergency visual signs for guidance in case of sudden power failure. Now the project is in final

stage of approval and is being funded by DRDO.

A tie-up is being developed between IGCAR, Kalpakkam for R&D to make screens of photostimulable phosphor, a system which will reduce X-ray dose to a large extent for medical radiography. The role of NPL will be to search for suitable binder substrate and coat a uniform layer of phosphor as per the specifications laid down.

In addition, the group has been serving the industry regarding measurement and control of particle size distribution. A number of samples were tested during the year.

DISPLAY DEVICES

The major activities of the group include (i) processing and formulation of materials (ii) design and fabrication of useful device configurations and (iii) application and industrial utilization of these devices.

A summary of the materials / processes being developed and their possible industrial applications is given in following table. It gives a list of materials developed and under study ranging from bulk to ultra thin film forms along with the techniques being utilized.

Table

MATERIALS / PROCESS

Form	*Technique*	*Materials*
Bulk	sol-gel, chemical	titanate, oxides, polyaniline, biosensing, immobilization
Thick films Membranes Fabrics	chemical & electrochemical polymerization and doping; screen printing; photo & thermal induced polymerization	conducting polymers polyaniline, polypyrrole, poly thiophene, ruthenium complexes
	spinning	polymer dipersed liquid crystals (PDLC)
Thin Films	sol-gel, thermal evaporation, e-beam vacuum evaporation	TiO_2 ,SnO_2 ,ZnO, ferroelectric, Se alloys, metals, polyanilines;
	STM	liquid crystals
Ultrathin Films	Langmuir-Blodgett (LB)	polyaniline, organic materials

INDUSTRIAL APPLICATIONS

Bio-sensors	.....	glucose, urea, cholestrol, lactose
Image processing	.....	liquid crystal spatial light modulator (SLM)
Gas sensors	.....	CO, HCN, NH_3, HCL, ethanol, LPG, H_2
Molecular imaging	.....	liquid crystal alignment
Sucrose monitors	.....	cane sugar
Fruit / beverages	.....	alcohol content using FTIR / ATR/ NIR techniques.
Energy efficient windows	.....	electrochromic displays (ECD)
Membranes	.....	filters for virus monitoring in water
X-ray imaging on paper	.....	mammography and non-destructive testing
EMI shielding	.....	antistatic fibres, conducting plastics

LIQUID CRYSTALS

Some of the important achievements in this area include (i) high resolution imaging of liquid crystal molecules using Scanning Tunneling Microscopy (STM) (ii) the study of the surface ordering of liquid crystals using STM and (iii) successfully making of patterned orientation of liquid crystals by using innovative photo-polymerization and thermal induced photopolymerization techniques wherein no electrically conducting substrates are needed and no electric field is required to see the stored pattern.

Liquid Crystal Spatial Light Modulator (SLM) for Optical Computing

A new matrix - vector multiplication technique has been proposed in collaboration with Dept. of Applied Physics, University of Calcutta, where free-space optical interconnections are used. The multiplication is carried out by a convolution technique where one set of numbers (multiplicands) is represented by ON/off states of light sources and the other sets of numbers (the multiplier) are recorded in matrix form on a spatial light modulator. The partial products are recorded on a detector array which, when added by a microprocessor, yield the respective convolution coefficients. No analogue to digital conversion electronics are necessary in the proposed technique and instead only a thresholding circuit is used. Compared to other existing techniques, the processing time is also reduced in the proposed system.

Gray-scale Characteristics in Polymer Rubbed Surfaces of High-tilt Angle Ferroelectric Liquid Crystals

The anchoring strength of a high tilt angle ferroelectric liquid crystal with a phase sequence I-N* - SmC* on a polymer rubbed surface was found to be very high. This high surface anchoring was found to generate gray scale characteristics in these materials. The high anchoring surfaces were created by strong rubbing of the polymer-coated surfaces of the substrates. It has been observed that in thick samples (12 microns spacing) gray scale characteristics appear due to the untwisting of partially twisted structure and in thin cells (5 microns) the gray scale characteristics appear due to the reorientation of the ferroelectric liquid crystal molecules near the polymer coated surface. Further, this gray scale characteristic was found to be dependent upon the polarity of the applied field, indicating the polar nature of the surface anchoring of the rubbed polymer surface. These results have been discussed by considering the polar surface interactions on polymer surface of FLC cell.

Sol-gel Synthesis of Materials for Gas Sensor Applications

Tin-oxide based thin film catalytic combustion sensors have been developed by employing sol-gel process. The sol-gel technique is superior to most of the other conventional thin films deposition technique for fabricating stoichiometric polycrystalline and uniformly doped semi-conductor oxide thin films. SnO_2 thin films doped with 1% platinum were deposited by sol-gel technique on soda glass, fused silica and single crystal silicon wafers (100) by spin coating and dip coating techniques. The films were annealed at 500°C to make them polycrystalline. Thin film of SnO_2 doped with 1% platinum and having a thickness of 0.3 micron shows about 40% reduction in its resistivity when exposed to about 100 ppm of methanol vapour. The films are also sensitive, with varying degree, to other organic vapours like ethanol, iso-propanol, diethyl ether etc.

Development of Solid State Electrochromic Devices (ECD) for Display Applications

Structural and optical properties of e-beam deposited tungsten trioxide (WO_3) films in as-deposited and electrochemically coloured states have been investigated by spectrophotometric and XRD techniques. These investigations have shown the as-deposited WO_3 films to be porous and with small amount of H_xWO_3 pre-existing in them. Some of the other main achievements in this area include (i) the development of novel solid polymeric electrolytes based on polyvinyl butyral (PVB) with the best conductivity of about 10^{-5} S Cm^{-1} and (ii) feasibility has been established of all solid state ECD incorporating PVB based solid polymeric electrolyte.

Development of X-ray Xerography

The photoreceptor plates developed at NPL have been tested on the mammography machine located at LNJPN hospital. The high lights of radiologists report from this hospital in Delhi says; "The performance of plates developed at NPL have been found quite good and comparable to that of the imported plates in terms of images, contrast, resolution and X-ray dose requirement. In fact in terms of X-ray does requirements the NPL plates appear to be more X-ray sensitive than the imported plates."

Bio-molecular Electronics, Biosensors and Conducting Polymers

The technical know-how on production of glucose biosensor has been transferred to two companies (i) Pulsatum Health Care Pvt. Ltd., Bangalore and (ii) Gamma Instrumentation Pvt. Ltd., Faridabad.

The representatives of these companies are being trained at NPL.

Some of the main achievements of this group during this year include (i) a detailed a.c. conductivity studies of polyemeraldine base, one of the form of polyaniline (ii) measurement of electrical properties of metal-insulator (LB) layer-semiconducting polymer devices (iii) observation of electrochromic behaviour in polyaniline (iv) studies on electroactivity and proton doping in photo-conducting polycarbazole (v) feasibility studies towards the application of polyaniline as glucose biosensor and (vi) development of ion-exchange based glucose biosensors. The technical development of cholesterol biosensor and lactate biosensor is in progress. Preparation and characterization of Langmuir-Blodgett films, self-assembled layers and a range of conducting polymers have yielded a variety of new materials and promising applications.

Electronically Conducting Polyaniline: Thermal and Environmental Stability and its Applications

Thermal stability of polyaniline doped with various organic dopants and emeraldine base have been investigated. The undoped polyaniline (emeraldine base) is highly heat-stable polymer with thermal stability up to 425° C. The thermal stability of the doped polyaniline is highly dependent on the dopant anion attached to the polymer backbone. Polyaniline doped with organic dopants are more stable than polyaniline doped with inorganic dopants. Doped polyaniline shows a two step decomposition. The first step corresponds to the loss of doped anion and the second step corresponds to the decomposition of the polymeric backbone. It has been observed that polyaniline doped with certain proprietory organic dopants is thermally stable upto

300° C which may find applications in the formation of conductive composites with the conventional thermoplastics. A patent is under preparation based on these exciting developments.

Some other important achievements in the area of conducting polymers include (i) making of metallized fabrics for the EMI control is 80 GHz-100 GHz range which is under extensive testing presently and (ii) observation of very interesting charge transfer chromism in conducting polyaniline without the application of any external electric field. This phenomenon is quite intriguing and further work is under progress to understand possible redox mechanism.

Quantitative Analysis of Sugar Mixtures by Infra-red Spectroscopy Application to Sugar Industries

Quantitative analysis of sugar mixture is very important in sugar industry. Recently a new R & D programme has been initiated at our laboratory towards the exploration and development of spectroscopic techniques to meet this analytical requirements of the industry. The present work utilizes the potential of Fourier Transform Infrared Spectroscopy in mid infra-red region as an analytical method for determination of sucrose, glucose and fructose concentrations in aqueous solutions and assesses the feasibility of the technique for on-line applications in sugar refinery. An advance matrix method has been used in concentration ranges typically encountered in sugar cane juice. The calibrations have been applied to real and synthetic samples and results compared with those obtained from traditional methods of analysis. The analysis of bagasse, filter cake and prepared cane are very promising. A patent is being prepared based on this methodology. The potential of infrared spectroscopy for on-line analysis in sugar cane and other food-processing industries is being further explored using fibre optic probe with ATR crystal attached to it.

Development of Conducting Polymeric Filters for Virus Monitoring in Water

An exploratory research programme, in collaboration with All India Institute of Medical Sciences, New Delhi, has been started for looking at the feasibility of using conducting polymer filters for virus monitoring in water. Firstly, polypyrrole based conducting membranes have been developed and through variation of processing parameters surface resistance of these membranes have been optimized. Virus retention on the membranes is being examined by AIIMS. A good percentage of viruses has been found to be arrested on the membranes. Further work is in progress towards the optimization of processing conditions and towards the measurement of the charge on the surface of the membranes processed under different conditions.

The growth kinetics of polypyrrole, poly (n-methyl pyrrole) and their copolymer, poly (n-methyl pyrrole - pyrrole) has been studied. The effect of annealing on their conductivity and surface structure has been examined. Further, the mechanism of charge transport in poly-pyrrole, poly (n-methyl pyrrole) and their copolymers has been investigated using dielectric measurement techniques.

Development of Polyaniline Based Gas Sensors

In order to control air pollution and to detect combustible, toxic or smelling gases at low levels, tremendous efforts are being made towards the development of simple

and inexpensive semiconducting oxide gas sensors. However, the semiconducting oxide film sensors generally operate efficiently only at about 300° C. In order to overcome this limitation, new materials are being attempted. Recently a great deal of excitement has been generated towards the study of electroactive conductive polymers such as appropriately doped poly-pyrrole, polythiophene and polyaniline. We have observed that vacuum deposited thin films of polyaniline exhibit excellent gas sensing properties. The electrical conductivity, optical absorption and electrical capacitance of metal polymer interface is strongly influenced by the presence of certain gas molecules. These results have led to the development of gas sensing elements for gases such as CO, NH_3, HCl and HCN. Thin film polyaniline based gas sensing elements are inexpensive and operate at room temperatures with satisfactory selectivity for these gases.

CARBON PRODUCTS

1. Carbon Fibres

Because of limitations in batch experimentations, PAN fibres could be stretched to only 20% during post spinning modification with succinic acid. The experiments were therefore carried out on the experiment pilot plant on a continuous scale where in the degree of elongation could be increased to 40%. Such PAN fibres when carbonized to 1500°C and 2500°C respectively in the graphitization furnace gave carbon fibers with T.S. = 3.5 GPa (Max) and Young's modulus = 500 GPa (Min).

a. *Intercalation studies under IFCPAR project*

A comprehensive review of the work done during the entire course of the project was undertaken with the French collaborators at CRPP.

Three manuscripts were prepared and the salient features of each are described briefly below :

A detailed study was made on the TGA and DSC runs obtained at NPL on the fluorinated carbon fibre samples received from France. The results proved to be highly useful as these could give an indication about the thermal stability of the intercalated compounds. A very important conclusion was drawn that the decomposition behaviour of stage-1 compounds seems to be somewhat different from those of higher stages.

A Complete analysis of the results obtained on the insitu resistivity changes of carbon fibres during bromination under different conditions was made.

Complete data on the Hall measurements and transport properties of bromine intercalated carbon fibres was also compiled and the charge transfer calculations made. The basic difference in these studies as compared to the earlier ones is that these have been carried out on one particular variety of carbon i.e. P120 but intercalated to different extents of bromine uptake by controlling the reaction conditions. It has thus been possible to estimate the charge transferred between the bromine and the carbon atoms at different levels of intercalation in the same host.

Raman micro-probe analysis on a single carbon filament was carried out both in the axial as well as perpendicular direction. The technique proved to be very useful in ascertaining the uniformity of bromine diffusion inside the core of the fibre.

b. Structural modelling of fractals

In recent years, the fractal geometry has been considered as a powerful tool to

characterise the metal solution interface in terms of the surface roughness besides having its widely published utility in chemistry and physics. Our work deals with the description on the basic steps to generate the Modelbrot Apple-tree sets with an emphasis on determinstic of stochastic fractals and also provides accounts on the build-up of impedance diagrams of different complex equivalent circuits by viewing the surface through fractal patterns. Effects of the surface roughness on the kinetics of the reaction in relation to the homogenous surface is also dealt with. A general programme for the calculation of Nyquist plots with respect to Fractal electrode-electrolyte interface is included in one of our recent communications. The implications of this model for electrochemical surface technology have been proposed.

2. Carbon-Carbon Composites

(i). Inter-relationship between surface energetics of reinforcement, and mechanical properties of the composites were evaluated. Surface energetics of the reinforcements influence to a large extent the fiber/matrix interactions, pyrolysis behaviour and mechanical properties of the composites shrinkage experienced during pyrolysis as well as flexural strength of composites is directly proportional to the amount of surface energetics present on the reinforcements. Surface energetics also effect to large extent the fiber/matrix interactions which influence the fracture behaviour and mechanical properties of the carbon/carbon composites. The development of microstructure in carbon/carbon composites is also influenced by surface energetics of the reinforcements. The development of columner type of microstructure in carbon/carbon composites heat treated from 1000° C to 2600° C is dependent on the fiber/matrix interactions, bonding, debonding and shrinkage stresses which further depends on the surface energetics of carbon fibers. The development of anisotropy is more in case of composites having maximum amount of surface energetics on the reinforcement. In case of strong bonding shrinkage stresses lead to formation of radial compressive and circumferential tensile stresses which lead to the development of columnar microstructure of the resin matrix on HTT to 2200° C and above.

(ii). A unique set up has been set up for processing of high tech., ceramic materials. This will be particularly used for the processing of carbon/carbon composite (Plasma enhanced CVD) for airbrake materials.

(iii). A project entitled "Development of Blast insert as protective material for antimine Boot material" sponsored by Ministry of Defence was initiated.

(iv). A collaborative project "Development of activated carbon cloth on experimental set up has been taken up between NPL and M/s. HEG Limited, Bhopal.

3. Synthesis of Silicon Carbide Whiskers (SiCw) from Rice Husks

(i) Synthesis of silicon carbide whiskers (SiCw) from rice husks was carried out. The characterisation by chemical analysis and also by X-ray and SEM revealed that SiCw and particulates produced were having excess of carbon and silica. The advantage of the reported method is that it is economical and the synthesis was carried out at relatively lower temperature when

compared to the temperature conditions reported in the literature.

ii) *Synthesis of SiC incorporated Carbon/Carbon composites*

Preliminary studies were carried out to develop SiC incorporated Carbon/Carbon composites employing sol-gel technique. Carbon/Carbon composites containing up to 20% SiC were developed and characterised. Such composites offer higher degree of oxidation resistance as compared to C/C composites.

4. Special Pitches

(i) Consultancy project relating to impregnating coal tar pitches having 2-3% of quinoline insolubles, sponsored by M/s Himadari Chemicals & Industries Ltd., was undertaken. Experiments were carried out at the Vishakapatnam Plant of the party, which involved centrifugation of suitable coal tar pitches-tar oil mixtures through special filter clothes. Methods to improve the quality of coal tar pitch were also suggested.

(ii) High density-High strength-Isotropic graphite

Extensive studies were carried out to develop this high density graphite from mesocarbon microbeads (MCMB) obtained by the extraction of suitable heat-treated low-QI tar pitches with two types of tar oils, I and II, with relatively lower and higher boiling ranges, respectively. It was found that the tar oil -II is a better solvent for the separation of MCMB out of mesophase pitch for the production of this graphite.

Besides the above, a large number of experiments were conducted to develop such high density monolithic graphite from the mesophase pitch based green coke, which seems to be an economical route. Accordingly, a suitable coal tar pitch was prepared and heat treated to form mesophase based green coke powder having an optimum amount of the volatile binding components. This self sintering powder was hot pressed into plates and then heat treated to 2500° C to obtain graphite of density of 1.9 gm/cc, shore hardness of 76, electrical resistivity of 2.6 Ohm cm. Further work to optimise the processing conditions is in progress.

(iii). Carbon Bipolar Separator Plate

The carbon bipolar plates of the size 215 mm x 110 were made from the phenol formaldehyde-synthetic graphite mixtures using a modified die design and a 100 M Tonne hydraulic press. The plates were characterised with respect to the usual parameters. The compilation of the Final Project Report is in progress.

