वार्षिक प्रतिवेदन
Annual Report
1993-94

राष्ट्रीय भौतिक प्रयोगशाला
National Physical Laboratory
New Delhi

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Director's Report

The annual report for the year 1993-94 is in your hands which gives an account of the major achievements and overall work of the laboratory during this year.

The standard time and frequency service broad cast was continued. The latest use of this service is by All India Radio for frequency calibration of its synchronised transmitters. Research and development work in the field of materials development was continued which included the work on silicon devices, interface micro structure devices, luminescent materials, display devices, liquid crystals, sol-gel processed materials, conducting polymers, carbon products, thin film systems & metals & alloys.

NPL has developed carbon-carbon composites using PANOX fibres and carbon matrix derived from coaltar pitch. Work on metal/extrinsic dielectric/silicon structures for memory and sensor devices was extended. Influence of cobalt doping on the magnetic properties of YIG has been investigated for the first time.

The main achievements of NPL relate to development of Al-based light weight strategic materials, superconducting persistent switches, High Tc superconducting SQUIDS, 38 KHz pinger, Source transducer for seismic modelling and mechanical distrometer.

A license of the NPL process for indelible ink, M/S Mysore Lac & Paints Co. exported the ink to various countires including Ghana, Turkey and Singapore, resulting in a foreign exchange earning to the tune of several crores of rupees.

Standards were developed for dead-weight piston gauge pressure, Hydrogen maser atomic frequency, optical radiation and specular spectral reflectance.

Two Hi-Tech experiments were carried at Antarctica to study ozone depletion in the atmosphere.

Super conducting persistent switches have been developed by NPL successfully. A device for rotating a disc using ultrasonic vibrations has been developed. This device can be used for both continuous as well as step wise rotation.

A high frequency square array antenna using 22 piezoelectric tweeters has been designed, fabricated and characterized. A dead weight piston gauge pressure standard has been developed. This can be used as a stable pressure generating measuring system in the range 0.2-60 MPa (2-600 Kg/cm^2).

An active hydrogen maser atomic frequency standard has been developed. In the field of optical and Infrared standards lab photometric scales have been cross-checked with BIPM standards. Infrared standards are not readily available from any of the standards laboratories in the world. We have developed the Infrared standards for specular reflectance for near as well as glancing angles of incidence from 10° to 70° in the spectral region 2.5 to 25 μm.

In the field of crystal growth & characterization as a part of an Indo-US project entitled "High resolution X-ray diffraction imaging for advanced materials characterization", a scientist from the university of Maryland (USA) worked with us in Dec. 1993. He had brought with him gallium arsenide crystals implanted with Si+ ions. The implantation was carried out in two stages and these crystals were characterized on a multi-crystal X-ray diffractometer developed at NPL.

Radio science is also another major field in which the laboratory continued the work. The activities in this area include International Geosphere Biosphere Programme, photo chemical modelling, and radio communication. NPL continued R & D work in low temperature physics too. Both basic and applied research work was carried out in this field.

NPL maintained active collaboration with R & D organisations, scientific laboratories and educational Institutions for exchange of scientific & technical knowledge. These include public sector, Governmental and other national and International organisations. Several projects were taken up during the year under sponsorship from DST, DOE, ONGC, DNES, IRDE, DRDO and ARD etc.

A number of processes were released to various industries for commercial exploitation, including liquid Nitrogen Containers & Blood Glucose Biosensor etc.

In the academic field, ten candidates were awarded Ph. D for their work done in NPL. About fourteen candidates from different departments were given training in different fields of science. One hundred & sixty papers and more than one dozen Research reports were published by Scientists in leading national and International Journals.

Several distinguished visitors from scientific community delivered lectures at NPL. This year XXIV Krishnan Memorial lecture was delivered by Prof. Norman F. Ramsey, NL, Harvard University, USA on 22nd March 1994 on the topic entitled "Time and the physical Universe".

I find here an opportunity to congratulate some of our scientists for their outstanding contributions in science for which they have been honoured, Dr. A.V. Narlikar was awarded Doctorate of Science degree by the Cambridge university. U.K. Dr. Ajay Dhar and Dr. Keshav Kumar won the CSIR young scientist Awards, Dr. B.K. Das was selected for one of the best Metallurgists award for 1993 by the Indian Institute of Metals. I myself was elected as the president of the Instrument Society of India. I was nominated for Homi Jehangir Bhabha medal by Indian National Science Academy for its 1993 Academy award. I was also elected a member of the council of BIPM, Paris. This year as a whole was successful which has encouraged us. Redeployment of scientific and technical staff was continued for their maximum utilisation to serve the laboratory and hence the nation to their utmost ability.

We have an encouraging past, a fruitful present and a hopeful future.