THIN FILM SYSTEMS

Amorphous Thin Films, Devices and Systems

A novel pulse plasma technique has been proposed and experimented in which a constant low RF power level is maintained throughout the deposition time and additional square wave modulation of the source creates a high power condition which can be varied both in power and duration (dwell time). The film deposition rate under such conditions is found to depend both on the high power level and dwell time of the pulse.

Higher band gap (~2 eV) a-Si:C:H material

with improved photoconductivity ($\sim 2 \times 10^{-5}$ ohm^{-1} cm^{-1}) has been grown by sustained optimisation studies and identifying the parameter space where this becomes possible.

Similarly device quality silicon nitride and oxy-nitride films (a-SiN:H and a-SiON:H) were grown in an indigenously developed PECVD reactor. Breakdown strength in excess of 1×10^6 V/cm were obtained for such films and other properties tailored to meet CEERIs device development programme.

Diamond Like Carbon Films with graded refractive index were grown by manipulation of the RF self bias voltage in a programmed manner so that integrated IR intensity of the films in 8-11-5 μm range, could be enhanced. DLC films grown by a saddle field fast atom beam source were analysed and role of ionized precursors identified in such growth.

On request from the Electronic Science Department of the University of Kurukshetra a load locked PECVD system with provision for insitu substrate transfer has been designed that also incorporates a 500 watt solid state RF generator.

Optical Coatings

Narrow band pass interference filters for the 2-10 um range (IR) have been designed. The design and technical know-how for 2% half-bandwidth interference filters with sharply rising transmission characteristics for the visible region are being developed for HHV, Bangalore. Designs for anti-laser goggles, anti glare coatings, broad band anti-reflection coatings and phototopic eye response filter were developed for OLF, Dehradun (Min. of Defence) under the terms of a MOU between OLF and NPL. A technique for the in-situ determination of the optical constants of an absorbing thin film being deposited on an absorbing substrate has been developed successfully.

HIGH PRESSURE TECHNOLOGY

The synthesis of harder phases of boron nitride under high pressures and temperatures was studied using low ordered boron nitrides as the starting material employing the catalyst-solvent process. The main achievement of the present study was the lowering of the synthesis pressure (25 kb) from the present value of 40 Kb used to synthesize cubic form of boron nitride if amorphous form of boron nitride is used as the starting material.

A new project entitled "To Investigate a new category of catalysts used for the synthesis of diamond under high pressures and temperatures" has been submitted to DST for funding.

METALS & ALLOYS

The work during the year was mainly concentrated in the area of Metal Matrix Composites (MMC) and processing of other hi-tech materials. Efforts were also made in developing usable components for different industries.

MMC Synthesis and Characterization

The stir-casting (ingot metallurgy route) technique was designed and developed for the synthesis of Metal Matrix Composites and has been designed for handling up to 10 kg of melt. The matrix material used was high strength aluminium alloys (2124 grade) reinforced with silicon carbide particulates. This stir casting system essentially involves addition of the dispersoid particles into the vortex formed in a pool of mechanically stirred molten alloy at

730-740° C. Silicon carbide particulates were sieved and pre-heated in a separate furnace for about 3 hours at 775° C before addition to the melt. After the reinforcement is incorporated in the melt, stirring is continued for some time and then cast into permanent moulds using a specially designed bottom pouring mechanism from the crucible. Various process parameters like temperature cycle, stirring time, stirring speed, reinforcement addition rate, melt pouring temperature, etc. were optimized for each volume fraction of dispersoid in the MMC. Different composite billets (80mm x 250mm) were produced using varying volume fraction (5-15%) of the reinforcements (SiC). The optical characterization indicated good microstructure and uniform distribution of the reinforcement within the matrix. The volume fraction analysis of the cast composites also exhibited uniform distribution of the reinforcement (+/- 1%) in the matrix.

Work was initiated on the synthesis of Metal Matrix Composites using Spray Atomization and Deposition process as this is the state-of-art technique of synthesizing MMC and not being currently persued anywhere in India. This process uses a spray nozzle to atomize a molten aluminium alloy matrix, into which heated silicon carbide particles are injected. The preform produced using this technique is very dense with uniform distribution of the reinforcement and has a good matrix-particulate interface bonding. The design of the vacuum chamber of the Spray Atomization and Deposition Unit was done and the fabrication and commissioning of the skeleton vacuum chamber has also been completed.

A 5-ton Universal Tensile Testing Machine (Instron 4204) was installed and commissioned and we have started testing samples for their mechanical properties for private automobile and other Industries.

MMC Component Development

Efforts were made to make actual MMC components out of the synthesized MMCs using powder metallurgy and from billets made out of stir casting technique. Various techniques like extrusion, machining and pressure die casting were attempted to make actual MMC components. All the MMC components were fabricated out of high strength aluminium alloy reinforced with 15 wt % silicon carbide particulates.

MMC Tubes as Cylinder Liners

The main emphasis in the automobile industry is to reduce vehicle weight in order to improve fuel economy. Thus it is useful to replace conventional cast iron engine blocks with cast iron blocks fitted with MMC liners. This reduced the weight and improve wear resistance of the liners apart from achieving thermal and dimensional stability. We have extruded MMC billets made using powder metallurgy route and fitted them in cast iron engine block (Fig. 1) on a trial basis and tests are in progress to evaluate their performance.

MMC Connecting Rods and Gear Shifting levers

Some actual MMC components like connecting rods (Fig.2), gear shifting lever etc. were developed by pressure die casting, by remelting the MMC billets made by stir casting. These components exhibited reasonable mechanical and metallurgical properties and the work is underway to improve their mechanical properties.

MMC Gears and Pulleys

Machining characteristics of MMC were

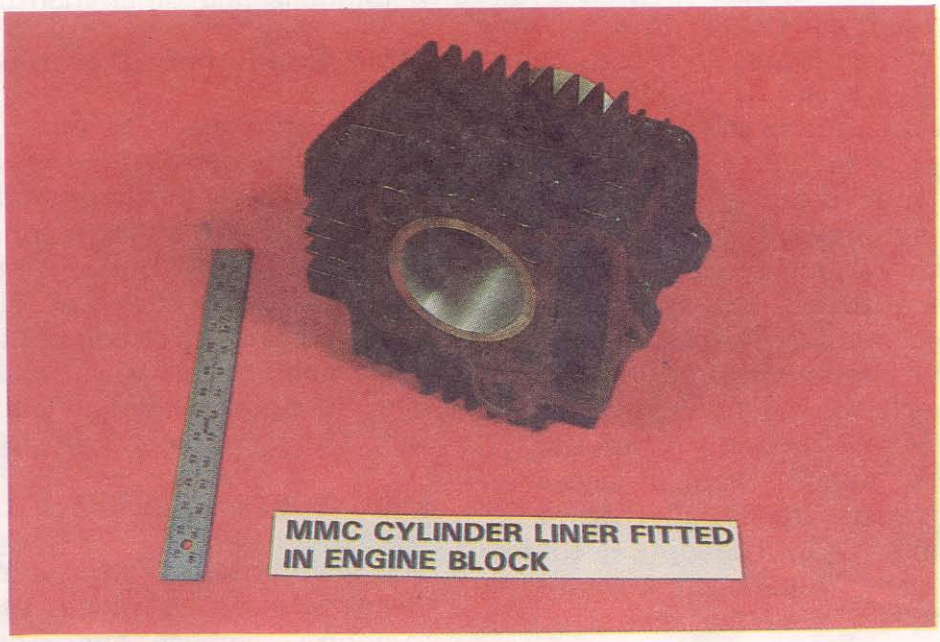

Fig. 1 MMC circular tube fitted as liner in cast iron engine block

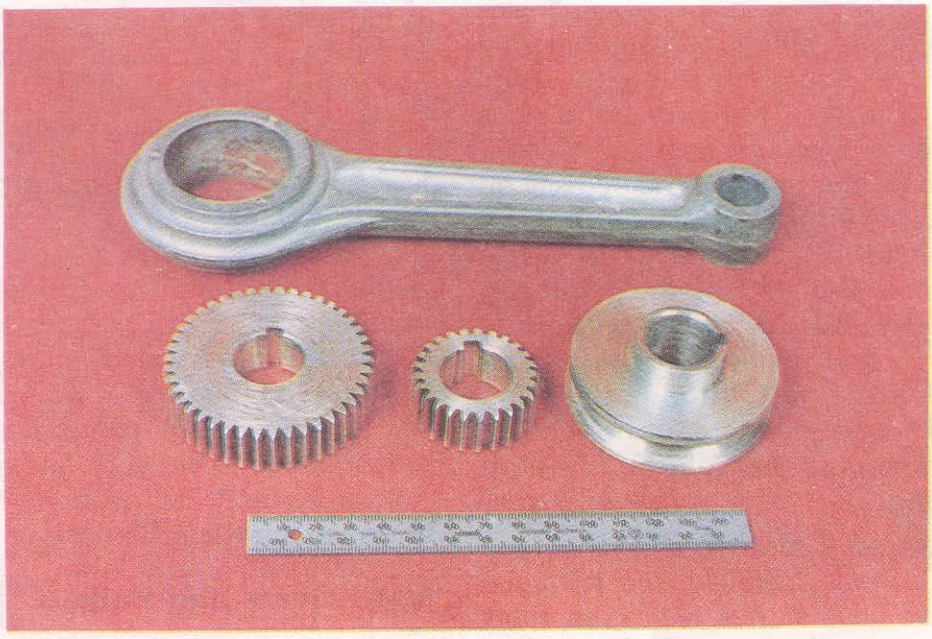

Fig. 2 Some of the secondary processed MMC components

also studied using different machining operations like turning, milling, drilling and grinding operations. A few automobile components like automobile piston, pulleys, gears (Fig. 2), etc. were developed by utilizing these machining the operations on hot extruded MMC billets synthesized using Powder Metallurgy route.

MMC Tubes for Satellite Applications

Work was continued in developing MMC rods and tubes by hot extrusion of MMC billets synthesized by Powder metallurgy (PM) route at DMRL, Hyderabad. A "modified" PM route was developed which eliminated the expensive process of vacuum heating and degassing as in the conventional powder metallurgy. MMC tubes produced by extruding these billets produced by modified PM process exhibit better mechanical properties especially the ductility, and a 5% elongation has been achieved in case of 2124 Al-alloy+SiCp.

MATERIALS CHARACTERIZATION

CHEMICAL METHODS

During the year 69 samples were analysed for different organizations including different sections of the laboratory and for CEERI Pilani. Testing work was carried out for sister Divisions of the Laboratory and for CEERI Pilani. Three instruments were calibrated for two industries.

Research & Development Work

1. Spectrophotometric methods have been developed for the determination of Boron and Phosphorus in P N N polycrystalline silicon solar cells. The silicon slice was etched with hydrofluoric acid and nitric acid mixture (1:1) for 30s to 300s to achieve desired depth etching. After etching each portion is divided into two parts. Boron was determined by forming redish brown colour complex with curcumin. Optimum conditions for the formation of stable complex have been worked out. The absorbance was measured at 545 nm. The molar absorbance is 1,54,000 and Beer's law is obeyed upto 0.2 ppm boron.

   The other half liquor of the etched solution was used for the estimation of boron, the solution was heated to fumes. 1 ml of perchloric acid to remove silicon, cooled and phosphoantimonyl molybdate colour developed. The coloured complex was extracted in MIBK and the absorbance was measured at 795 nm. Beer's Law was obeyed upto 0.8 ppm phosphorus. The detection limit for boron and phosphorus are 1 and 6 parts per billion respectively.

2. A new indirect method was developed for the estimation of NO_2 (Nitrogen dioxide) in the environment by atomic absorption spectrophotometer.

3. Highly sensitive spectrophotometric method was developed for the estimation of sulphur dioxide.

4. Determination of toxic element present in the milk was carried out by AAS and by spectrophotometric methods.

5. Determination of fluoride in water present in 1 ppm range was standardised using ion chromatograph. The concentration of fluoride in 1 ppm range was checked by spectrophotometric method and the results obtained are comparable with those of ion chromatograph.

INDIAN REFERENCE MATERIALS

Work on preparation of Indian Reference Materials has been continued. Two new reference materials viz nickel and fluoride in high purity water have been prepared under this programme. Stock solutions of these elements were prepared at NPL. Stability and storage conditions for these solutions have been studied and optimised. Analytical evaluation was carried out using different techniques viz ion chromotography, ion selective electrodes, atomic absorption spectrometry, ICP-emission and mass spectrometry etc. These solutions were provided to sixteen different laboratories, analytical data obtained from them was compiled and statistically analysed. The certified values assigned to the fluoride solution is 1.00 ppm with standard deviation ±0.03 and random uncertainty 0.003.

Indelible ink used for making identification mark in general elections is being manufactured by M/s Mysore Lac & Paint Company, Mysore on the know how provided by N.P.L. The ink has been exported to countries like Ghana, Singapore and Turkey.

SURFACE AREA & POROSITY

Twelve samples, received from various industries, were tested for their BET-surface area. Some of the materials tested include activated carbon grannules, (Korba Super Thermal Power Project) manganese oxide powder, (Sterling Oxide Ltd.) catalyst for CO oxidation (Defence Science Centre, Delhi) and precipitated silica (S R P Industries, New Delhi).

Eleven samples of activated carbon cloth were prepared under various conditions and characterized for their pore structure, in order to understand the mechanism of pure formation during activation.

FTIR SPECTROSCOPY

FTIR spectroscopic characterisation of materials was done for the samples received from outside institutions and from NPL projects. This includes silicon wafers from Central Electronics Limited, Sahibabad (U.P.), PSG coated high resistivity Silicon from CEERI, Pilani (Rajasthan) and silicon crystals from NPL projects. Emission spectroscopy characterisation was done for a number of samples for their elemental constituents. These samples included carbon powder with different heat treatments from Carbon Technology unit.

Infrared high resolution FTIR Spectroscopy was used to study internal vibrations of Neodymium oxalate. Librational modes of the various species present in the crystal were observed in this region which provided information about the molecular structure of the crystal unit cell. Isotopic studies were also carried to confirm the vibrations related to water molecules. IR absorption bands pertaining to lattice water were obtained and recorded. However no IR absorption band related to coordinated water could be recorded. Molecular deformation was found higher in hydrated crystals than in deuterated analogue.

Librational modes of lanthanum sulphate were studied in the high resolution low temperature studies by FTIR spectroscopy. These vibrations were related to different molecular groups such as water molecules, sulphate groups etc. It was concluded that nine water molecules of lanthanum sulphate form triangular prismatic structure with six water molecules at the apex of the prism and three at the centre of the three faces of prism. The lanthanum ion was found at the centre of inversion of the prism.

EPR SPECTROSCOPY

EPR spectrometer was maintained and used for investigating different materials. Non-stoichiometric $Cu_{2-x}Se$ ($0<x<0.25$) films were prepared for investigating process induced defects formed during different heating treatments. Variation in electrical resistivity of $Cu_{1.9}Se$ films in the temperature range RT-400°C was explained on the basis of EPR results. The octahedral symmetry on the V^{4+} site in the ternary glasses $xCoO$ $(0.4-x)$ $Bao.0.6B_2O_3$ ($0<x<0.25$) doped with 2.0 mole% of V_2O_5 was found to improve when diamagnetic modifier Bao was replaced by paramagnetic modifier Co0 keeping B_2O_3 constant. Apart from this EPR data of Cu^{2+} ion in single crystals, polycrystals and liquids that appeared between 1985 and 1992 were collected and consolidated for a review article. A number of samples from different projects of the laboratory were also characterized.

X-RAY DIFFRACTION & FLUORESCENCE

X-ray diffraction and fluorescence studies were carried out for about 415 samples of materials including high Tc superconductors & their films, Lead Zirconate Titanate, garnet, Eu doped Yttrium Oxysulphide, CulnSe2, CdTe, AIF, Carbon fibres & composites, SiC, PEO films, air pollution samples, multilayer thin films of Fe/Co, iron silicide, kimberlite and cordierite etc. Assistance was provided to IIT, New Delhi; CEL, Sahibabad and M/s. Tanfac Industries Ltd., Madras regarding the X-ray analysis of their materials.

Oxide superconductors in Bi (2212 & 2223) system were characterized by X-ray diffraction technique. In particular, in $Bi_{1.7}$ $Pb_{0.3}$ Sr_2 $Hg_1Ca_2Cu_3O_y$ composition where x varies from 0 to 1.0, an interesting finding was that all the specimens show the presence of a predominantly Bi(2212) phase and no reflections corresponding to either a mercury compound or pure metallic mercury were seen. For x = 0.3 composition the observed Tc enhances to 130K and all the lines in the XRD pattern were found to be sharp and belong to 2212 phase only. Similarly effect of Li concentration in the Bi(2223) nominal composition was studied. The larger amounts of Li were found to deteriorate the superconducting properties, probably due to the presence of Cu0 as revealed from XRD.

Structural characterisation of solid polymeric electrolyte films of PVB polymer complexed with Lil, to be used in solid state electro-chromic devices, was carried out. The XRD results showed that these films have amorphous structure. Some samples of PEO polymer (pure and complexed) were also analysed and found to be semicrystalline. X-ray studies were carried out on Cu/Al bi-layers on Si (111) substrate and found that there is an epitaxial growth of copper on silicon.