E R Gopal

(E.S.R. Gopal)

निदेशकीय प्रतिवेदन

वर्ष 1993-94 की वार्षिक रिपोर्ट प्रस्तुत है जिसमें वर्ष के दौरान प्रयोगशाला की मुख्य उपलब्धियों तथा कार्य क्लाप का लेखा जोखा है।

मानक समय और आवृत्ति की प्रसारण सेवा जारी रखी गई। इस सेवा का सबसे अंत में आरम्भ आकाशवाणी ने सिंक्रोनाइज्ड ट्रांसमिटरों की आवृत्ति के अंशांकन के लिए किया। पदार्थों के क्षेत्र में अनुसंधान और विकास का कार्य जारी रखा गया जिसमें सिलिकन डिवाइसो, इंटरफेस माइक्रोस्ट्रक्चर डिवाइसों, संदीप्तिशील पदार्थों, प्रदर्श डिवाइसों, द्रव क्रिस्टलों, सौल जैल प्रक्रियित पदार्थों, चालक पॉलीमरों, कार्बन उत्पादों, तनुपरत सिस्टमों तथा धातुओं और मिश्र धातुओं के क्षेत्र में कार्य सम्मिलित है। एन. पी. एल. में PANOX रेशों के इस्तेमाल से कार्बन कार्बन संयुक्तों तथा कोलतार-डामर कार्बन मैट्रिक्सो के विकास का कार्य किया (धातु) एम्स्ट्रिजिक परावैद्युत। सिलिकन स्ट्रक्चरों के मैमोरी और संवेदक डिवाइसों के लिए कार्य को आगे बढ़ाया गया। पहली बार YIG के चुम्बकीय गुणों पर कोबल्ट डोपन के प्रभाव के क्षेत्र में खोज का कार्य किया गया।

प्रयोगशाला की मुख्य उपलब्धियाँ Al- आधारित हल्के सामरिक पदार्थों, अतिचालकीय पर्सिस्टेंट स्विचों, उच्चतापीय अतिचालक स्विचों, 38 KHz पिंगर, भूकंम्पीय माँडलिंग के स्रोत ट्रांस्डयूसर तथा यांत्रिक डिस्ट्रोमीटर के क्षेत्र में है।

घाना, टर्की तथा सिंगापुर सहित कई देशों को एन. पी. एल. में विकिसित अमिट स्याही की निर्माणविधि का लाइसेंस दिया गया जिसके फलस्वरूप कई करोड़ रूपए की विदेशी मुद्रा की प्राप्ति हुई।

डैड वेट पिस्टन गेज दाब मानक हाइड्रोजन मेसर परमाण्विक आवृत्ति, प्रकाशीय विकिरण तथा स्पेकुलर स्पेक्ट्रयी रिफ्लेक्टेंस के मानकों का विकास किया गया।

एंटार्कटिका पर वायुमंडल में ओज़ोन में कमी आ जाने के सम्बन्ध में दो हाई टैक प्रयोग किए गए।

प्रयोगशाला में सफलतापूर्वक अतिचालकीय परसिस्टेंट स्विचों का विकास किया गया। पराध्वनि कम्पनों द्वारा एक डिस्क को घुमाने के लिए एक डिवाइस का विकास किया गया। इस डिवाइस का इस्तेमाल लगातार तथा रुक रुक कर डिस्क को घुमाने में किया जा सकता है।

22 दाबवैद्युत ट्वीटरों का इस्तेमाल करके एक उच्च आवृत्ति वाले वर्गाकार ऐरे एंटेना का डिजाइन निर्माण तथा अभिलक्षणन किया गया। एक डैड वेट पिस्टन गेज दाब मानक विकसित किया गया है। इसका इस्तेमाल 0.2–60 मैगा पास्कल (2–600kg/cm^2) के रेंज में स्थाई दाब उत्पादक विकास के रूप में किया जा सकता है।

एक सक्रिय हाइड्रोजन मेयर परमाण्विक आवृत्ति मानक का विकास किया गया है। प्रकाशीय तथा अवरक्त मानकों के क्षेत्र में बी. आई. पी. एम. मानकों के साथ प्रयोगशाला में प्रकाशमितीय स्केलों की जाँच की गई।

विश्व की किसी भी मानव प्रयोगशाला में अवरक्त मानक तैयार नहीं मिलते। हमने निकट तथा 10° से 70° के कोण पर आपतित कोणों तक के लिए 2.5 से 25 माइक्रोमीटर तक के स्वेक्ट्रमी क्षेत्र में अवरक्त मानकों का विकास किया है।

दिसम्बर 1993 में क्रिस्टल विकास तथा अभिलक्षणन के क्षेत्र में भारतीय-अमेरिकी परियोजन, "हाई रिजोल्यूशन एक्स-रे डिफ्रैक्शन इमेजिंग फॉर एडवांस्ड मैटीरियल्स कैरेक्टराइजेशन" के अंतर्गत मैरीलैंड (यू. एस. ए.) के एक वैज्ञानिक ने हमारे साथ कार्य किया। वे अपने साथ Si^+ संरोपित गैलियम आर्सेनाइड क्रिस्टल लाए थे। संरोपण का कार्य दो चरणों में किया गया तथा अभिलक्षण का कार्य एन. पी. एल. में विकसित मल्टी क्रिस्टल एक्सरे डिफ्रैक्टोमीटर पर किया गया।