Ferrofluid (FW40)-polymer (PVA) composite films were prepared under the influence of magnetic field and without magnetic field and were characterized for their physical characteristics. The films prepared under magnetic field were found to have directional clustering of ferrofluid particles of size ~500-2000 nm whereas randomly oriented particles of grain size ~100-300 nm were observed in the films prepared without magnetic field. A small increase in crystallite size was also observed by XRD. The clustering of particles enhances the effective magnetic moment and results in a larger intensity of the EPR signal and higher transmission loss in microwave absorption experiment.

XRD studies on solid solutions of chalcogenide materials CuGaTe and $ZnGa_2Te_4$ were completed. The solid solutions were found to crystallize in tetragonal structure with the lattice parameters lie in between the end compounds. Crystal structure of Ga_2Te_4 a defect zinc blende with one-third cation sites randomly vacant, has also been solved completely. A low temperature form (hexagonal) of Ga_2Te_4 has been obtained by either storage or mechanical grinding or long annealing of high temperature form (zinc blende) of Ga_2Te_4.

A project on the Development of Powder X-ray Diffractometer with the financial support of DST has been continued. All the essential parts of diffractometer have been designed, fabricated and assembled. Some electronic components have been procured and integrated with the system. The complete diffractometer has been optically aligned. Also, development and preparation of silicon powder X-ray diffraction standard reference material has been continued

further. Desired crystallinity of the powder material has been achieved by heating the material at about 1220°C for 20 hours in Ar atmosphere.

ELECTRON MICROSCOPY

As a part of a joint collaborative programme with Indian Association for the Cultivation of Science, Jadavpur, Calcutta, several samples of thin films of ZnTe deposited at temperatures of -30°C, -10°C, room temperature and different evaporation rates were examined by electron microscopy and diffraction techniques. The study showed that as deposited films when examined at room temperatures revealed nano-particles of varying size in the range of a few nm. The films annealed at higher temperature did not reveal any major change in the particle size. The study was undertaken with the intension that the structural information of the ZnTe films will be helpful in the understanding of the optical properties of these films.

In order to understand the erosion of silicon by the impact of argon ions of energy in the range of 2 to 4 kev, SEM study was carried out with bambarded silicon. For this purpose Si wafer having (100) orientation was cut into small discs of 3 mm diameter with ultrasonic cutter and the discs were bambarded with argon ions of energy varying from 2 k.e.v. to 4 k.e.v. for different period of time. The work is in progress and the results will be analysed soon.

The microstructure at the interface can be investigated with the help of T.E.M. The preparation of specimens for TEM examination requires special procedure and skill. With a view to study Si-Sio interface attempts have been made to prepare sample. The work is in progress.

Using transmission electron microscope 47 samples were characterized for particle size & shape and in respect of structure of different materials. 481 samples have been examined by SEM to determine the surface morphology & Topography. Samples from M/s Punia Chemicals (Pvt.) Ltd., M/s Gulshan Sugar and Chemicals, M/s Libra Techno (P) Ltd. were tested to provide information about the particle size & shape of powder samples supplied by them. Samples of fine diamond powder received from collector of Customs Bombay, were examined and report submitted to ascertain the size of the particles.

CRYSTAL GROWTH AND CHARACTERIZATION

The five crystal X-ray diffractometer designed and developed at the National Physical Laboratory has been used for study of crystalline perfection and determination of biaxial stress in the system: low temperature oxide (LTO) + polysilicon on silicon substrates covered with thermal oxide. Polysilicon film of varying thicknesses lying in the range : 0.27μm to 0.725μm were deposited at different temperatures in the range of 585°C to 625°C on silicon substrates having 0.86μm thick thermal oxide. These polysilicon was covered with 0.2μm thick LTO films on both the sides. Substrates single crystals were found to have good degree of crystalline perfection. Deposition led to slight broadening of diffraction curves, but no significant change in contrast was observed in traverse topographs. The main effect of film deposition was considerable bending of the substrates. From the experimentally measured value of radius of curvature of specimens, the value of biaxial stresses were determined. The stress was found to be compressive in nature and its values were in the range : 154 MPa - 318 MPa. This investigation has showed that lowest value of biaxial stress is obtained for polysilicon films of thickness 0.27μm deposited at 585°C.

Point defect clusters in nearly perfect high purity silicon single crystals with resistivity of ~10^4 Ωcm, grown by the Czochralski (Cz) and the float zone (FZ) methods were characterized by high resolution X-ray diffractometry, absolute integrated intensity measurements and diffuse X-ray scattering (DXS) Technique. The half width of diffraction of curves of Cz grown crystal was found to be ~6 arc sec, which is slightly less than that of FZ crystals (~8 arc sec). The absolute value of integrated intensity for Cz specimen was found to be 1.69 x 10^{-6} rad which was slightly less than the theoretically expected value for an ideally perfect crystal i.e. 1.97x10^{-6} rad. The absolute integrated intensity for Fz specimen was found to be 2.34 x 10^{-6} rad. These results show slightly higher degree of perfection for CZ crystals. However, both types of crystals were nearly perfect and free of boundaries and dislocations. An analysis of DXS intensity distribution observed for CZ crystals showed the presence of point defect clusters. The cluster parameters were determined as: cluster radius Rcl = 0.8μm Volume of cluster Acl = 2.02 x 10^{-16} cm^3 and number of defects within cluster Ncl = 1.26 x 10^6. Similar analysis of DXS intensity distribution for the FZ crystals showed that vacancy clusters are the dominant sources of diffuse scattering. The defect parameters were : Rcl = 0.6μm, Acl = 1.32 x 10^{-16} cm^3 and Ncl = 8.3 x 10^5.

BF^+_2 implantation in silicon crystals is widely used to produce shallow junctions for submicron devices. Defects generated in device quality (100) silicon by BF^+_2 implantation have been characterized by using high resolution X-ray diffractometry and diffuse X-ray scattering. The silicon specimen were: n-type, 4-6Ωcm resistivity, 50 mm diameter and 0.3 mm thick. These were implanted with following dose values of BF_2 ions : 1 x 10^{14} cm^{-2}, 5 x 10^{14} cm^{-2}, 1x10^{15} cm^{-2}, and 5x10^{15} cm^{-2}, while the energy was kept constant at 90 kev. Diffraction curves of these crystal showed broadening due to implantation. The absolute values of integrated intensities for implanted specimens were found to decrease with increase in dose value upto a dose value of 1x10^{15} cm^{-2}. This is anomalous and it could be understood only if the top layer of implanted specimens was taken highly disordered and not completely amorphous as was considered till now. A simple model was evolved to explain the observed integrated intensities.

A new non-thermal annealing process has been developed to remove implantation induced damage. This is most effective at dose level of 1x10^{15} cm^{-2} and at lower doses annealing is not appreciable.

It was observed that implanted specimens after annealing contain interstitial clusters. The size of these clusters and other parameters like cluster volume and number of point defects per cluster were determined. The cluster size at the smallest dose level is 1.5x10^{-4} cm and decreases to ~1x10^{-4} cm at the highest dose level with exception at dose level of 1x10^{15} cm^{-2} for which it is ~1.7x10^{-4} cm.

Existing facilities for high resolution X-ray diffraction topography have been extended for recording topographs of large diameter (100 mm) single crystals. A high power rotating anode X-ray generator with $MoK\alpha_1$ radiation has been used to record X-ray diffraction topograph of 100 mm dia (100) Si single crystal wafers. The exploring beam has been monochromatized by using a (111) Si single crystal aligned for (111) reflection. The specimen was aligned for (220) reflection. The contrast in the topographs showed good quality of the specimen without any dislocation lines.

Superlattice structures of GaAs/Al_xGa_{1-x} As are being used in a variety of micro-electronics devices including non-linear optoelectronic devices. Structural characterization of these superlattices is required to evaluate their crystalline perfection and to monitor lattice mismatch between the substrates and epitaxial layers and also between epitaxial layers of different compositions. With the usual double and triple crystal X-ray diffractometers, the experimentally observed value of lattice mismatch is composed of the real lattice mismatch and the physical misorientation between the 'film lattice planes' and the 'substrate lattice planes'. We have used a five crystal X-ray diffractometer designed and developed at NPL for quantitative determination of the two components mentioned above for GaAs/Al_xGa_{1-x} As superlattices. Substrates were Cr compensated semi insulating (100) GaAs single crystals. The structural perfection was determined by using high resolution X-ray diffractometry and topography. The specimens were model superlattices for non-linear optoelectronic devices prepared at IRE, Moscow. One of the specimens (#205) had 100 layers of 14.5 nm thickness of Al_xGa_{1-x}As/GaAs. The other (#276) had 10 layers of thickness 114 nm each. $MoK_{\alpha 1}$ radiation, 400 reflection, symmetrical Bragg geometry, a (100) GaAs crystal as an analyzer crystal and (+, -, +, -) and (+, -, +, -, +) configurations of the diffractometer were used. High resolution X-ray diffraction curves of specimen #205 showed well resolved peaks due to substrate and the epitaxial film. The specimen was placed at the 4th crystal position and the analyzer was not employed in this experiment. The separation between peaks $\Delta\theta_4$, was 40 arc sec. This angular separation was found to be sensitive to azimuthal orientation of the specimen, showing that there is a physical angular misorientation between the diffracting planes of the substrate and the films. We determined with the analyzer crystal, the actual lattice mismatch. The analyzer gives the angular separation only due to lattice mismatch and the orientational mismatch has no effect on the value obtained by this experiment. This value was 46.5 arc sec which corresponds to $\Delta d/d = 1.794 \times 10^{-4}$. The difference of this value and $\Delta\theta_4$ is the orientational mismatch. In specimen #276, the superlattice reflections could be obtained clearly. We have also evaluated the perfection of these specimens. All the diffraction curves were quite sharp. Half-widths of some of the curves was ~6 arc sec in (+, -, +, -, +) configuration showing that the crystalline perfection was of high degree.

A double crystal X-ray diffractometer with $CuK\alpha_1$ radiation was also used to study superlattice satellites in $Al_xGa_{1-x}As$/GaAs system. The specimen was (001) oriented 10 period superlattice with superlattice thickness of 1140±25°A. $CuK\alpha_1$ from (001) GaAs single crystal monochromator was used for (004) reflection of GaAs superlattice substrate. Two satellite peaks J_{-1} and J_{-2} were recorded at lower angle side of J_0 peak. No peak on higher angle side was observed. Half width of the peaks was found to be ~20 arc sec. Angular separation between zeroth order peak and J_{-1} was found to be 120 arc sec. Now, we plan to repeat this experiment with (001) Ge single crystal monochromator.

For growing large size lithium niobate single crystals, various components like a new ceramic crucible holder for large crucible, quartz chamber, R.F. coil, after heaters etc. were designed and fabricated at the National Physical Laboratory. This updated experi-mental set up has been used to grow a ~50 mm diameter lithium niobate single crystal by Czochralski technique on a pulling machine developed in this group.

A powder X-ray diffractometer has been designed, fabricated and assembled at the NPL under a project sponsored by Department of Science and Technology, New Delhi. All mechanical parts of the goniometer have been designed, fabricated and mechanically tested. Two synchronous motors with shaft rotation of ½ r.p.m. and 1 r.p.m. have been coupled with the goniometer for theta - 2 theta rotations. The system has been optically aligned and goniometer has been tested on an X-ray source. X-ray diffraction curves of single crystal quartz and silicon have been recorded.

Assembly of different parts for experimental set up for in situ measurement of biaxial stress due to thin deposits on semiconducting crystals is in progress.

Characterization facilities have been provided to outside institutions: Solid State Physics Laboratory, New Delhi and Indian Institute of Technology, Kharagpur

An extensive characterization of InP single crystal substrates with InGaAs epitaxial layers regarding perfection and composition of film has been carried out. These experimental findings provided valuable feedback to the scientists of SSPL, New Delhi in their epitaxial growth of thin films.

p-type Si substrates with SiN_x epitaxial film grown over widely/different growth conditions were characterized for IIT Kharagpur. Growth parameters which produced minimum stress in substrate were found out which helped in optimising the growth condition for good epitaxial thin films.

LOW TEMPERATURE PHYSICS

SUPER CONDUCTIVITY

(i) Site-dependent Substitutional Effects in Er 123 System

A systematic study of resistivity, a.c. susceptibility and heat capacity was carried out for pure and substituted Er 123 system where Cu had been partly replaced by Ni, Zn, Fe, Co and Ga. These substitutions were aimed at studying the role of in-planes and out-of-plane disorders resulting from the above cationic substitutions. Of these Ni and Zn occupy Cu (2) site of Cu-O planes while Fe, Co and Ga prefer Cu (1) site of Cu-O chain. The latter primarily have the effect to reduce the interlayer coupling between Cu-O planes where superconductivity resides and thereby make the system more two dimensional. Manifestation of this is the enhancement of fluctuation effects which are depicted in the form of broadened transitions of the specific heat anomaly, magnetic susceptibility and resistivity close to superconducting transition.

This work which was published in Phys. Rev. B has received appreciation from Dr. J.C. Phillips of AT & T Bell Laboratories.

(ii) Superconductivity in Pr Doped Y-Eu-124 System

The role of Pr incorporation in $(Y/Eu)_xPr_{1-x}$-124 system was investigated to understand doping effect of Pr on superconductivity of 124 system. As compared to 123 system dTc/dx is smaller. Secondly, the role of T_c depression with Pr doping is more for Eu-124 than in Y-124 system. The results are discussed in terms of hole-filling model and also the AG theory. The different T_c variations in Y and Eu based systems is understood on the basis of the indirect effect of Pr on the coupling of the Y Eu-state with Cu3d-o2p state. (The work has been published in Phys Rev. B).

(iii) STM Studies of Cuprates

STM studies were carried out on many cuprate superconductors like Bi-2122 and single crystals of Y-123 and Pb-Sr-Y-Ca-Cu-O. Through STS studies carried out in conjunction with STM, it has been possible to identify various cationic layers such as Ba-O, Y, Cu-O planes and Cu-O chains etc. seen in STM images. In particular LDOS in the conductance spectra show gap structures which are absent in the case of conducting Cu-O planes. Since in most of these cuprates O 2p states are placed at E_f, the low voltage images in general reveal oxygen atoms. At higher voltages, however, both species of ions can be visible. Fig. 1 shows STM image of twin boundaries in YBCO single crystals grown at Clarendon Laboratory, Oxford.

SUPER CONDUCTIVITY & MAGNET SYSTEMS

I Basic Research

A. A most exciting work of the year is the finding of an internal source of oxygen in YBCO superconductors. YBCO continues to be an interesting material with T_c above LN_2 temperature (77K) and available in a pure single phase form. Oxygen stoichiometry well inside the material has, however, remained an unsolved problem even when the sample is sintered in flowing oxygen for long periods. Through a series of systematic

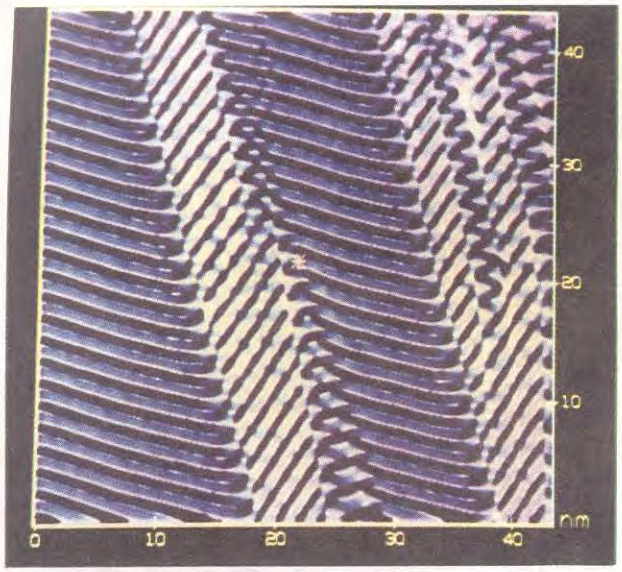

Fig. 1: STM observation of twin boundaries in YBCO single crystal

studies we established that small quantities of an oxide added to the YBCO system acts as an internal source of oxygen for the formation of a stoichiometric compound with T_{CO} = 90K. No external oxygen flow is needed. Samples can be prepared in ambient air and the oxygen stoichiometry inside the material is uniform. A variety of other rare earth substituted 1-2-3 compounds are being synthesized and studied.

B. We had postulated some times back that the percolation threshold for thermoelectric power (to become zero at T_C) in a super conductor is far too small compared to the threshold for electrical conductivity. To verify this postulate we have prepared a series of composites consisting of YBCO diluted with CuO (70-95 wt%) and thermoelectric power measurements are now in progress.

C. Studies-have also been carried out on partial replacement of di-valent Ca by a tri-valent d-band material (yttrium) and tri-valent f-band material (dysprosium) in Bi-2212 and Bi-2223 superconductors. Y-substituted 2212 samples show an abnormal increase in T_{CO} varying between 93 and 95K. The Dy substituted samples, on the other hand show a decrease in T_C. These studies are being extended to other d and f band impurity additions with a view to understand the role of cationic substitution.

II. Applied Research

1. Development of a Superconducting Magnet and a Long Hold LHe-Dewar for 100 MHz NMR System

A. *The Cryostat :* The cryostat for housing the SC magnet was got fabricated. The special features of this cryostat are that it has a total LHe capacity of 190 litres, a 20K radiation shield and an outer LN2 vessel. All the interspaces are filled with superinsulation. The cryostat has a room temperature bore of 52 mm.

The cryostat was brought back to NPL from the fabrication site and reassembled. The cryostat was thoroughly checked for vacuum leaks, then with LN_2 and finally with LHe. The evaporation rate of LHe was found 1.30/ day. Thus establishing a hold time of more than 90 days slightly better than it was designed for.

B. *The Magnet :* A super conducting magnet with a winding bore of 112 mm and a winding length of 380 mm, the largest size we handled so far, was fabricated using a Cu-(Nb-Ti) single strand wire. For field stability the magnet was designed with low operating current ~30 amp and large inductance. For homogeneity the magnet had six order compensation coils (outside notch). Shim coils have been provided to improve the homogeneity of the field. A set of six concentric coils have been used to provide axial field correction and a set of 32

saddle shaped coils used to provide radial correction. The main coil as well as each shim coil has been provided with a persistent switch of suitable current rating. Superconducting joints between switches and coils were made using a specially designed welding system.

A support system was made for the LHe testing of the magnet using a bucket type of LHe dewar. The magnet was put in persistent mode at the specified field of 2.35T (see Fig. 2). The performance of the magnet was satisfactory. Shim coil testing has to be carried out since the shim heater current provided by the shim power supply was insufficient. The shim power supply current has since been enhanced.

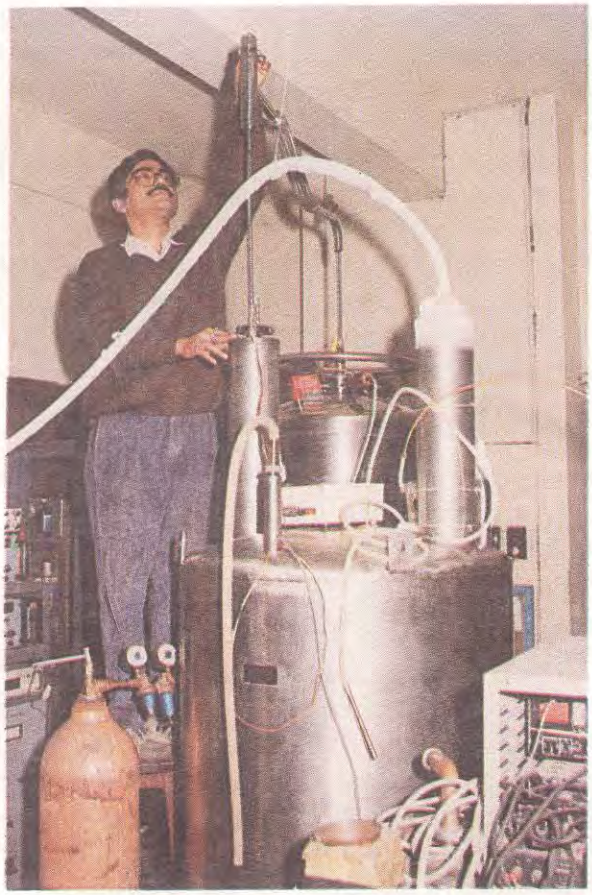

Fig. 2: A 2.35 T super conducting magnet and a liquid helium dewar with a hold time of 90 days developed at NPL for a 100 MHz NMR spectrometer

2. *Consultancy to a 200 KVA to BHEL on Super Conducting Generator*

The year also saw the successful completion of the BHEL's project on a prototype 200 KVA super conducting generator. NPL, provided significant support related to superconductor testing under high field (8T) and high current conditions, installation of the liquid helium and liquid nitrogen plants, testing of the subsystems for vacuum and low tempreature thermal cycling, static test at 4.2K of the SC rotor etc. The generator, was finally tested successfully this year at an excitation current of 410 amp producing a power of 40 KVA. The rotor was tested upto the specified rotation speed of 3600 RPM. The power was fed to the grid. The critical components of the project were rotor design, SC winding, impregnation, LHe feed throughs, rotating LHe cryostat, design of radiation shield, optimized current leads, recovery of He-vapours. By all standards it was an exciting experience to have been involved in a high tech system and more so to have interacted with BHEL in the persuit of applications based on conventional superconductors.

THEORETICAL STUDIES

A model theory is proposed to explain the superconductivity in C^{n-}_{60} fullerides. It involves Jahn-Teller interaction in the two low lying triplets T_{1u} and T_{1g} and a mixing between the two under an odd vibration γ_{1u}. The theory predicts a maximum pair-binding energy at n=3, the doping level at which the super-conductivity appears. This is in contrast to the results of earlier theories which show an equal pair-binding for all odd dopings.

INTERNATIONAL GEOSPHERE BIOSPHERE PROGRAMME

Solar UV-B Radiation and Aerosol Measurement

The data on UV-B radiation at 280, 290, 300 and 310 nm were analysed for the period 1985 to 1992. The ratio of the differential variation in UV-B intensity to the differential variation in ozone content were calculated to find the magnification factor. Its value ranged from 1 to 10 depending upon wavelength and total ozone content. A relationship between UV-B radiation and cloud cover was also established.

The intensity of global UV-B radiation at 310 nm was correlated with sunspot number for the period 1984 to 1987. The relationship between global radiation at 310 nm versus sunspot number showed a negative correlation.

The UV-B and aerosol measurements were carried out during biomass burning campaign from 17th Feb. to 25th Feb. 1995 at Haflong, Assam.

Solar Infrared Spectroradiometer

Measurements by spectroradiometer for the period 1992-93, were analysed to determine the integrated columns of NO_2, N_2O, NO and H_2O. It has been found that the summer time values of NO_2. N_2O, NO contents show the same trend as total ozone, wheras water vapour does not show the same variation. The increase in water vapour during July is possibly attributed to the on-set of S.W. monsoon in this region, which loads the troposphere with excess water.

Ozone Trend Analysis

Late summer maximum to total ozone at subtropical Indian latitudes has been studied and the change in rate of production due to decrease in insulation, after the late maximum, has been calculated which agrees well with the observed variation at 25 km.

One dimensional modelling of Ozone depletion due to volcanic aerosols at upper stratospheric heights has also been completed. It is observed that even after a lapse of one year after the E1 Chichon Volcanic eruption there is a disturbance in QBO at 10° N latitude due to ozone depletion upto 35km. The investigation reveals that at these upper stratospheric heights of 30-35 km, the large hydrated sulphuric acid aerosols formed after one month of the eruption, introduce radioactive changes which affect ozone production and loss rates resulting in net depletion.

Planetary Atmospheres

Work continued on the ionosphere of Venus and its interaction with solar wind. In particular studies were concentrated on electron cooling rates, Venus ionopause and H^+ flow.

Electron cooling processes and their rates in the region between 200 and 400 km in both the magnetised and unmagnetised conditions were studied. Langmuir probe measurements of electron density and electron temperature from the Pioneer Venus Orbiter were used for these studies.

A comparison has been made of the altitude location of density ionopause (DI) and the pressure ionopause (PI) by using elec-

tron temperature probe and flux gate magnetometer measurements on the Pioneer Venus (PV) Orbiter. It is suggested that the "density" ionopause is an appropriate definition for the altitude where the ions pause. It is least restrictive and can be applied to low as well as high solar wind conditions. An attempt has also been made to estimate the horizontal velocity of the plasma at the density ionopause. A velocity of about 27 km/sec is inferred for extremely high Psw coditions when DI is at its lowest altitude limit of 290 km.

At Venus, H^+ is expected to be under diffusive equilibrium above about 400 km, but is difficult to verify this under normal circumstances, because solar wind interaction terminates the subsolar ions around 400 km. After searching through the Pioneer Venus data, we have been able to identify some orbits with ionopause altitudes above 1000 km. Altitude distributions of O^+ and H^+ measured by ion mass spectrometer experiment, have been studied for these orbits. It is found that while O^+ distribution is consistent with diffusive equilibrium, H^+ shows large departures providing evidence for upward flow of H^+. Approximate calculations indicate that the flow is subsonic.

MST Radar

Radar time was allocated to the NPL-MST Group during this year for two of its proposals - one on winds and the other on E-region field aligned irregularities.

During MST mode operation, the Indian MST radar was used to study the winds, waves and turbulence in the troposphere and lower stratosphere. The Doppler power spectrum data were obtained using five beams E-W-ZY-N and S between May 20 and June 1, 1994, covering a range from 5-24 km. With a height resolution of 150 m. On all the days, except 26th May, 1994, the wind was calm with the maximum average wind shear remaining below 0.036 (m/s)/300 m. On 26th May the average wind shear reached as high as 0.066 (m/s)/300 m at altitudes well above the meteorological tropopause. Also the region near and above the tropopause showed strong turbulence, coupled with the enhanced relative echo power. For the first one hour (~10:00-11:00) of the event, the Doppler width was observed to be very high (~2Hz), which gradually became normal after the event.

Indian MST radar at Gadanki was also used to observe field aligned irregularities in the ionospheric E-region during July-August, 1994. Three dirunal cycles of observations were taken on 26-27 July, 2-3 August and 4-5 August 1994 with radar beam pointing transverse to the geomagnetic field lines. Doppler spectra were obtained at every 20 seconds with a range resolution of 600 meters. Field perpendicular echoes were observed throughout the diurnal cycle of observations. During the daytime, echoes were observed from 87 to 97 km altitudes, while during night time these were observed from 85 to 118 km altitude. Significant differences between the morphologies of the echoes during the daytime and night time were observed, both in time and height distribution.

During the post sunrise period, echoes were observed from 87-98 km altitude range, while during post sunset period, these were observed from 85 - 118 km altitude range. There are significant differences between the morphologies of the echoes observed during post sunset and post sunrise period, both in time and height distribution.

INDIAN ANTARCTICA RESEARCH PROGRAMME

Laser Heterodyne System

A laser heterodyne system using a tuneable CO_2 laser as a local oscillator and sun as a

source with one GHz acousto-optic spectrometer (AOS), developed at NPL was set up at Maitri (70° 46' S 11° 44' E), an Indian Antarctica station, to measure the vertical profiles of minor constituents in the stratosphere and troposphere during 13th and 14th Indian Antarctic Scientific expeditions. Data for ozone profiles was generated and is being analysed.

Infrared Sun Photometer

An infrared Sun photometer is in use at NPL to study the absorption spectrum of the Earth's atmosphere in the 2.5 μm-14.5 μm wavelength range. The observed atmospheric spectrum in the 2.5 μm - 14.5 μm range showed absorption by water vapour, carbon dioxide and ozone. The resolution of the present Sun photometer was improved by incorporating a monochromator of spectral range from 0.8 to 15 μm instead of variable circular filter.

The IR Sun photometer was also taken to Antarctica during 14th Indian Scientific Expedition to monitor the infrared solar radiation absorption spectrum in the spectral range 0.8 - 1.6 μm. The spectra obtained there show very low water vapour content over Antarctic region than that at Delhi.

mm Wave Radio Spectrometer

The mm wave ozone radiospectrometer which was brought back from Antarctica at the conclusion of the 13th Antarctic expedition was taken to DEAL - Dehradun for EMI/EMC testing. The instrument has since been sent back to Antarctica during the 14th Antarctica Expedition and installed at the Indian Antarctic Station Maitri. It is currently observing ozone on a continuous basis and shall provide us our first measurement of ozone height profiles through the depletion period this October (1995). A sample comparison with ozoneesonde is shown in the Figure 1.

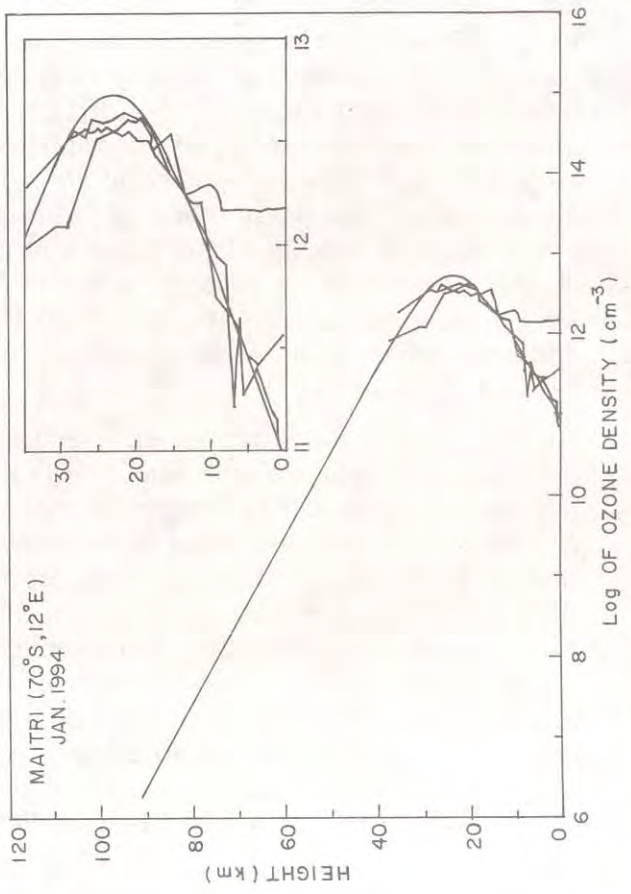

Fig. 1

Planetary Boundary Layer

In the area of PBL over Antarctica, it was found that the fluxes of heat and momentum pay a vital role in linking the lower and upper parts of the PBL. The PBL is in the convective state for a short period in summer and is most stable for the rest of the period. A study of the thermal plumes using acoustic sounder and a microbarograph shows that the two techniques are complementary to each other.

RADIO COMMUNICATION

Short Term Forecasting and Consultancy Services

RWC (New Delhi) continued to cater to the

needs of a large number of users during 1994. Daily, as well as, special forecasts on solar and magnetic conditions were provided to user agencies - forecasts on disturbed magnetic conditions to Indian Institute of Geomagnetism, Bombay, to aid in their experimental comparisons of Antarctica, forecasts of solar and magnetic activities of Physical Research Laboratory, for their Fabry-Perot experiments and to VSSC, Trivandrum for their Rocket experiments, being some of them. ISAC, Bangalore continued to receive short term forecasts on solar and magnetic indices.

Comprehensive study was initiated to find the ionospheric responses to magnetic storms. One of the major results of this study has been a spectacular midnight collapse in F region ionization at equatorial latitudes. This collapse has been found to occur in both main and recovery phases of the storm. Expected departures in Maximum Useable Frequency (MUFs) during these periods are being modelled for use in HF communication predictions.

Prediction of HF field strength over the Indian subcontinent using CCIR procedures, generally, showed large departures from observations. As part of a Defence sponsored project on ionospheric models for HF communication, special campaigns were conducted to formulate our own procedures suitable for the Indian ionosphere. The procedure evolved by us has been passed on to the relevant Defence Communication Services for their use.

Plasma bubbles generated at the geomagnetic equator are responsible for the observed ionospheric scintillations in VHF and UHF bands in a wide belt of latitudes extending upto 20 geomagnetic latitudes. The occurance probability of scintillations at low latitudes was found to be only 40 per cent of that at equator.

Long Term Solar and Ionospheric Predictions

Sunspot predictions were supplied to the user organisations six months in advance on routine basis.

Distribution functions for daily variations of FoF2 and MUF (4000) F2 have been calculated for three Indian stations : Delhi, Ahmedabad and Kodaikanal.

Peak parameters of the F-region based on regional model of F-region parameters over the Indian subcontinent were compared with those obtained from global CCIR-340 model. It was found that regional model gave a better representation than the Global model.

Consultacy of HF circuits was provided to Indian Navy and Border Security Force.

Anomalous Long Distance TV Signals

An attempt has been made to predict percentage occurrence of spread-F and sporadic E at any place over Indian subcontinent during high and low solar activity periods from the ionosonde data. This can explain scintillations received from the satellites at any place in India

Effects of Rain on Radiowave Propagation

An integrated package consisting of identifying the origin of fading and choosing the appropriate remedial measures has been developed based on the study of various IOS Links. Diversity techniques usually used to reduce the fading and improve the performance of the links have been explored and evaluated.

A comparison of various rain attenuation prediction with the observed radiometric attenuation comulative distribution functions over northern India has been carried

out and the errors of prediction methods and their r.m.s. deviations calculated. The study shows that Garcia-Lobez method appears to be suitable for predicting the attenuation due to rain once the rain rate comulative distribution function is known.

Based on the observed rain rate distribution over Shillong using 10 sec. rapid response raingaugees, it is seen that they differ considerably from the once reported by ITU-R s observations.

Microwave/mm Wave Radiometry

The data obtained from 22.235 GHz radiometer were evaluated for the water vapour content in the troposphere. An inversion technique was evolved to retrieve the water vapour profile from microwave radiometer measurements of antenna temperature at 22.235 GHz. This basically takes into account the attenuation co-efficient from the theoretical work obtained from the literature. Attenuation data obtained by 11 and 18 GHz microwave radiometers have been analysed for annual and annual-worst month attenuation statistics.