रेडियो विज्ञान एक अन्य महत्त्वपूर्ण क्षेत्र है जिसमें प्रयोगशाला ने कार्य जारी रखा। इस क्षेत्र में इंटरनैशनल जिपोस्फिर बायोस्फियर प्रोग्राम, प्रकाश रासायनिक मॉडलिंग तथा रेडियो संचार सम्मिलित है। प्रयोगशाला में निम्न ताप भौतिकी के क्षेत्र में कार्य भी सम्मिलित है। इस क्षेत्र में मूल भूत तथा अउप्रयुक्त दोनों प्रकार का अनुसंधान कार्य सम्मिलित है। प्रयोगशाला ने अनुसंधान एवं विकास प्रयोगशालाओं, वैज्ञानिक प्रयोगशालाओं तथा शैक्षिक संस्थाओं से सक्रिय सहयोग बनाए रखा जिससे तकनीकी तथा वैज्ञानिक जानकारी का आदान प्रदान जारी रहे। इनमें सार्वजरिक क्षेत्र, सरकारी तथा अन्य राष्ट्रीय और अंतर्राष्ट्रीय संगठन सम्मिलित हैं। वर्ष के दौरान डी. एस. टी., डी. ओ. ई., ओ. एन. जी. सी., डी. एन. ई. एस., आई. आर. डी. ई., डी. आर. डी. ओ. तथा ए. आर. डी. आदि द्वारा प्रायोजित अनेक परियोजनाएँ हाथ में ली गईं।

द्रव नाइट्रोजन पात्रों तथा रक्त ग्लूकोज जैव संवेदकों सहित अनेक प्रक्रियाएँ व्यापारिक उपयोग के लिए उद्योगों को दी गईं।

शैक्षिक क्षेत्र में एन. पी. एल. में किए गए कार्य के आधार पर 10 व्यक्तियों को पी. एच. डी. की उपाधि प्रदान की गई। विभिन्न विभागों से आए लगभग 14 व्यक्तियों को विज्ञान के विभिन्न क्षेत्रों में प्रशिक्षण दिया गया। वैज्ञानिकों ने अनेक जाने माने राष्ट्रीय तथा अंतर्राष्ट्रीय जर्नलों में एक सौ साठ पत्र प्रकाशित किए तथा एक दर्जन से अधिक अनुसंधान पत्र प्रकाशित किए।

वैज्ञानिक समुदाय के अनेक विशिष्ट आगंतुकों ने एन.पी.एल. में व्याख्यान दिए। इस वर्ष 24वां कृष्णन स्मारक व्याख्यान प्रो. नॉर्मन एफ. रामसे, नोबेल पुरस्कार विजेता हार्वर्ड यूनिवर्सिटी यू. एस. ए. ने 22 मार्च, 1994 को दिया। इसका विषय "टाइम एण्ड द फिज़िकल यूनिवर्स" था।

यहाँ पर मैं अपने कुछ वैज्ञानिकों के वैज्ञानिक क्षेत्र में उनकी उपलब्धियों पर सम्मानित किये जाने के लिए बधाई देना चाहूँगा। डॉ. ए. वी. नार्लीकर ने कैम्ब्रिज यूनिवर्सिटी यू. के. से डॉक्टर ऑफ साइंस की उपाधि प्राप्त की। डॉ. अजय धर ने सी. एस. आई. आर. युवा वैज्ञानिक पुरस्कार प्राप्त किया। डॉ. बी. के. दास को 1993 में इंडियन इंस्टीट्यूट ऑफ मैटल्स ने सर्वोत्तम मैटलर्जिस्ट के लिए चुना। स्वयं मुझे इंस्ट्रूमैन्ट सोसाइटी ऑफ इंडिया का अध्यक्ष चुना गया। 1993 के एकेडेमी पुरस्कार के लिए इंडियन नेशनल साइंस एकेडेमी द्वारा होमी जहाँगीर भाभा पदक के लिए नामित किया गया। इसके अतिरिक्त बी. आई. बी. एम. काऊंसिल, पैरिस के लिए मुझे एक सदस्य भी चुना गया। कुल मिला कर यह वर्ष सफल रहा जिससे हमें बढ़ावा मिला है। वैज्ञानिक तथा तकनीक कर्मचारियों को रीडिप्लॉय किया गया जिससे उनकी योग्यताओं का भरपूर इस्तेमाल हो सके और वे अपनी पूरी क्षमता से देश की सेवा कर सकें।

भूतकाल से हमें बढ़ावा मिला है वर्तमान सफलतापूर्ण तथा भविष्य हमारे लिए आशापूर्ण है।

ई एस आर गोपाल

(ई. एस. आर. गोपाल)

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

1. Length

A transportable type of methane stabilised He-Ne laser at 3.39 um is built by NPL Scientist at FIAN, Moscow under Indo-Russian Collaborative programme. This unit has been received and is being installed at NPL. The estimated frequency stability of this laser is $3x10^{-13}$. The computer controlled mask aligner technology is now ready for commercial exploitation.

2. Dimensional Metrology

With the establishment of three coordinate measurement facility, measurements were carried out on checking of the profile and generation polynomials of the following components :

a. TV masks
b. TV picture tube screen

This was a developmental programme of M/s Semtel Color Limited for the manufacture of these components in India. These are imported from Japan and manufacture of these is a closely guarded technology.

With the establishment of this facility CMM the calibration of coordinate measuring machines of four compaines was carried out at their site providing them the traceability of the measurements carried on CMM. Efforts are in progress for modernization of Dimensional Metrology Section and strengthening of the measurement and calibration facility.

Intercomparison of Gauge Blocks was undertaken. The standard laboratories of different countries participated in the exercise. 1, 3, 8, 40 and 100 mm gauges were calibrated for their mean length with an uncertainty of 99.7% confidence level. The deviations in measurement of 1, 3 and 8 mm have been found to be within 10 µm while the deviations in measurement of 40 and 100 mm are yet to be confirmed by the CSIRO, Australia, the Coordinating Laboratory.

MASS

National Prototype Kilogram copy No. 57 was calibrated at BIPM. The calibration work of reference standards from states organisations was continued in addition to normal mass calibration work. Calibration of 1000 kg weights were carried out using 2000 kg balance. Viscosity scale upto 2500 has been set-up. Regular calibration of viscometers, hydrometers, measures and performance evaluation of electronic balance was carried out.

PRESSURE & VACUUM

1. Pressure

In order to ascertain and reaffirm the uncertainty of the measurement of pressure in this region, the three different secondary standards of the laboratory are intercompared among themselves to determine the effective area of each of three piston cylinder assembly at 23^0 C. The mass of the weights, calibration of the temperature sensor of each of these assemblies have been redetermined. The measurements were made in five pressure cycles by direct comparison (cross-floating) between two of the transfer standards. Each pressure cycle consisted 22measurements at 10 applied pressures between 0.4

MPa to 4 Mpa both with the increasing and decreasing order of pressure and at intervals of 0.4 MPa although NPL-8 can go with a particular piston cylinder combination to a maximum pressure of 10 MPa. These gauges are metrologically characterized to a maximum pressure of 10 MPa. These gauges are metrologically characterized through cross-cylinder assembly, so that it can be traceable to the primary standard i.e. the Harwood controlled clearance piston gauge. The agreement of the deviation of the observed values of the effective are Ap from the appropriate least squares best fit straight line is within 5ppm in the whole pressure region.

The characterization of the newly developed piston gauge pressure standard with particular reference to its fall rate, engagement length of the piston and the deceleration rate for the measurement of hydraulic hydrostatic pressure upto 60 MPa has been made. The low pressure effective area of the gauge derived from its dimensional measurements when compared with the value obtained by its direct calibration against NPL transfer pressure standard agrees within - 0.025 %. The pressure gauge is quite stable, reproducible and has a sensitivity of 3 ppm. Though the theoretically calculated value of the pressure coefficient is low as compared to the experimentally observed one in its absolute terms, the pressure dependent effective area agrees within - 0.25% over whole of the pressure range which is well with in the uncertainty statement of the two independent techinques used.

2. Vacuum

Calibration of the air piston gauge (transfer standard) received from NPL, Teddington, UK was carried out at different pressures starting from 11 kPa to 131 kPa at intervals of 20 kPa and 21 kPa to 121 kPa with the pressure increment of 20 kpa. We have determined the pressure generated and the effective area of the pressure balance against "Ultrasonic Interferometer Manometer" which is a primary pressure standard using Nitrogen gas. At each generated pressure 50-60 observations were taken and the deviation is not more than 10 ppm.

An internation intercomparison of vaccum leak standards was carried out under the INDO-US collaborative project "Establishment of Transfer Leak Standards in Vacuum Metrology". For this purpose a crimped capillary leak previously characterized at NIST, USA and IMGC, Italy was used to make leak rate measurements on the NPL leak standard in the range of 10^{-12} mol/s to $1x10^{-8}$ mol/s for three different gases argon, helium and nitrogen. Preliminary results suggest that the comparison has gone fairly satisfactorily, judging by the NPL prebake data and the IMGC data which are all within 0.8% of the NIST data. The results are being analyzed.

3. Surface Physics

Studies on transition metal silicides and oxides using Auger Electron spectroscopy (AES), Electron Loss Spectroscopy (ELS) were completed and the results have been compiled.

The effect of Ar^+ion beam energy on the bonding of contaminants (carbon and Oxygen) with Si (111) surface has been carefully studied by Angle Dependent X-ray Photoelectron Spectroscopy (ADXPS). It is observed that a threshold of 500eV is necessary for SiC formation at the interface. The secondary electron emission anisotropy due to forward scattering is used to probe the structural changes.

A dedicated Secondary Ion Mass Spectrometer (SIMS) Model MIQ 256 CAMECA-RIBER was successfully commissioned and installed at the group with three different ion sources; (i) Duo plasmatron (ii) Ceasium and (iii) Liquid metal (Ga) ions. This equipment is

unique of it's type in the country with all it's versatility and capability. This was procured through the technical & financial assistance from UNDP (1.25 million US $). A one day workshop on awareness of SIMS was conducted with theoretical deliberations and practical demonstration to the user industries from micro electronic and high-vaccum manufacturers.

Improvements were made in the realization of Tin & Zinc fixed points resulting in Plateam of increased duration. This would speed up calibration work of standard Platinum resistance thermometers.

Two triple point of water cells, one using Antarctic water, were made.

A simple heat-pipe to freeze the TPW cell has been developed 3 Nos made, one such heat pipe & one triple point of water cell are being gifted to Saudi Arabia under CSIR-SASO technical co-operation.

Two extension heat pipe baths for calibration of glass thermometers have been fabricated.