RADIO AND ATMOSPHERIC PHYSICS

Improvement of International Reference Ionosphere (IRI) Model

The electron density (Ne) profiles from incoherent scatter radar at Arecibo have been used for comparison with IRI model to test its validity for F2-peak altitude, hmF2. Good agreement has been found between the median values of the observed hmF2 and IRI.

The LAY formulism is a procedure for analytical representation of layered structure of Ne (h) profile between E and F2 peak. For this purpose IRI uses combination of 4 LAY functions (each associated with transition height, scale width and amplitude). Using Ne profiles we have obtained 12 parameters by fitting a sum of 4 LAY functions to the observed profiles. Large discrepancies were found in primary transition height parameter during night and scale parameter both during day and night.

Comparison of the IRI - 90 profiles for the lower ionosphere with those derived from A, absorption measurements indicate that the IRI-90 values of electron density are consistently higher in the lower E-region.

For the generation of bottomside electron density (Ne) profile shape, IRI provides an option for using the height of half density point h0.5, which is based on mid latitude stations. When compared with low latitude, however, large departures were noted in h0.5, between observed and IRI values. Ratio of h0.5/HmF2 is now modified with IRI based upon our results from the low latitude station at Arecibo.

MICROBAROGRAPH

Three Microbarograph units were fabricated, with the help of a private firm at Bangalore in order to reduce the cost and save foreign exchange. The units were supplied to the Physics Deptt. of Pondichery University, Pondichery.

SATELLITE RADIO BEACON STUDIES

Comparison of Faraday rotation measurements at Delhi with those derived from International Reference Ionosphere (IRI) shows that the IRI model overstimates FR values in all seasons and solar activity conditions by 55 to 32%. However, in the 05-06 hrs time slot the estimates are within 20% in all seasons during low solar activity and in winter and autumnal equinox of high solar activity.

The plasma-bubble rise velocities were also calculated using the time difference in the

onset of scintillations at Bangalore, Hyderabad and Delhi and are found to be in the range 33-88 m/s in the 415-525 km altitude range and 110-210 m/s in the 525-1300 km range above the gm equator.

The performance of GPS receiving system has been evaluated as the system employs dual frequency correlation for determining the differential group delay due to the ionosphere, which could be considerably affected when the two L-band frequencies (1575 & 1227 MHz) are strongly scattered by spiky ionospheric structures.

SROSS AERONOMY MEASUREMENT

Under the continuing NPL-ISRO collaborative programme, the second aeronomy Payload of Retarding Potential Analyser (RPA) was sent into space on May 4, 1994 aboard Indian satellite SROSS-C2 for studying the energetics and dynamics of the equatorial and low latitude ionosphere/thermosphere. SROSS-C2, a 114 kg. satellite was launched from SHAR Range of ISRO by the ASLV-D4 satellite launch vehicle and was placed in an elliptical orbit having orbit inclination of 46° and apogee and perigee at 930 and 430 km respectively. Later, the orbit was brought down to 630 x 430 km SROSS-C2 is spin stabilised orbitting satellite with an orbital period of 100 seconds approximately.

In orbit performance of all the payload elements has been extremely good and quality data is being collected over the Indian subcontinent. The payload is switched on for data collection in 2 high elevation passes out of the 4 orbits visible from telemetry stations located at Bangalore and Lucknow. Thus, on a average, RPA data is collected for 2 orbits a day, one during day time and one in night over the Indian subcontinent. So far RPA data has been collected for more than 600 orbits during the past one year and analysing is being done on a continuous basis.

TECHNICAL INFRASTRUCTURE

LIBRARY

In order to carry out the task of providing information support in physics and related sciences the Library undertakes all necessary functions and activities such as updating collections, offering and generating information services, developing network linkages with local scientific libraries. About Rs. 55 lakh were spent towards collection development, acquiring 205 titles, of which 23 were in Hindi language, and subscribing 188 journals. Most of the journals that library acquires are high impact journals, coming from reputed publishing houses in the world.

Until last year the library had been getting INSPEC on disk-Physics Abstracts (CD version), Current Contents on Disk. This year Materials Science Citation Index (CD version) has been added bringing up the total number of databases, that the library subscribes, to three. The library supplied latest references on 50 on-going research projects. It compiled 18 bibliographies on demand. CD-Search facility, which started in 1994, was in great demand this year also. A total of 71 searches were made downloading 38,582 references from CD databases. In its photocopying service the Library took out 1,02,091 copies in response to requests made by the scientific staff.

The Library has network linkages with DELNET. Its E-mail services were used for document identification, procurement, and delivery. Effective from this year the Library has started offering its membership to R & D institutions on payment basis. It enrolled one member this year against this facility.

GLASS WORKSHOP

This Unit has continued its activities in the field of design development, fabrication and repairing of Scientific Glass and Quartz Apparatus & Equipments for the uses with in the Laboratory as well as for outside Institutions, Industries, R & D Organisations. In addition to this the GTU activities are going on well and has made very satisfactory progress by way of saving the foreign exchange.

The following are the representative organisations/Institutions benefited by the work carried out for use in their's Research & Development works.

(i) M/S Indian Oil Corporation Ltd. Faridabad-121007 (Hr.)
(ii) Deptt. of Electronics Sciences, University of Delhi.
(iii) Osmania University, Hyderabad.
(iv) Deptt. of Chem. Engg. I.I.T. Bombay.
(v) School of Physical Science, J.N.U. New Delhi.
(vi) Deptt. of Chemistry, Punjab University, Chandigarh (Pb.)
(vii) S.N. Bose National Centre for Basic Sciences, Calcutta.
(viii) Deptt. of Physics, Jamia Millia Islamia, New Delhi.
(ix) Division of Biochemistry, IARI, New Delhi.
(x) V.P. Patel Chest Institute, University of Delhi.
(xi) M/s Industrial Carbon, Calcutta.

During the year 371 Internal Jobs were undertaken of various Division/Projects of our own Laboratory.

INSTRUMENTATION

Design layout of ophthalmic probe and associated electronic circuitry has been completed. 10 MHz piezoelectric (PZT) crystal has been studied for use in the probe. Associated circuits have been designed.

Micro-sensor chips developed have been tested for their performance parameters. The chips have been put in the form of four-arm Wheatstone bridge with p-type resistors each having 900 to 1000 ohms resistance. The chips made have been used in precision instrumentation systems for industrial and biomedical applications, due to their features of signal conditioning, auto-calibration, self-testing, small size and greater sophistication.

The smart pressure sensor chip with p-type silicon piezoresistors in the Wheatstone-bridge-form has been further improved for on-line pressure measurements. The bridge and its associated electronics are mounted on a thin metal diaphragm. A blood pressure system has been used for calibrating the pressure sensor system in the range 0 to 500 mmHg. The smart sensor has been interfaced to a PC (personal computer) and LAN (local area network) system for on-line measurement of pressure. This is very useful in process controls.

Acoustical studies of various complex and heterogeneous materials media were started. Both biological and engineering materials would be studied. Carbon composites were studied for knowing the strength and elasticity of the material for shoe soles for the defence personnel in mine operations.

Pulse delay generation of 1 pps was achieved from standard 10 MHz source in steps of 100 msec, 10 msec, 100 usec and 1 usec., for precision measurements. Know how is almost ready for commercialisation.

Improvements were made in the digital TCXO (temperature controlled crystal oscillator) for use in time-base of DFC (digital frequency counter) in precision clocks for frequency measurements with 1×10^{-8} level. A low cost ultrasonic power meter, based on measurements of radiation pressure with the help of sensitive microgram balance was designed and fabricated.

168 instruments were tested and evaluated/checked for their workability and performance before return to Central Stores. Some of the major instruments were glass technology furnaces/rectifiers, Data Loggers, Recorders, Frequency Counters, CROs, RF Analysers, Induction Motors, R.F. Voltmeters, DMM, DVM, Power Rectifiers, Power Amplifiers, Printers, Computers, Electronic Typewritters etc.

From time to time technical assistance has been rendered to various scientists for inhouse projects in the design of electronics circuits and subsystems for their measuring systems.

Inward inspection was made for Electronic and Electrical Stores when the materials were procured in the Central Stores. More than 50 test reports were prepared and submitted to the Central Stores during the year, for various electronic components, ICs, devices and sub systems.

PUBLICATIONS

(Published in Journals. Conference proceedings not included)

STANDARDS

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APPENDICES

SPONSORED/SUPPORTED PROJECTS

Sr. No.	TITLE	AGENCY	AMOUNT RECEIVED (Rs. in Lakhs)
	NEW		
1.	Development/Fabrication of Zeeman Split Frequency Stabilized 633 nm He-Ne Laser Source for Precision Laser Based Instrument.	DST	5.000
2.	A Study on the Deteriorating Effect of Selective Availability on Precise Positioning and Timing in Normal GPS and DGPS Modes.	DRDO	8.000
3.	Development of High Tc RF Squid Basic System suitable for Operation at Liquid Nitrogen Temperature. (6 Nos)	DST	5.500
4.	Development of Ultrasonic Biometry Equipment.	DST	10.000
5.	Development of Conducting Polymeric Filters for Virus Monitoring in Water	DBT	7.900
6.	Development of Solid State Electrochromic Devices (ECDS) for Display Applications.	DOE	7.250
7.	Manufacture of 50 prototypes of Glucose Biosensor and 50,000 Glucose Biosensor Strips for Full Scale Field Trials.	NRDC	1.506
8.	Development of Polyaniline Based Gas Sensors.	DOE	6.176
9.	Development of Module Hydride Air-Conditioner.	DST	1.500
10.	Atmospheric Studies using Microbarograph.	Pondichery University	1.350
11.	Electron Acceleration using Radiation Characteristics and Development of Solar Flare Model.	DST	1.498

12. Interaction with Universities/Laboratories in the Area of Superconductivity.	UGC	2.000
13. Brainstorming Session at NPL on Global Phenomenon in Geoenvironment.	DST	1.050
14. Development of TGS Pyroelectric Detector	DST	6.230
15. Spectral Shift due to Source Correlation and its Implication in Optical Measurements	DST	15.146
16. Basic Aspects of High Temperature Superconductivity.	DST	3.000
17. Design, Development & Fabricatioin of Piezoelectric Acelerometer (5Nos)	CRRI	0.225
18. Optical and Electrical Properties of Langmuir Bhodgett Films.	DST	6.497
19. Nitrous Oxide Emission from Agricultural Fields and Wetlands in Northern India.	DST	1.250
20. Development of Suitable Insert Material for Antimine Boot.	DRDO	7.000
21. Organisation of PAC Meeting on Condensed Matter Physics on Nov 21 - 22, 1994, at NPL, New Delhi.	DST	1.400
22. Development and Fabrication of a System for Ion Beam Microetching of Materials for Microstructure Analysis by Transmission Electron Microscopy.	DST	8.000
23. Estimation of Aluminium in Sera, Water, Bore and Dialysite by Flameless Atomic Absorption Spectrophotometer.	AIIMS, New Delhi	0.200
24. Fabrication & Characterization of Prototype Hydrophones using PZT Polymer Composite Material Developed at NCML, Bombay.	NCML	3.000

25. Development of a unit for the Destruction of Benign and Malignant Tumors in the region of ENT., based on High Refrigeration Capacity J.T. Cryo Probes.	DST	3.000
26. Measurement of Thermospheric Wind and Temperature with Ground-Based Fabryperot Interferometer.	DST	25.000
27. Development of Process and Coating System for Fabrication of Infrared Optical Filters for use in Environmental and Pollution Control Instruments and Agri-Electronic Instruments.	DST	12.000
28. Development of a Focussed Ultrasound System for Tumor Therapy.	DST	18.000

CONTINUING

1. Calibration Service Programme under the NABL Programme.	DST	14.550
2. Development of Graphite Reinforced Carbon Bipolar (Separator) Plate for Fuel Cell.	MNES	1.300
3. Development of a Vapour Compressor Based Refrigerator for Storage of Life Saving Vaccines like DPT etc for the National Immunization Programme.	DST	1.500
4. Preparation and Characterization of Halogan Intercalated Carbons.	Indo-French	0.384
5. Design Development & Fabrication of Doppler Mini-Acoustic Sodar (MINI SODAR) for Studies of the Atmospheric Boundary Layer.	DST	1.500
6. Development of High Critical Current High Tc Superconducting Thin Films for Fabrication of Squids and Infrared Detectors.	Indo-French	12.678
7. Deformation Behaviour of Composite Materials (Aluminium Alloy Matrix Composites).	DST	3.000

8. Synthesis, Characterization and Application of some Conducting Polymers (Phase II).	Indo-EEC	7.976
9. Development of Ionospheric Models for High Reliability HF System.	DRDO	1.372
10. Impact Assessment Studies of Noise Pollution.	ME & F	0.303
11. Development of Powder X-Ray Diffractometer.	DST	30.870
12. Laser Heteradyne System for the Study of Ozone and other Minor Constituents in Antarctica.	DOD	2.000
13. Studies on Reliability and Availablity of GPS Signals in India (SARGI).	DOE	2.000
14 Development of a Semiconductor Processing Equipment.	CEERI Pilani	1.238
15. Use of Laser Heterodyne System with Acousto-optic Spectrometer for Atmospheric Studies over Tropical Lattitude.	Indo-French	7.994
16.Development of Process for Fabrication of 15% efficiency Single Crystal and Multicrystal Silicon Solar Cells.	MNES	7.000
17. Laboratory Level Technology Development of Some Biosensors and Related Biomaterials.	DST	6.550
18. Development of a Superconducting Magnet with a Long Hold Dewar for a 100 MHz NMR Spectrometer.	DST	3.000
19. A Study of Biomass as Energy Source and Technical Option for Green House Gas Emission Reduction.	AIT Thailand	1.550

COMPLETED

1. Technical Feasibility & Concept Proving in the Area of Biomolecular Electronic Devices. *(Project Already Completed)*	DST	4.815
2. Comprehensive Programme of Manpower Development-Associateship/Fellowship Programme. *(Project Already Completed)*	DOD	0.291

R & D COLLABORATION

The laboratory maintained scientific collaboration and liaison with other scientific institutions, universities, government departments, CSIR laboratories and international institutes regarding various activities. The names of the organisations and the areas of collaboration are listed below :

INDIA

1. Indian Institute of Technology, New Delhi (Dilute Magnetic Semiconductors and Superconducting Ceramics
2. University of Delhi PZT Films for MOS Devices
3. E Co Solar Systems Ltd Pune (CDTE Solar Cells)
4. AIIMS, New Delhi (For estimation of aluminium in plasma and bone samples)
5. TIFR Bombay, I.I.T. Kanpur, Jamia Millia Islamia, New Delhi. (Superconductivity).
6. CEERI, Pilani (Characterization, Semiconductor and Processing)
7. Physics Department M.D. University Rohtak. (Characterization)
8. Dept. of Environment, New Delhi
9. Dept. of Science and Technology Promotion Council, New Delhi
10. Building Material Technology Promotion Council, New Delhi.
11. Kurukshetra University (Fabrication of PECVD Reactor)
12. I.I.T. Kanpur (Radiation Detectors)
13. ASSCP - BHEL, Gwalphari (Reactor and Panel Fabrication)
14. IRDE, Dehradun (Large Area PECVD Reactors and DLC Coating)
15. IGCAR, Kalpakkam
16. NMRL, Bombay (Characterization)
17. NSTL, Visakhapatnam (Fabrication Pinger Unit)
18. CSIO, Chandigarh (Development of Ultrasonic Transducer)
19. Hindustan Aeronautics Ltd., Nasik (Carbon Fibre)
20. C.E.C.R.I. Karaikudi (Carbon Fibre)
21. BHEL Hyderabad (Carbon Fibre)
22. Himadri Chemicals and Industries Ltd. Calcutta (Carbon Fibre)
23. Defence Research and Development Laboratories, Hyderabad (Carbon Fibre)
24. Defence Materials and Stores Research and Development Establishment, Kanpur. (Carbon Fibre)
25. M/s. Fl. E Reserch Institute at Ichalkarauji, Maharashtra (Development of 300 Kgf dead weight machine).
26. Centre for Liquid Crystal Research Banglore (Electrolumine Scent Panel)
27. Defence Research Laboratory, Jodhpur
28. M/s. Opto Electronics Factory, Dehradun
29. Rajastan Electronics & Instrumentation Ltd., Jaipur. (Silicon Solar Cells)
30. Defence Metallurgical Research Laboratory (DMRL), Hyderabad.
31. Regional Research Laboratory, Trivandrum
32. Indian Institute of Science (IISC), Bangalore.
33. Hindustan Aeronautics (HAL), Bangalore.

OVERSEAS

FRANCE

Laboraitoire de Genie Electrique de Paris France (Josephson Voltage)

CNRS Laboraitorie de Physique des, Slides de Bellevue, France (Josephson voltage)

The NPL Aichi Instt. of Technology, Toyota Japan (micro-dimensional Measurement)

Laboraitoire Marcel, Mathieu, CNRS, Pau, France (Carbon-Fibre)

GERMANY

PTB, Germany Collaboration for Augmentation (Standards Calibration Facility)

PTB,Braunschweig, (Josephson Voltge)

PTB, Germany Collaboration (High Frequency Voltage & Power Standard)

Fraunhofer Institute for Solar Energy Systems, Freiburg, Germany (Silicon Solar Cells)

PTB Cooperation after the visit of Dr. J. Tschrmish in the field of length Standard with the help of ILTP with Russia He-Ne/ CH_4 laser developed.