About 400 (Four hundred) test reports were issued to the industry to promote their work, helping them to acquire ISO-9000. This has sufficiently increased the revenue earning.

The spectroradiometric measurement facility existing in the spectral range upto 1.1µm has been extended to cover the range upto 2.5 um. A number of working standards covering the range between 1.1 to 2.5 um have been prepared. Calibration facility in this range has been extended to a few institutions. We are capable of offering spectroradiometric calibration in the range 250 um to 2500 um.

With the upgrading of photometric laboratory by way of setting newer and more precision instruments received under NPL-PTB Phase II cooperation facilities to a larger section of industry, there has been a noticeable increase in the revenue earnings for the laboratory.

In the area of basic research, some new interferometric techniques have been devised. These techniques have been used to determine the intensity distribution across a sources and also to determine the angular separation of a pair of sources. These studies might find their applications in astronomy.

The infrared reflectance standards thus were developed for normal and glancing angle of incidence for entire radiometric/photometric scale in 2.0 to 25 µm spectral region.

Two infrared scanners of different types from the industry were calibrated for their responsivity. Though, ingeneral, infrared spectroscopic characterization facilities were extended to various developmental projects of the laboratory, but essential and important feedback were provided by measuring the spectral transmittance of antireflection coating of Diamond like carbon (DLC) on polished silicon and germanium blanks to one of the sponsored projects.

Because of the scientific advancement, knowledge about UV radiation is finding vide applications in physical, biological, agricultural sciences and industrial fields etc. Some important applications include illumination of fluorescent lamps, phosphorescence for illuminating industrial panel dials, chemical synthesis and analysis, production and process inspection of photo-imaging, crime detection, sterilisation of food, water and air, vitamin production, medical diagnosis

and therapy, photocopying processes, photoelectric scanning etc. Most of the effects deal with the germicidal effects of UV against wide varieties of micro-organisms such as molds, bacteria and virus etc. Accurate measurement of UV radiation is a tedius job as measurement involves not only the use of a stable well characterised spectro-radiometer but also a suitable UV standard source or detector. It has been found that for most of the spectro-radiometeric applications, a standard source should be used for the measurement of the spectral output of the radiation source. Also a standard source or a calibrated detector is required if the system is to be used to calibrate the detector.

In this direction the NPL is establishing a UV radiometeric scale in 2ϕϕ-4ϕϕ nm range and UV measuring facilities for different domestic appliances such as lamps of common use, welding arcs for industries, calibration of UV detectors and filters etc. in 2ϕϕ-4ϕϕ nm spectral region. The automation of the radiometer has been completed to record the spectral energy distribution of radiation sources. The provision of comparing/ normalising the spectral energy distribution (in 2ϕϕ-4ϕϕ nm) of two sources has been made. With this facility, if one of the sources is replaced by a standard source, the calibration of the unknown source can be done. We are now in the process to procure a standard source and power supply for this purpose. Similarly, to perform filter radiometry, we have procured a set of ten standard UV filters and a standard calibrated detector.

ACOUSTICS

The acoustics of various public warning sirens/systems was examined in the light of the available information in the literature and the data collected in the section over the years. Also a typical siren was analysed to select a suitable siren for permanent installation on NPL building for giving time signals to the employees.

A complete literature survey was undertaken in respect of EIA studies of noise pollution in India,. Based on the available data it was possible to classify the following types of noise pollution existing in Delhi. They are transportation, industrial, social activities, domestic, constructional, business establishments, human activities, natural and man made causes/situations.

Another important concept developed in respect of EIA studies is the intimate relationship existing between noise and air pollution in Delhi. With more than 50% of the total air pollution is caused by vehicular emission and as the major contribution of noise pollution comes from vehicular traffic, the remedial measures that can be adopted to control noise pollution will autommatically reduce the extent of air pollution in Delhi.

Two monostatic sodars were designed, developed, fabricated, installed and commissioned respectively at IIP Dehradun and SAIL, Bhillai. In the process of developing Doppler Sodar Facility at NPL a noise filter and antenna switching network for 3-axis Doppler Sodar have been designed and developed. Also a suitable software or Doppler data acquisition, an exponential horn for Doppler Mini Sodar, an array of piezoelectric transducers etc. have been developed. A preliminary experiment for Doppler Sodar Sounding have been carried out and encouraging results have been obtained.

ULTRASONICS

A PVDF membrane hydrophone has been calibrated using phase locked laser interferometer at a frequency of 0.54 MHz by measuring the vibrations on a mylar pellicle and output of the hydrophone when substituted in place of a pellicle. The receiving sensitivity is measured to be 0.12 μV/Pa with an accuracy of 1.1dB.

Ultrasonic transducers were designed and fabricated having peak positive pressure 3.5 MPa. Focal zone 75mm, pulse duration 500ns, beam width at focal point 2.6mm and receiving sensitivity of 4 μV Pa at a frequency of 3.5MHz. The transducers are miniature in size and assembled ina bore of 15mm diameter and 15mm length. Trials at CSIO are in progress.

Miniature source transducers of frequency in the vicinity of 250kHz, with omnidirectional response have been developed. The acoustic signature of the NPL transducer is superior to the commercial one by a factor of 37%. The transducers have been delivered to KDMIPE., Dehradun for trials.

A prototype pinger unit of 38kHz with a source level of 168dB re 1μPa/m and required pulse width and directional characteristics was developed. Driving electronics for the unit was also developed and marine alloy housing for transducers and device and Li Mn cells were procured. The prototype tested to a pressure of 1000 psi and was delivered to NSTL.

A piezoelectric sensor element at 16kHz with receiving sensitivity of - 140dB re 1V/ μPa was developed for picking the acoustic signals produced by the rainfall. An experimental system was then set up for continuous recording of the rainfall. Pattern of rainfall from drizzle to medium intensity in mm/ sec has been recorded. Typical measurements from medium rainfall show a signal 20 dB above the one due to no rain.

The tubular elements with O.D. 4mm, I.D. 2.5m and length 2mm have been fabricated for work on transducers for seismic modelling for ONGC with a capacitance of 600 pf and electrical conductance under loaded conditions of 0.13ms at frequencies about 250kHz. Tubular elements having resonant frequency of 38 kHz under loaded conditions have been developed:

Basic Investigations

Ultrasonic vibration amplitude and distribution over the transducer surface has been studied for a number of transducers including quartz, Pzt, Pzt with backing, with front layer, tapering in thickness etc. The vibration measurement provide valuable information about the design and performance of the transducers.

Investigations on the feasibility of characterisation of piezoelectric ceramic materials by ultrasonic velocity measurements have been carried out. The change in ultrasonic velocity over that of unpoled ceramic is seen to have correlation with the state of polarisation.

Thermoacoustic investigations have been carried out in a resonator tube acoustically driven at a frequency of 337Hz at a peak acoustic pressure of 141dB re 20 μPa. Using a mica stack, an initial fall in temperature is seen followed by temperature stabilisation.

The standard Time and Frequency Signal (STFS) broadcast via INSAT ID was continuous and uninterrupted. The number of users has increased gradually. The latest use of this service is by All India Radio for frequency calibration of its synchronised transmitters.

The active hydrogen maser has been made operational at NPL. It was formally inaugurated by Prof. N.F. Ramsey, Nobel Laureate.

Submicrosecond time synchronisation via INSATID TV signals in a commonview has been established for a short base line. Work has been initiated to extend this range over the whole country and evaluate its accuracy limit.

Work on the automation of ATA broadcast has been completed.

Two projects-one on the reliability of GPS signals and the other on the study of the effect of selective availability have been undertaken. These are funded by DOE and DRDO respectively.

A milistone has been achieved by integrating the indigenously developed Rb^{85} atomic frequency standard with the Rb filter cells at NPL. Efforts are on to fill the isotopic cells with different buffer gases at varied gas pressures so to arrive at the optimum filtering efficiency.

An rf shielded chamber, received under NPL-PTB Phase II Programme, has been installed. All the subsystems of the series array 1 volt Josephson standard has been installed and tested inside the shielded room. Several chips, containing 2000 to 3000 $Nb/Al_2O_3/Nb$ thin film Josephson junctions in series, were investigated and interesting results on their degradation behaviour were observed.

The Transfer level Power standard ILM 03 (typical accuracy ±0.01%) and three phase reference standard TPZ 301-37 (typical accuracy ±0.05%) are installed and are used for semiautomatic calibration of induction type as well as static type energy meters. The 3 phase source SDE 106 has been updated to supply 0-576 volts and 0-120 Amps. using high stablity transformers. Also the facility of 3rd harmonic and dosage. for dial test have been included. The phase measurement technique has been estabilished using Phase standard model 5000 and phase calibration bridges (typical accuracy range 5-20 millidegrees for frequency range 10 HZ to 100 KHZ).

(i) A new facility for the measurement of voltage standing wave ratio (VSWR) in the frequency range of 10 MHz to 26 GHz has been established. So far we did not have any direct technique for the measurement of VSWR at the frequency mentioned above. For this reason we were using indirect method to estimate the probable VSWR of a coaxial component or a device with power

accuracy. With the establishment of this new facility, we have been able to evalate the performance of the recently developed and fabricated coaxial microcalorimeter in the frequency range of 10 MHz to 18 GHz. This technique has an accuracy of ±0.02 in the measured VSWR value. This facility now finds application in the calibration of power sensors received from user organisations.

(ii) Automation has been introduced in the calibration of power meters and power sensors. This has resulted in the saving of calibration time and also enhanced the precision of measurement.

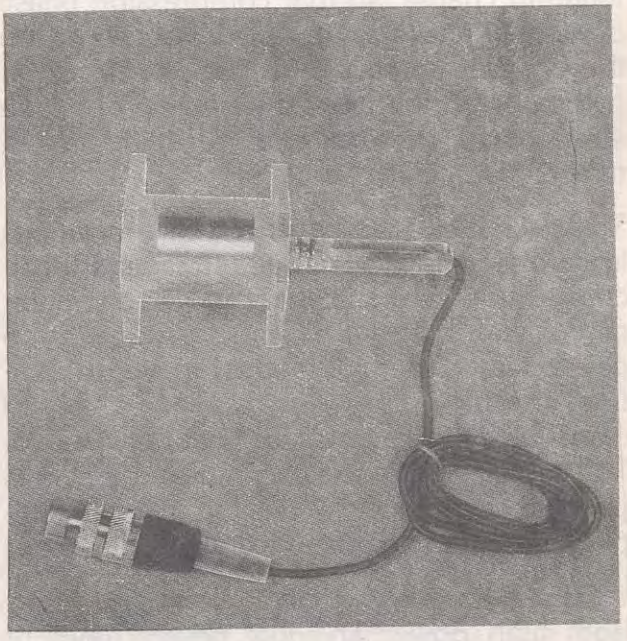
Calibration of coaxial and rotary vane attenuators, T-P testers, coaxial mismatches and wavequide phase shifter was carried out for the different Govt. Departments. VM-4-B attenuator calibration system has been commissioned in the manual mode for calibrating coaxial attenuators in the frequency range 30 MHz to 18 GHz.