Institute of Molecular Science, Japan, (Magnetization, Optical Studies)

PTB, Germany

IMGC Italy

USA

University of California, Irvine, USA (Superconducting Films)

University of Milwaukee, Wisconsin, USA.

National Institute of Standards & Technology USA, University of Hawaii, USA.

U.K

Technical Collaboration with PTB (Germany)

Delft Hydraulics (Holland), and NEL (U.K.) (Fluid Flow Measurement)

DST, PTB, University of Rochester (Optical Standards).

British Council U.K. for support to Indian Industry (Ultra Sonic Standards)

RUSSIA

1. DI Mendeleyev Instt. of Metrology Russia under ILPT Phase-II (length)
2. Institute of Inorganic Chemistry, NOVOSO birsk, Russia (Metal organic Compounds)

THAILAND

For Green house gas emission reduction

SWEDEN

Continuous projection atmospheric chemistry

(i) Precipitation and aerosol measurement.

(ii) Green house gas emission study

JAPAN

Institute of Molecular Science, Japan (Magnetization & Optical)

CALIBRATION/TESTING CHARGES
(Realised during 1994-95)

ACTIVITY	AMOUNT (Rs.)	REPORTS (No.)
PHYSICO MECHANICAL STANDARD		
Force & Hardness Standards	15,64,815	821
Pressure & Vacuum Standards	15,31,200	248
Dimensional Metrology	15,15,100	803
Temperature Standards	11,09,510	689
Optical Radiation Standards	8,48,950	295
Mass, Density, Volume & Viscosity Standards	5,76,135	568
Acoustical Standards	4,22,900	142
Length Standards	1,32,200	17
Ultrasonic Standards	11,350	7
Infrared Radiation Standards	5,000	3
UV Radiation Measurements	1,500	2
ELECTRICAL STANDARDS		
AC & LF Standards (Up to 1 kHz)	6,02,350	140
DC Standards	4,29,900	97
HF & Microwave Standards of Voltage Current, Power, Frequency & Noise	4,11,200	46
Time & Frequency Standards	1,31,550	69
LF & HF Impedance Standards	77,200	51
HF & Microwave Attenuation and Impedance Standards	42,300	17
Magnetic Measurements	24,550	13
Josephson Voltage Standards	1,000	1
TOTAL	**94,38,710**	**4029**

PROCESS RELEASED

PROCESS	LICENCEE	TERMS AND CONDITIONS
1. Blood Glucose Bio Sensors	Pulsatum Health Care (P) Ltd., Bangalore.	Premium Rs. 3.00 Lakhs Royalty - 5 % Licence Period - 7 Years.
2. STFS Decoder for Time Disse VIA INSAT - 1B	Punjab Digital Industrial System, Mohali.	Premium Rs. 50000 Royalty - NIL
3. Interferometer, Ultrasonic.	Sandeep Enterprises, New Delhi.	Premium Rs. 10000 Royalty - 5 % Licence Period 5 Years
4. Activated Carbon Fibre Cloth	HEG Ltd., Bhopal	Premium Rs. 5 Lakhs Royalty - NIL
5. Monostatic Acoustic Sounding System For Arctica (Massa)	Orbit Biotech Innovations (P) Ltd., Jabalpur.	Premium Rs. 65000 Royalty - NIL
6. Flexible Graphite Tapes and Sheets.	Ranbro Industrial Maintenance, New Delhi.	Premium Rs. 2 Lakhs. Royalty - 2 % Licence Period - 10 Years
7. Piston Gauge Pressure Standards.	Ravika Industries, New Delhi.	Premium Rs. 2.75 Lakhs Royalty - NIL

Shri. A.B. Giri, President, of HEG Limited, Bhopal (front right) and Prof. E.S.R. Gopal, Director, NPL, (front left) seen before of the collaborative research programme on "Development of Activated Carbon Cloth on Experimental Set-up". Others (from L to R) are : Shri. V.S. Gopal (from IIEC), Dr. Krishan Lal, Dr. J.N. Bohra (from NPL).

Prof. E.S.R. Gopal, Director, NPL & the Proprietor of M/s Ravika Industries, New Delhi on the occasion of handing over the NPL's know-how document relating to Piston Gauge Pressure Standard.

Prof. E.S.R. Gopal, Director, NPL, & Sh. Tajinder Singh Rana, Proprietor of M/s Ranbra Indl. Maintenance, New Delhi, on the occasion of handing over the NPL's know-how document relating to Flexible Graphite-Tapes & Sheets.

Dr. Krishan Lal, Acting Director, handing over the know-how document to Mrs. Basanti, Proprietor, M/s Sandeep Enterprises, Karol Bagh, New Delhi relating to the NPL's Process entitled "Ultrasonic Interferometer" on 28-10-94.

Prof. E.S.R. Gopal, Director, NPL, handing over the NPL's know-how document to Sh. Samir Gupta, Director, Pulsatum Health Care Pvt. Ltd., Bangalore, relating to Blood Glucose Biosensor, (on. the left) Dr. B.D. Malhotra Sc, NPL.

Prof. E.S.R. Gopal, Director, NPL, on the occasion of handing over the NPL's know-how document relating to STFS decoders to Sh. R.S. Chopra, Sr. Dy. Manager, M/s Punjab Digital Industrial System Ltd., Mohali.

CONSULTANCY

Nature of Consultancy	Party	Amount (Rs. in Lakhs)
1. Reconditioning of He-Ne laser model HN 576 and putting back in working order Ar-ion laser model 955.	Vikram Sarabhai Space Centre, ISRO, Thiruvananthapuram.	5.000
2. Determination of stress samples oi 75 mm dia silicon wafers by high resolution X-Ray diffraction technique.	University of Waterloo Ontario, Canada.	Canadian Dollar 1000
3. Revamping of existing computer system and installation of appropriate hardware/Software.	National Council of Hotel Management and Cater Technology, New Delhi.	0.056
4. Consultancy relating to brittleness in ferrites.	Sh. Ovijit Ray, Dy. Manager, Co-ordinator Cosmo Ferrites Ltd., New Delhi	0.560
5. Institutional consultancy for rendering professional expertise/advise on ways of eliminating black corrundum stone.	Sh. Rattan Chand Jweller, K-29, NDSE-II, New Delhi.	0.200
6. Consultancy work relating to impregnating C.T. pitch processing.	M/s. Himadri Chemicals and Industries Ltd., 23 A, Netaji Subhas Road, Calcutta.	3.000
7. Putting up Rb vapour frequency reference (RVRF) of HP Rb Std. to optimum working condition.	Sh. Jog Raj, Executive Officer Deptt. of Light House and light ships, R.K. Puram, New Delhi	0.998
8. Supply of acoustic sodar for generation of data on mixing height for Durgapur Steel Plant.	Sh. A. Prasad. Sr. Manager SAIL, Research and Development Centre for Iron and Steel, Ranchi.	6.000
9. Evaluation of the Quality of Expandable Graphites.	M/s. Pandian Graphites (India) Ltd., 280, Mount Road, Teynampet, Madras.	0.500
10. Cd-Te photovoltaic solar cell module production line.	M/s. Polyplex Corp. Ltd., 75, Amrit Nagar, New Delhi.	0.545

11. Upgradation of electronics smoke density instrument.	M/s. Envirotech Instrument Ltd., A-271, Okhla Industrial Area-1, New Delhi.	0.630
12. Inversion study at IPCL, Nagothane.	M/s. Indian Petrochemicals Corpn. Ltd., Maharashtra Gas Cracker Complex Division.	2.000
13. Design and fabricate the piston cylinder of the hydraulic system.	Manager (Civil) Dam Circle CHEP/Chhanamorh National Hydroelectronic Corpn. Ltd., Distt. Chamba (HP)	1.568
14. Evaluation of quotations and recommendations for purchase of PC 486.	Sh. Bhagat Singh, Dy. Director National Council for Hotel Management and Catering Technology Library, Pusa Complex, New Delhi.	0.028

ACTUAL EXPENDITURE
(1994-1995)

Budget Head	Rs. (Lakhs)
Salaries	853.955
Contingencies	180.110
Maintenance	29.229
Chemicals	88.885
Works etc.	17.282
Equipment	169.804
Other	56.308
Total	1391.573
Sponsored Projects	299.518

HUMAN RESOURCES

SCIENTISTS OFFICERS

(In order of Gp. IV to Gp. III as on 1.4.95

DIRECTOR

ESR Gopal

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

RP Singhal, Sc EII
VT Chitnis, Sc EII
VG Kulkarni, Sc EI
LS Tanwar, Sc EI
Shanta Chawla (Smt), Sc C
M Karfa, Sc C
Rina Sharma (Smt), Sc B
V Roonwal (Smt), TOC
NK Aggarwal, TOC
BK Roy, TOC
A.K. Kanjilal, TOB
Ram Narain, TOB
SL Thind, TOB
VD Sharma, TOB

MASS

DC Sharma, Sc EII
SN Nangia, Sc EI
Tripurari Lal, Sc EI
ML Das, Sc EI
Sudarshan Kumar, Sc EI
S Sinha, Sc B
S. Verma (Smt.), TOB
Ashwani Kumar, TOA
T.K. Parmeshwaram, TOA

FORCE

M.K. Dasgupta, Sc F
RS Sharma, Sc EI
JK Dhawan, Sc EI
MK Chaudhary, Sc EI
T.K.. Saksena, Sc C
Anil Kumar, Sc C
VD Arora, TOA

PRESSURE & VACUUM

AC Gupta, Sc EII
KK Jain, Sc EI
AK Bandyopadhyay, Sc EI
BR Chakraborty, Sc EI
DR Sharma, Sc EI
Pradeep Mohan, Sc EI
SM Sivaprasad, Sc C
C Anandan, Sc C
Arun Vijaykumar, Sc B

TEMPERATURE

RK Luthra, Sc EI
NK Srivastava, Sc EI

YP Singh, Sc C
Mansha Ram, Sc C
OP Bhola, TOC
NK Kohli TOC

OPTICAL RADIATION

KC Joshi, Sc F
JS Vaishya, Sc EII
S Manrai (Smt), Sc EI
HC Kandpal, Sc EI
Jai Bhagwan, TOB

INFRARED RADIATION

SP Varma, Sc EII
Joginder Singh, Sc EII
D Gupta, Sc C

ULTRAVIOLET RADIATION

RS Ram, Sc EI
Om Prakash, Sc EI

ACOUSTICS

V. Mohanan, Sc EII
DR Pahwa, Sc EI
BS Gera, Sc EI
Omkar Sharma, Sc EI
RM Khanna, Sc EI
HLB Bhaskar, Sc C
Mahavir Singh, Sc B
OP Sharma, TOA

ULTRASONICS

Janardan Singh, Sc EII
Ashok Kumar, Sc EI
SK Jain, Sc EI
RP Tandon, Sc EI
Ved Singh, Sc EI
Harish Bahadur, Sc EI
Mukesh Chandra, Sc EI
N.N. Swamy, TOC
Jagdish Lal, TOB
Subhash Chandra, TOB
Reeta Gupta (Smt), TOA
NC Soni, TOA

FLOW MEASUREMENT

JN Som, Sc EI
Raj Singh, Sc EI
Virendra Babu, TOC

ELECTRICAL STANDARDS

TIME & FREQUENCY

BS Mathur, Sc G
P Banerjee, Sc EII
A Sengupta, Sc EII
GM Saxena, Sc EI
AK Hanjura, Sc EI
M Saxena (Smt.), Sc EI
A Chatterjee (Smt), Sc C
C Sri Kumar, Sc B
GK Goel, TOC
Gurdial Singh, TOB
AK Suri, TOA

JOSEPHSON VOLTAGE

Ashok K Gupta, Sc F
VS Tomer, Sc EII
ND Kataria, Sc EI

VN Ojha, Sc EI
Manmohan Krishna, Sc C
VK Gumber, Sc C
Neeraj Khare, Sc C

DC MEASUREMENT

SK Mahajan, Sc EI
PK Mittal, TOB
B Sircar, TOB

HF IMPEDANCE & AC, LF

Omkar Nath, Sc EI
Gurmej Ram, Sc EI
SR Gupta, Sc EI
MK Mittal, Sc EI
MR Nagar, Sc EI
AK Saxena, Sc C
Kewal Krishan, Sc C
Naib Singh, Sc C
JC Biswas, Sc B
AR Kaushik (Smt.), TOB

HF & MW VOLTAGE, POWER, FREQUENCY & ATTENUATION

VK Agrawal, Sc F
RS Yadava, Sc F
Ram Swarup, Sc EII
VK Rustagi, Sc EI
AK Govil, Sc EI
Ritander Aggarwal, Sc EI
PS Negi, Sc C
RL Mendiratta, TOB

MAGNETIC STANDARDS

PC Kothari, Sc EII
HM Bhatnagar, Sc C

CALIBRATION SERVICES PROGRAMME

Mahesh Chandra, Sc EII
HS Dahiya, Sc EI
NS Natarajan, Sc EI
CP Singh, TOC
PC Sharan, TOA
GK Kapoor, TOA
SP Sharma, TOA

MATERIALS DEVELOPMENT

SILICON, CERAMICS & SUPERCONDUCTORS

BK Das, Sc F
SK Sarkar, Sc EII
AC Rastogi, Sc EII
SN Singh, Sc EII
RB Tripathi, Sc EII
PK Ashwini Kumar, Sc EI
ST Lakshmikumar, Sc EI
Mohan Lal, Sc EI
BR Awasthy, Sc EI
BC Chakravarty, Sc EI
SN Ekbote, Sc EI
NK Arora, Sc EI
Ram Kishore, Sc EI
PK Singh, Sc EI
ML Sharma, Sc C
RK Kotnala, Sc C
Kiran Jain (Smt), Sc C
S Singh (Smt.), Sc B
SM Khullar, TO EI

NS Bangari, TOC
HS Kalsi, TOC
RC Goel, TOC
Prem Prakash, TOC
KS Balakrishnan (Smt), TOC
Ravi Kumar, TOB
BS Khurana, TOB
SK Sharda, TOB
HP Gupta, TOB
MK Banerjee, TOB
TR Pushpangadan, TOA
Mukul Sharma, TOA

LUMINESCENT MATERIALS

PK Ghosh, Sc F
H.P. Narang, Sc. EII
V Shankar, Sc EI
Harish Chander, Sc EI

DISPLAY DEVICES

Subhas Chandra, Sc F
SC Jain, Sc EII
S.S Bawa, Sc EII
MN Kamalasanan, Sc EI
SCK Misra, Sc EI
Suresh Chand, Sc EI
AM Biradar, Sc EI
CP Sharma, Sc EI
SA Agnihotri (Smt), Sc EI
Ramadhar Singh, Sc EI
VS Panwar, Sc EI
BD Malhotra, Sc EI
KK Saini, Sc C
NS Verma, Sc C
Ranjana Mehrotra (Ms), Sc C
RK Sharma, Sc C
SK Dhawan, Sc C
RC Bhateja, TOB

CARBON PRODUCTS

OP Bahl, Sc F
Gopal Bhatia, Sc EII
RK Aggarwal, Sc EI
RB Mathur, Sc EI
TL Dhami, Sc EI
V Raman (Smt), Sc EI
Chhote Lal, Sc C
DP Bhatt, Sc C
P Sivaram, Sc C
SR Dhakate, Sc B

THIN FILM SYSTEMS

R Bhattacharya, Sc EII
Devindra Singh, Sc EII
A Basu, Sc EI
BS Verma, Sc EI
M Kar (Smt), Sc EI
PN Dixit, Sc EI
OS Panwar, Sc C
SS Rajput, Sc C
TK Bhattacharya, TOA

HIGH PRESSURE TECHNOLOGY

MM Bindal, Sc F
AK Aggarwal, Sc EII
BP Singh, Sc EI
SK Singhal, Sc EI
Rajeev Chopra, Sc C

RK Nayer, TOC
KD Sharda, TOA

METALS & ALLOYS

Anil K Gupta, Sc EII
RC Anandani, Sc EI
Ajay Dhar, Sc C
AK Padma (Km), Sc B
IA Malik, TOC
Rajiv Sikand, TOB
HB Singh, TOA
Jaswant Singh, TOA
Rakesh Khanna, TOA

MATERIALS CHARACTERIZATION

CHEMICALS & POROSITY

DC Parashar, Sc F
PK Gupta, Sc F
JN Bohra, Sc EII
VK Amar, Sc EII
JC Trehan, Sc EII
R Ramchandran (Smt), Sc EI
AK Sarkar, Sc EI
AK Aggarwal, Sc EI
PK Gupta, Sc C
Ranjan Kothari, Sc B
MK Dasgupta, TOA
RC Sharma, TOA
Niranjan Singh, TOA

IR & EPR SPECTROSCOPY

MM Pradhan, Sc EII
SK Gupta, Sc EI
RK Garg, Sc EI
S Parthasarathi, TOC

X-RAYS

DK Suri, Sc EI
U Dhawan (Smt), Sc EI
Rashmi (Km), Sc C
RP Pant, Sc B

ELECTRON MICROSCOPY

SK Sharma, Sc F
Narendra Kumar, Sc EII
SUM Rao, Sc EI
Sukhbir Singh, TOA

CRYSTAL GROWTH

Krishan Lal, Sc Dir Gd
RV Ananthamurthy, Sc EI
Vijay Kumar Kohli, Sc EI
SK Haldar, Sc EI
G Bhagawannarayana, Sc EI
SNN Goswami (Smt), Sc C

LOW TEMPERATURE PHYSICS

SUPER CONDUCTIVITY

AV Narlikar, Sc G
RG Sharma, Sc F
YS Reddy, Sc EI
RB Saxena, Sc EI
BV Reddi, Sc EI
BV Kumaraswamy, Sc EI
PK Dutta, Sc EI
UC Upreti, Sc C
Ratan Lal, Sc C

SK Aggarwal, Sc C
PL Upadhyay (Km), Sc C
SB Samanta, TOB
VS Yadav, TOA

CRYOGENIC SYSTEMS

SC Gera, Sc EI
Hari Kishan, Sc EI
SS Verma, Sc EI
Kasturi Lal, Sc EI
NK Babbar, Sc C
Ganga Prasad, Sc C
GS Bhambra, TOA

THEORY

Ramji Rai, Sc EI

RADIO SCIENCE

KK Mahajan, Sc G
SBSS Sarma, Sc F
TR Tyagi, Sc F
SC Garg, Sc F
YV Ramanamurthy, Sc EII
S Aggarwal (Smt), Sc EII
DR Lakshmi (Smt), Sc EII
RC Saksena, Sc EII
SL Jain, Sc EII
PK Banerjee, Sc EII
AB Ghosh, Sc EII
HN Dutta, Sc EII
MK Raina, Sc EI
RS Arora, Sc EI
SK Sarkar, Sc EI
R Venkatachari, Sc EI
PN Vijaya Kumar, Sc EI
Lakha Singh, Sc EI
RK Pasricha, Sc EI
MC Sharma, Sc EI
KS Zalpuri, Sc EI
PL Malhotra, Sc EI
MK Goel, Sc EI
Mahendra Mohan, Sc EI
N Kundu (Smt), Sc EI
Madhu Bahl (Smt), Sc EI
JK Gupta, Sc EI
SD Sharma, Sc EI
RS Dabas, Sc EI
DR Nakra, Sc EI
VK Pandey, Sc EI
P Subrahmanyam, Sc EI
MVSN Prasad, Sc EI
BC Arya, Sc EI
NK Sethi, Sc EI
SK Singhal, Sc C
CB Tandel, Sc C
Jayanta Kar, Sc C
VK Vohra, Sc C
P Chopra (Smt), Sc C
HK Maini, Sc C
VP Sachdeva, Sc C
John Thomas, Sc C
Risal Singh, Sc C
Meena Jain (Smt), Sc C
RS Tanwar, Sc B
SK Shastri (Smt), TOC
Abdul Hamid, TOB
Didar Singh, TOB
Raksha Marwah (Smt), TOA

DB Sharma, TOA
KGM Pillai, TOA
Vishram Singh, TOA
JP Sharma, TOA

TECHNICAL INFRASTRUCTURE

PLANNING & COORDINATION

GK Arora, Sc F
RS Khanduja, Sc EII
FC Khullar, Sc EI
PK Kohli, Sc EI
Satbir Singh, Sc EI
TK Chakraborty, Sc C
SK Sharma, Sc C
Shikha Mandal (Smt), Sc C
Indra Tewari (Smt), Sc C
SS Bhakri, TOB
TR Tomer, TOB
SC Verma, TOA

LIBRARY

SM Dhawan, Sc F
SK Phull, Sc EII
DK Tewari, Sc C
Hasan Haider, TOA

COMPUTER

VK Batra, Sc F
Ravi Mehrotra, Sc EI
Sanjay Raizada, Sc C

INSTRUMENTATION

VR Singh, Sc EII
S Dwivedi, Sc C
IJ Banaudha, TOC
DS Sachdeva, TOB
YPS Negi, TOB

WORKSHOP

JR Anand, Sc F
HNP Poddar, Sc EI
Ravi Khanna, TOB
MK Chibber, TOB
Kewal Krishan, TOB
Dharam Chand, TOB
Ram Swarup, TOA

GLASS WORKSHOP

VP Varma, Sc EI
MC Jusht, TOC
Mohan Lal, TOC
Shashi Bhushan, TOC
Chandan Singh, TOC
JP Vashist, TOC
GS Hans, TOB
Karnail Singh, TOB

SERVICES

CSP Kumar, Sc EII
JC Sharma, Sc C
OP Tagra, TOC
RS Singh, TOC
J.S. Dhama, Sc B
SL Sharma, TOB
KL Ahuja, Asstt. Executive Engineer
SS Kapur, Asstt. Engineer
SK Kulshrestha, Asstt. Engineer
BS Negi, TOA

Damodar Prasad, TOA

STAFF ON DEPUTATION

VD Dandawate
AR Jain
Ranjit Singh
K. Vardan (Smt)

SCIENTISTS, FELLOWS, RESEARCH ASSOCIATES AND POOL OFFICERS

A.P. Mitra, Bhatnagar Fellow
A.R.Verma, Emer Sc
T.R. Anantha Raman, Emer Sc
B. Buti, Emer Sc
R.N. Chaudhury, Sc (DST)
S. Govindarajan, Sc (DST)
V. Soni, Sc (UGC)
S.K.Gupta, Sc (UGC)
Pradeep Kumar, Sc (Sch)
Anindya Bose, Fellow
Deepak Varandani, Fellow
Rajbir Singh, Fellow
P.K. Singhal, Fellow
V.C. Nagar, Fellow
Manju.M. Vergheese (Km), Fellow
Abha (Km) RA
Aparna (Smt), RA
S.K. Arora RA
Pavas Asthana, RA
A.K. Bandyopadhyay, RA
S. Bhattacharya (Smt), RA
Subrata Bose, RA
S.K. Dhara, RA
Indu Dhingra (Km), RA
J.P. Gangwal, RA
R. K. Goswami, RA
Chetana Kachroo (Smt), RA
S. Khare,(Smt), RA
U.C. Kulshrestha, RA
R.K. Mandalapu, RA
Rupa Mitra (Km), RA
J. Mittal, RA
VHS Moorthy, RA
G.K. Padam (Km), RA
Rashmi Paul (Smt), RA
Rajesh Kumar, RA
M.K. Ram, RA
K. Ramanathan, RA
Subir Saha, RA
Biswanath Sarkar, RA
Kanchan Saxena (Km), RA
Sanjay Sengupta, RA
Taney Seth, RA
S.V. Sharma, RA
Mahesh Shrivastava, RA
P.K. Singh, RA
Hari Om Upadhyay, RA
Harsh Vardhan, RA
Nandini Chatterjee (Smt), PO
Jaivir Kaudinya, Consultant
Murlikrishna, PO
G.S. Reddy, PO
C. Sharma, PO

ADMINISTRATION, ACCOUNTS STORES / PURCHASES

M.M. Sharma, Sr. COA
CS Chohan, COA
HR Mehta, Sr F & AO
JM Sardana, SPO
AK Ghosh, TOB
Anil Kumar, SO
NA Khan, SO
Dharam Raj, SO
OP Meni, SO
Jitender Parasar, SO
Sardara Singh, SO
Vijayalakshmi D, (Km), SO
OP Yadav, SO (F & A)
S Sharma (Smt), Hindi Offr.
Lamba Prem (Smt), Dy. SPO
RC Gupta, Dy. SPO
Brijesh Sharma, Dy. SPO
B.B. Chopra, PS
RK Bhasin, PS
SA Joseph (Smt), PS
Jagdish Kumar, PS
Shish Ram, PS
Pran Nath, PS
DV Sharma, PS
Vijay Kumar, Sec. Offr.
Lakhpat Singh, Sec. Offr.

RETIRED

S.B. Manmohanan, Sc C., April
A.R.S. Vashist, TOB, May
Prem Ballabh, Tech. VIII, June
R.S. Khandekar, Sc EI, June
Hari Charan, Daftary, June
Dwarka Prasad, Bearer, July
C.P. Gaur, Tech Gr VIII, Aug.
K.L. Gulati, TOA, Sept.
Net Ram, Tech VIII, Sept.
Prabha Malhotra, (Smt), Asstt., Sept.
Dr. B.M. Reddy, Sc . G., Sept.
T. Poodikunju, TOA, Sept.
Dr. A.P. Jain, Sc F, Oct.
G. Govindaswamy, Sc EI, Oct.
T. K. Saxsena, Sc F, Oct.
Ran Singh, Record Keeper, Oct.
Kunwar Singh, Asstt., Nov.
O.P. Kakkar, F & AO, Nov.
Sawanti Lal TOA, Dec.
Sh. Jadu Nath, W/shop Asstt., Dec.
Sh. K.V. Krishnamurthy, Asstt. Exe. Engineer, Jan.
Sh. Santokh Singh Bhatti, Tech. Gr VIII, Feb.
Sh. Chhel Kumar, Tech Gr VIII, Feb.
Sh. Jagdish Chand Popli, Tech Gr. VIII, Feb.
Sh. A.S. Kalsi, SMA, March
Sh. Om Prakash Sharma, Asstt. G, March
Sh. Om Prakash Verma, Tech. VIII, March

TERMINATED

Santosh Kumari, Sc C (Service terminated w.e.f. 27-4-95)
B. Jayaraman, Sc B (Service terminated w.e.f. 16-1-95)

OBITUARIES

Balbir Singh, Sc EI, April 13

SD Bahl, TOB, May 3

Murli Ram, W/Shop Asstt. June 8

Ramesh, Daftry, Nov. 30

Devinder Bhanot, SMA, Feb. 19

RK Kulshrestha, Sc C, March 17

STAFF STRENGTH
(as on 01-04-95)

Category	Grade	Number
SCIENTIFIC & TECHNICAL STAFF		
Scientific Staff	Group IV	281
Technical Staff	Group III	168
Engineering Cadre Staff	Group V	1
Supporting Technical Staff	Group II	377
Supporting Technical Staff	Group I	118
	Sub Total	**945**
ADMINISTRATIVE & NON-TECHNICAL STAFF		
Administrative (Gazetted)	Group A	4
Administrative (Gazetted)	Group B	26
Administrative (Non-Gazetted)	Group C	147
Non-Technical	Group D	129
	Sub-Total	**306**
	Total	**1251**

Ph. Ds. AWARDED

S.No.	Name	Title	University	Guide
1.	V.P.S. Awana	Superconductivity	Delhi	Dr. A.V. Narlikar, N.P.L. Dr. G.C. Trigunayat (Delhi University)
2.	Mrs. Sangeeta Khare	Sodar Studies of High-Tc Superconducting Thick Films and RF-SQUIDs	Delhi	Dr. Ashok Kumar Gupta, N.P.L. Prof. P. N. Dheer (Delhi University)
3.	D.R. Pahwa	Sodar Studies of Atmospheric Boundary Layer and Application to Air Quality.	Delhi	Dr. A.P. Mitra, N.P.L. Dr. S.P. Singhal, N.P.L. Prof. M.P. Srivastava (Delhi University)
4.	Joginder Singh	Infrared Radiation Measurement, System Development and Applications.	Meerut	Dr. R.S. Ram, N.P.L. Dr. A.N. Pandey, (Meerut College)
5.	Santanu Bera	Studies of Oxidation and Silicidation of some transition metal oxides by AES and ELS.	BITS, Pilani	Dr. J.K.N. Sharma, N.P.L.
6.	Km. Rupa Mitra	Study on Vibrational Amplitude Characteristics of Ultrasonic Transducers.	BITS, Pilani	Dr. T.K. Saksena, N.P.L.

7. S.S. Singh	Studies of the low latitude Ionospheric F- Region	Bhagalpur	Dr. M.K. Goel N.P.L., Prof. N.R.Mitra (Bhagalpur,University)
8. Yudhisther Kumar	(M.S) Degree	BITS,Pilani	Dr. Ashok Kumar, N.P.L.
9. P.K. Jain	Development & Thermo-mechanical Characterisation of Carbon-Carbon Composites	Delhi	Dr. O.P. Bahl, N.P.L. Prof. N.K. Nayar Delhi University.
10. J.J. Mittal	Studies on the processing of PAN Fibers to develop high performance Carbon Fibers.	Delhi	Dr. O.P. Bahl, N.P.L. Prof. N.K. Sandle I.I.T. Delhi
11. Km. Manju Arora	Study of Vibrational Spectra of Rare Earth Components	Delhi	Dr. M.M. Pradhan, N.P.L. Dr. M.C. Bansal Ch. Charan Singh University, Meerut
12. G Bhagavannarayana	High resolution X-ray diffraction study of as grown and BF_2^+ implanted silicon crystals.	Delhi	Dr. Krishan Lal, N.P.L. Prof. G.C. Trigunayat Delhi University
13. S. Dhara	Growth and characterization of metallo-organic chemical vapour deposited magnetic oxide thin films.	BITS,Pilani	Dr. B.K. Das, N.P.L.

14. S. Saha	Type-II behaviour of ceramic superconductors granularity, irreversibility and hysteresis	BITS,Pilani	Dr. B.K. Das, N.P.L.
15. I. Dhingra	Investigations on effect of dopants and magnetic properties in YBCO system	IIT, Delhi	Dr. B.K. Das, N.P.L. S.C. Kashyap I.I.T. Delhi

HONOURS AND AWARDS

1. Mr. A.K. Kanjilal was elected Visiting Fellow to Aichi Instt. of Technology, Toyota, Japan from May- June 1994.
2. Mrs. Rina Sharma was elected Visiting Fellow to Aichi Instt. of Technology, Toyota Japan . Feb-March 1995.
3. Dr. A.V. Narlikar received Khosla National Award from University of Roorkee, for research on Superconductivity November, 1994.
4. Dr. S.K. Gupta was invited Regional Scientific Officer for India and member of the Organising Committee for the 4th International Symposium on ESR Dosimetry and Applications which was held at Munich, Germany during May 15-19, 1995.
5. Dr.S.K.Sharma has been elected as the President of Electron Microscope Society of India during the election held on Dec. 15, 1994 for a term of two years.
6. Mr. S.U.M. Rao received "Philips Award" for the best SEM micrograph in material science category in Electron Micrograph Contest held during XIX EMSI Conference in December, 1994.
7. Dr. D. Gupta was elected fellow of Indian Society of Lighting Engineers (ISLE).
8. Mr. R.P. Singhal was elected as General Secretary of Metrology Society of India.
9. Dr. Anil K. Gupta was awarded the Material Research Society of India (MRSI) Medal in 1994.
10. Dr. K.K. Mahajan was awarded "Shri Om Prakash Bhasin Award" in the field of Space and Aerospace for the year 1994. The award carries a sum of Rs. 50,000/-, a memento and a citation.
11. Dr. M.K. Raina was made a fellow of the Institution of Electronics and Telecommunication Engineers, India.
12. Dr. Vishnu Datt Sharma was Awarded Pt. Govind Vallabh Pant Award on Hindi Book "Vish Aur Upchaar"
13. Dr. V.R. Singh continued to serve on Editorial Review Committee of IEEE on Instrumentation and Measurements. He has reviewed twenty one papers during the year.

    He was also elected as a Member of International Committee of First Regional Conference of IEEE-EMBS, New Delhi, Feb. 1995.

    He was elected as Fellow of Indian College of Medical Ultrasound.

    He was also elected as Life Member of Instrument Society of India.
14. Dr. D.P. Bhatt has been assigned the task of guest editor of a special issue of the Bulletin of Material Science.
15. Dr. D.C. Parashar was appointed Member Secretary NC-IGBP.

    He was elected as a member of Rice Committee of IGAC IGBP.

    He was also nominated as a member of Editorial Board of Int. J. of Chemosphere.

16. Dr. A.V. Narlikar served on Scrutiny Committee and Evaluation Committee of project proposals at All India Council for Technical Education New Delhi.
17. Dr. E.S.R. Gopal, Director, N.P.L. was elected President of Metrology Society of India 1994-96.

Delivered the Homi. Bhabha Lecture of Indian National Science Academy, Aug. 1994.

He was reappointed member, Governing Council of Fluid Control Research Institute Palghat, 1994-96.

VISITS ABROAD

1. Shri Ram Kishan Luthra, Scientist EI visited Saudi Arabia from 16th April to 6th December, 1994 on foreign service terms to take up assignment in the area of Temperature Metrology in Riyadh.

2. Dr. Krishan Lal, Scientist (Director's Grade) visited USA from 17th-21st April, 1994 to attend 6th Intl. Symposium on Biological Environmental Reference Materials.

3. Dr. V.R. Singh, Scientist EII was deputed to Belgium and Netherland from 2nd-11th May, 1994 as a member of Doctoral Committee to evaluate a Ph.D. thesis at Kathalike and visit to DELFT University of Technology to discuss project on Smart Sensors respectively.