A new magnetics standards laboratory is being setup at the National Physical Laboratory, New Delhi. As a first step, it was considered important to ascertain the needs of Indian industries and other organisations and their expectations from this group. In light of the above, a detailed questionnaire on "Magnetic Measurements, Calibrations and Standards" was prepared and sent to a number of Indian industries and other organisations. The result of this survey has given a concrete direction towards the establishment of facilities for magnetic measurements at N.P.L. In addition, it has helped in raising the awareness level amongst persons working in this area about the present and planned activities of the group. The facilities which will be made available at NPL are:

- ❒ Calibration of H-Sensors (using NMR Setup)
- ❒ Calibration of fluxmeters (using precision electronic calibrator)
- ❒ DC & AC measurements on soft magnetic materials
- ❒ Measurements on permanent magnetic materials
- ❒ Measurements on feebly magnetic materials

The work on setting up these facilities is in progress.

Presently, facilities exist for calibration of standard magnets, gaussmeters and fluxmeters with measurement uncertainty of 5 x 10^{-3} - 1.5 x 10^{-2}.



Standard Search Coil

INSTRUMENTATION

An ultrasonic single probe transducer with focussed front face is made by using 25 mm diameter discs of PZT-4 (Lead Zirconate Titanate) materials with resonant osciallating frequency of 1 MHz. In the present investigation, several lenses have been developed by using different solids, for achieving the better focussed ultrasonic systems for tumour therapy. Among the metals, aluminium and bronze are used for making the lenses while among the plastics, polyethylene and perspex are used.

The focal intensity, as one of the important factor for a particular beam intensity and time interval, in order to achieve proper impact or crushing strength to destroy tumour. It was found that with an increase in the focal length and hence focal area, the intensity generated by the transducer was found to decrease when the wave was in contact with the interface, the sound impedance was found to charge, so that compression phase or tensile phase is reflected depending on the acoustical quality of this interface. At point where the focussed wave had optimum strength of the material, destruction of tumour was found to occur.

Theoretical intensity distribution for various lense materials of focussed ultrasound transducer has been analysed and a computer model for intensity distribution has been developed. A thermal model for the predication of temperature rise in a tissue due to ultrasonic absorption has been developed. The results of this model predicted that it is possible to achieve a desired rise in temperature in a tissue by varying transducer parameters.

Both high power and low power types of piezoelectric transducers were made for diagnostic and therapeutic applications in biomedical and other fields. Performance evaluation of transducer systems was made for precision scientific measurements.

A special multi-element transducer system having a common focal point/intensity because a single element transducer cannot give good intensity gain. Theoretical model was also developed to understand the pressure amplitudes at the surface of the transducer as well as on kidney stone surface.

Detailed electrical and acoustical studies of both normal and fractured bones were made for investigating the behaviour of bone matrix in relation to its anatony. Bone fracture size and its location were investigated on the basis of these findings.

An ultrasonic system was developed to measure adulteration in petrol, diesel and various food materials, both liquids and solids.

Testing of improved Proto-type models of a standard quartz crystal frequency standard was made to give standard 6 Vpp, 10 MHz sine and six 3.5 Vpp levels quare wave frequencies of 1,10, 100 and 500 KHz, and 1 and 5 MHz. The long term stability was found to be 5×10^{-10}/day when averaged over a period of 10 days and short term stability as 1×10^{-9}/sec.

An oven controlled crystal oscillator (OCXO), with double ovens systems, was developed for precision frequency measurements. The oven temperature was maintained at 60°K. Frequency adjustment was done by using a bulit-in-trimmer kept inside the oven of OCXO.

An electronic acoustic dosimeter was developed to measure acoustic power from few milliwatts to several watts for both medical devices or industrial instruments. Optimisation of electronics and design of improved model of the instrument for measuring vehicular exhaust smoke density, was further continued for M/s Enviro-Tech, New Delhi.

MATERIALS DEVELOPMENT

SILICON DEVICES

One of the renewable source of energy is photovoltaics. The emphasis is on low cost large area high efficiency solar cells. Our thrust area is photovoltaics. We are working on 100 mm single crystalline and 100 mm x 100 mm multicrystalline solar grade silicon substrates. The diffusion furnace for processing such large area substrates has been procured and the diffusion parameters have been optimized for both types of substrates as mentioned above. On circular wafers 11% efficiency has been achieved with antireflection coating (ARC) of SiOx and 7% on the square wafers without ARC. Open circuit voltage (V_{oc}) of 585 mV, fill factor of 0.76 and current density of 14 mA cm^{-2} under AM 1.5,65 mW cm^{-2} have been obtained. The best parameters are not necessarily on the same wafer. The metallization is by screen printing. A comparative study of screen-printed and evaporated back contact of silicon solar cells and their effect on V_{oc} and short circuit current (I_{sc}) has been carried out. This was possible because an automatic screen-printer has been commissioned. The front and back contacts have been designed and cells fabricated to minimize power losses. The front metallization of both circular and square cells are shown in Figs. 1 and 2 respectively. Auger profiles of back metallization has been studied to study the back surface field (BSF) effects.