4. Dr. A.B. Ghosh, Scientist EI was deputed to USA from 5th-14th April, 1994 to attend a Conference on Global Change and to visit National Centre for Atmospheric Research.

5. Dr. R.S. Ram, Scientist EI was deputed to Canada for three months from 3rd May, 1994 to do research at University of Newbrunswick.

6. Shri A.K. Kanjilal, Tech. Officer B was deputed to Japan from 10th May to 9th June, 1994 to attend International Conference on Instrumentation & Measurement Technology at Himamatsu and to do research at Aichi Institute of Technology.

7. Dr. R.P. Tandon, Scientist EI visited Canada for 4 months from 1st June, 1994 on leave due and admissible to avail CIDA/NSERC Research Associateship at Queens University Canada.

8. Dr. A.K. Gupta, Scientist F visited France under IFCPAR Project for 30 days from 12th June, 1994 for carrying out chracterization of YBCO thin films fabricated at NPL and to bring films fabricated in France for studying Josephson and SQUID effects.

9. Dr. A.K. Bandyopadhyay, Scientist EI was deputed to USA from 1st July to 31st Dec., 1994.

10. Dr. V.D. Dandawate, Scientist EII visited Saudi Arabia for one year from 27th July, 1994 on foreign assignment as an expert in the area of dimensional metrology.

11. Dr. Pradeep Mohan, Scientist EI, visited Italy, from 1st-30th July, 1994 for taking training at IMGC Torino in the area of Characterization of Vacuum Materials related to UHV System by auger electrons and thermal desorption Spectroscopies.

12. Dr. R.S. Dabas Scientist EI and Dr. Lakha Singh Scientist EII were deputed to UK from 11th to 15th July, 1994 to attend and present papers at Intl. Symp. on Beacon Satellite.

13. Dr. S.C. Garg, Scientist F visited Germany from 12th-21st July, 1994 for presenting papers in the 30th COSPAR Scientific Assembly Congress.

14. Dr. S.K. Sharma, Scientist F, visited France and UK from 17th - 22nd July, 1994 to attend the International Congress of Electron Microscopy and visited LEICA Cambridge and a demonstration of their newly developed Electron Microscope.

15. Dr. B.P. Singh, Scientist EI, visited Germany for 2 months from 1st Sept., 1994 under CSIR-DAAD Exchange Programme.

16. Dr. Mohan Lal, Scientist EI, visited Germany for three months from 18th Aug.,1994 under INSA-DFG Exchange Programme.

17. Dr, D.C. Parashar, Scientist F, visited China from 7th-12th Aug., 1994 to participate in the International Symp. on Global change for Asia and Pacific Region apart from Attending the CSIR/NSFC meeting on Global Change.

18. Dr. S.L. Jain, Scientist EI, was deputed to Italy and France from 29th Aug., to 5th Oct., 1994 to attend 23rd meeting of the Scientific Committee on Antarctica Research and under IFCPAR Project entitled Use of Hetrodyne System with acquesto optic spectrometer latitude respectively.

19. Dr. R.B. Mathur, Scientist EI, was deputed to France from 5th Sept., 1994 for 4-5 days, carrying out study of Transport Properties of Intercalated Fibres and Pyri Carbons under IFCPAR project.

20. Dr. P.K. Gupta, Scientist F, visited Germany from 22nd Aug., 1994 for three weeks under INSA-DFG Exchange Programme.

21. Dr. V.K. Rustogi, Scientist EI, visited Germany from 12th Sept., 1994 for 24 weeks for fabrication and evaluation of National Primary Standards of High Frequency Voltage under NPL-PTB (Phase-II) Technical Co-operation Programme.

22. Dr. Krishan Lal. Scientist, (Director's Grade) visited Poland and Germany from 4th to 16th Sept., 1994 to attend International Summer School on Growth and Characterization of Crystal at Cracow and to visit Technical Hochschule for discussions under CSIR-KFA Programme respectively.

23. Sh. Niranjan Singh, STA, visited UK for training under TCTP Colombo Plan for three Months from 17th Sept., 1994.

24. Dr. V.R. Singh, Scientist EII, visited Netherlands and Germany from 18th-29th Sept., 1994 to attend the PIMRC 19 WCN. Programme and to visit PTB for a collaborative Programme.

25. Prof. E.S.R. Gopal, Director, NPL visited France and USA from 27th Sept. to 30th Oct., 1994 to attend CIPM meeting of BIMP (International Bureau of weights & Measures) and on study tour under UNDP supported project "Establishment of Surface Analytical Facility" respectively.

26. Dr. S.M. Sivaprasad, Scientist C visited Japan for six months starting in the first week of Oct., 1994 to work in the area of electron spectroscopy with selection to the Kinetics & Dynamics supported by UNDP Project 'Establishment of Surface Analytical Facilities.

27. Dr. B.S. Gera, Scientist EII and Shri R. M. Khanna, Scientist EI were deputed to USA from 3rd -7th Oct., 1994 to attend the International Symposium on Acoustical Remote Sensing.

28. Dr. B.S.Mathur, Scientist G visited Taiwan from 31st Oct. to 4th Nov., 1994 to attend workshop on establishing International recognition of national measurement standards.

29. Dr. D.C. Parashar, Scientist F visited Thailand and Phillipines from 12th-25th Nov., 1994 to attend Symposium on Asian Regional Research Programme on Energy Environmental & Climate and to deliver lecture at workshop on regional training on flux management.

30. Dr. Krishan Lal, Scientist (Directors Grade) visited Russia from 13th Nov., 1994 for 9 days.

31. Dr. Ashok Kumar, Scientist EI visited UK from 18th Nov. to 5th Dec., 1994 to learn experimental techniques of ultrasonic tomography with application to NDT under Indo-UK project of ultrasonics.

32. Prof. E.S.R. Gopal, Director NPL visited Saudia Arabia from 2nd-5th Dec., 1994 to attend Indo-Saudia joint Commission in Riyadh.

33. Dr. Rina Sharma, Sci B was deputed to USA and Japan from 19.2.95 to 5.3.95 to attend International Conference on Microlithography and visited AIT Japan respectively.

34. Dr. Omkar Nath, Sci. E-I visited Slovak from 2.3.95 to 7.4.95 under CSIR-S1ovak exchange programme.

35. Dr. D.R. Lakshmi, Sci. E-II and Sh. P. Subramanyam, Sci. C visited Indonesia from 20.3.95 to 24.3.95 to attend International Symposium on Equatorial Aeronomy.

SPECIAL LECTURES

DATE	SPEAKER	TOPICS
12/04/94	Dr. H.D. Finke PTB Germany	Metrology in Acoustics Part-I Instrumentation Standard Legal Metrology.
13/04/94	-do-	Metrology in Acoustics Part -II Measurement and rating environmental Noise.
15/04/94	Dr. Josef Tschirnich PTB Germany	International Comparators for Measurement of Line Scales & Thermal Expansions of PTB Germany bar-shaped materials.
19/04/94	Dr. H.D. Finke PTB Germany	Sound Intensity Measurements Theory and Applications
22/04/94	Dr. Hem Kaneti, of Intermagnetics, USA	Recent Development in Superconductivity at the Intermagnetics, USA
03/05/94	Dr. G. Venkataraman, (ANURAG) Hyderabad	Mind-Matter Question
12/05/94	Dr. J. Krowli Kowski, Polish Academy of Science, Warsaw	Some Ultrasonic Investigations Contacts between Solids at IPPT-PAN Warsaw
11/07/94	Dr.(Ms.) Sujata Dev, Physikalisches Institute Der Universitat, Heidelberg, Germany.	Scanning Tunneling Microscopy Thin Molecular Films.
22/07/94	Prof. S. B. Ogale, Deptt. of Physics, University of Pune.	Some New Results on Magnetic dopants in High Temperature Superconductors.
27/07/94	Dr. M.F.P.C.M. Costa University Minho Portugal	Microtopographic Inspection of Rough Surface.
02/09/94	Prof. Suri Oda, Physical Electronics, Tokyo Inst. of Technology	A Novel Plasma Processing Method for Fabrication of Amorphous and Nanocrystalline Silicon.

28/09/94	Prof. S.B. Lang, Deptt. of Chemicals Engineering, Ben-Gurion, University of the Neger, Israel.	Application of Pyro/Ferro Electricity
12/10/94	Dr. Baldwin Robertson NIST, Gaithersburg, USA.	Proton Pumping catalyzed by bacteriorhodopsin : An Electro-chemical Measurement.
12/10/94	Prof. Bimla Buti, RSD, NPL, New Delhi.	Chaos and its Implications.
14/11/94	Dr. Neeraj Khare, NPL, New Delhi.	Studies on SQUIDs & symmetry in high Tc superconductors using grain boundary junctions.
24/11/94	Dr. Alain Tressaud, Laboratoire de Chemiche	Materials issues in solidstate chemistry
08/12/94	Dr. Subhneesh Batra, Micron Technology, USA.	Development of TFT technology for advanced high density SRAMs.
08/12/94	Mr. G. Urquhart, University of Aberdeen, U.K.	Fish tracking using sonar and acoustic fish tags.
13/12/94	Mr. G. Urquhart, University of Aberdeen, U.K.	Automatic tracking using long baseline hydrophone array.
19/12/94	Mr. Jim Tatum, University of Texas Dallas, U.S.A.	Temporal and spatial dynamics in visible wavelength semiconductor lasers.
22/12/94	Prof. Rashmi C. Desi, Toronto University, Canada.	Pattern formation in laser induced melting
28/12/94	Dr. S.I. Rasool, France	Global change-science and data needs.
04/01/95	Prof. A.K. Ramdas, Physicist, West-Lafayette,USA.	Isotopic Constitution of Semiconductors : Manifestations in their electronic and vibrational spectra.
06/01/95	Dr. F.S. Rowland, National Research Council, USA.	Stratospheric Ozone Depletion by Chlorofluoro Carbons.
10/01/95	Prof. Anil Kumar, Indian Institute of Science, Bangalore.	Reentrant Phase Transition

16/01/95	Dr. (Mrs.) Anita Calcatelli, Instituto Di Metrologia, G: Colonnetti (IMGC),Italy.	Surface and bulk phenomena as limit to the stability of mass standards.
16/01/95	Dr. A.P. Jain, Ex-Scientist F, NPL.	Science and Religion - A well thought of Scientist view.
23/01/95	Dr. P.C. Scholten, Netherland.	Magnetism : Which S.I. Units
24/01/95	Dr. Tibor Toth Katona, Hungary	Nematic-Smectic B Interface: Equilibrium and Growth Properties
09/02/95	Dr. Robert Karls, Director, Netherlands, Meetinstitnut	Certified Reference Materials Activities at Netherlands
10/02/95	-do-	Accredition of Labs:-A European Experience.
14/02/95	Dr. T.K. Bose of Univ. of Quebec, Canada.	Absorption Storage of Gas Fuels on Activated Carbons
23/02/95	Dr. D.K. Sadana of IBM Thomas J. Watson Research Centre, Yorktown Heights, USA.	Recent Advances in SOI Materials for Low Power IC Technology
02/03/95	Prof. Helmut Klapper, Professor Mineralogisch Inst. University of Bonn.	X-ray Diffraction Topographical Studies of Phase Transitions and Domain formation.
06/03/95	Prof. Peter Liss, Chairman, International IGBP.	The role of an Air-Sea exchange of Gases in the Geo-Chemistry of the Atmosphere and the Oceans.
09/03/95	Mr. V. Jager, PTB, braunschweig, Germany.	Ultraprecision Manufacturing of Measuring Instruments-State of the Art in PTB
15/03/95	Dr. Sanjay Rastogi, IIT, Delhi.	Role of Mobile Phases in Crystallization of Polymers.

RESEARCH COUNCIL

Prof. B.V. Sreekantan, FNA,FASc, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore -560012 — Chairman

Shri. R. Muralidharan, Al Futtaim Electronics - Toshiba, P.O. Box 5866, Dubai (UAE) — Member

Dr. J.M. Garg, Managing Director, Garg Associates Pvt. Limited, D6, Industrial Area, Meerut Road, Ghaziabad - 201 003 — Member

Prof. D. Chakravorty, FNA, Director, Indian Association for the Cultivation of Science, Jadavpur, Calcutta - 700 032 — Member

Prof. N. Kumar, FNA, FASc, Director, Raman Research Institute, Bangalore - 560 080 — Member

Dr. V. Kumar, Director, Solid State Physics laboratory, Lucknow Road, New Delhi - 110 054 — Member

Shri N.S. Choudhary, Director-General, Bureau of Indian Standards, Manak Bhawan, 9, Bahadur Shah Zafar Marg, New Delhi-110 002 — Member

Dr. A.K. Chakrabarty, Adviser, Department of Science & Technology, Technology Bhavan, New Mehrauli Road , New Delhi — Member

Dr. K. R. Sarma, Director, Central Scientific Instruments Organisation, Sector 30, Chandigarh-160020 — Member

Dr. R. N. Biswas, Director, Central Electronics Engineering Research Institute, Pilani-333 031 (Rajasthan) — Member

Dr. E.S.R. Gopal, FNA, FASc, Director, National Physical Laboratory, Dr. K. S. Krishnan Road, New Delhi - 110 012 — Member

Dr. H.R. Bhojwani, Head, R&D Planning & Business Development Division, Council of Scientific & Industrial Research, Anusandhan Bhawan Rafi Marg, New Delhi - 110 001 — Member

MANAGEMENT COUNCIL

Prof. E.S.R. Gopal, Director, National Physical Laboratory, New Delhi-110012 — Chairman

Dr. K.V. Ramakrishna, Scientist-in-Charge, CSIR Complex, Dr. K.S. Krishnan Marg, New Delhi - 110 012 — Member

Dr. Krishan Lal, Scientist Director's Grade, NPL New Delhi-110012 — Member

Dr. V.S. Tomer, Scientist, NPL, New Delhi — Member

Dr. J.N. Bohra, Scientist, NPL, New Delhi — Member

Dr. T.K. Saxena, Scientist, NPL, New Delhi — Member

Dr. (Mrs.) Rina Sharma, Scientist, NPL, New Delhi — Member

Sh. H.R. Mehta, Sr. FAO, NPL, New Delhi — Member

Sh. H.R. Gupta, COA, NPL, New Delhi — Member Secty.

TRAINING

1. IRDE deputed scientists were trained on large area DLC coating process for one weak.
2. Flt Lt. S. Ramakrishnan from Institute of Armaments Technology, Girinagar Pune was given training on the operation and applications of MST infrared detector for a period of 15 days.
3. Two scientists one from ZAMBIA and another from Zimbabwe were trained in the field of force measurement.
4. Training was given to CEMET scientists from African and South American Countries in the field of length measurement.
5. Training was provided to Mr. Jong Jon-Ho, of DPR, North Koria for six months on lasers, length measurement and calibration.
6. Mr. P.K. Mohanti, DRDO was given training and guidance for his M. Tech. Project.
7. Miss Prapassorn Piromgraipak, Industrial Metrology and testing science centre, Thailand and Mr.Deenish Maharaj, Trinidad and Tobago Bureau of Standards, Trinidad were trained for two months in the field of Pressure and Vacuum.
8. Two foreign scientists Sh. A.B.B.S. Wijetilleka and Sh. A.M.M. Atapattu from Institute of Science Industrial Res (CISIR), Ceylon were trained on study of CO_2 and CO emission from biomas burning with the help of gas chromatography.
9. Training in calibration of length, angle standards and dimension measurement instrument was imparted to the persons from :-
   (i) Officers of Bureau of Indian Standards.
   (ii) Legal metrology departments of commonwealth countries like Guana, Uganda, Pakistan, Srilanka, Bangladesh, Nepal, Trinidad, Botswana.
   (iii) Tata Iron & Steel Co. Ltd., Jamshed Pur.
   (iv) Ordinance factory, Gurgaon.
   (v) C M E R I, Durgapur.
   (vi) National Test House Calcutta.
   (vii) Sri Ram Institute of Industrial Research Delhi.
10. Three SC/ST students of Secondary level attended the one week training programme.
11. 35 Students/Officers from an Engineering Institute/Govt. Deptt. carried out their project work towards the fulfilment of their course.

SYMPOSIA/WORKSHOP/SEMINAR

1. XIX Conference of Electron Microscope Socity of India held at NPL on 14th to 16th Dec. 1994.
2. Function for Launching of Leather Technology Mission CLRI & CSIR held on 12th Jan., 1995.
3. Workshop on Organisation, Transformation and Globalisation was held by Dr. Prabhu S. Gupta - 25th Jan., 95.
4. Workshop on "The Changing role of Administration in R & D organisation in the wake of Economic Libarlisation in the country" for Administration Staff held on 1st to 3rd Feb., 95 & 6th Feb., 95.

5. South Asian Committee (SASCOM) held for IGBP Meeting -10th & 11th Feb., 95.

6. Shanti Swaroop Bhatnagar Award distribution function was celebrated on 13th Feb., 95.

7. National Workshop on Electrical and Electronic Measurements was organised -23rd & 24th Feb., 95.

DISTINGUISHED VISITORS

1. Parliamentary Consultation Committee visited NPL, December 10.

2. Mr. P. Rohmingthanga, Secretary, Deptt. of Supply, Govt. of India, visited the Laboratory February, 23.

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