A new method has been developed to determine the dopant impurity profile in the front region using Lange's method of Hall measurement in conjunction with anodic sectioning. The profiles are compared to those obtained by spreading resistance method.

Optical confinement is yet another area which require special attention to improve I_{sc}. For this purpose texturing of the front surface is being improved and an inexpensive dip coating method of ARC is being developed.

The clue to high efficiency is preservation of life time (τ) and diffusion length (L). Photoconductive decay method is being employed to determine τ in virgin and heat treated wafers. It has been found that τ for virgin wafer is 50 micro second and that for wafer heat treated at 900°C is 35 micro seconds. For diffusion length measurement a new method of determination of minority carrier diffusion length in the base region of silicon solar cells using the middle wavelength spectral response of the cell has been established. This method has the advantage that it is independent of the thickness of the base region. Here midwavelength range e.g. $0.75 < \lambda < 0.90$ μm is used. L determined by this method has been found to be in close agreement with those obtained by photogeneration method and the spectral response measurement method. Measured values of L lie between 140-170 micrometer in the diffused wafer.

A reuseable graphite crucible has been developed for the directional solidification of silicon to cut multicrystalline silicon wafers from the directionally solidified ingot wherein grains are columnar in nature. 40 mm x 40 mm solar cells have been fabricated out of these wafers. Without surface passivation or optical confinement an efficiency of 6% was achieved. Efforts are on to make the wafers purer to achieve higher efficiency. The idea of reuseable crucible has caught the attention of Indian and International producers of solar grade silicon.

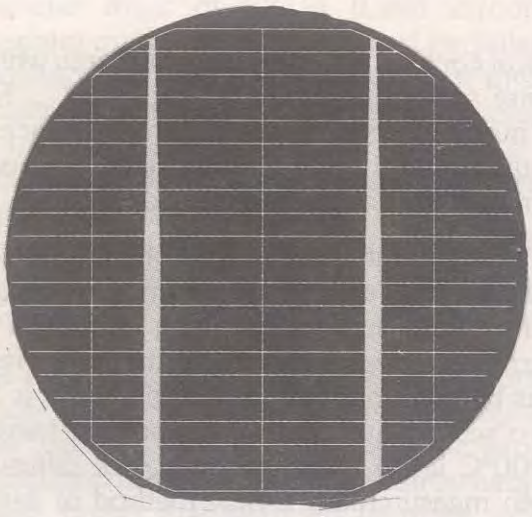


Fig. 1 Front side of a hundred mm diameter solar cell made in NPL.

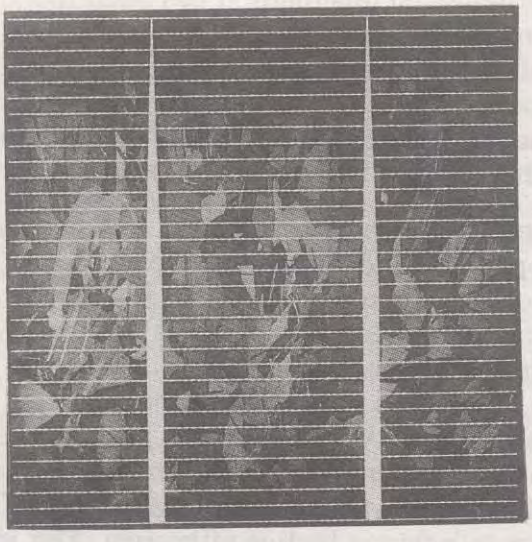


Fig.2 Front side of a 10 mm x 10 mm solar cell made in NPL.

For optical confinement surface texturing method is being improved and a novel method of dip antireflection coating followed by sintering is being developed to obtain higher efficiency.

High T_c Superconducting Thin Film and Silicides

Implantation irradiation studies of superconducting Bi_2 Sr_2 Ca Cu_2O_y by ^{14}N, ^{40}Ar have been studied as a function of ion dose on its resistance. X-ray diffraction studies and SEM studies are also being made. Super concuctivity is lost at a certain level of dose of the ions. These studies have been made on bulk 2212 samples.

Twenty-five bilayers of Fe (20A°)/CO (20A°) have been prepared by e-beam evaporation and magnetic hystersis is being studied. The system shows soft magnetic properties with a minimum coercivity of 90 Oe. B-H studies as a function of rapid annealing temperature are going to be made.

At the NSC Delhi 100 Mev 127I ion irradiation experiment on bulk and thin film YBCO, c-v measurements are also being done.

A rapid thermal processing unit with halogen lamps has been designed and fabricated. A temperature of 800°C is attained in less than 45 minutes and quick thermal processing of thick and thin films with and without dopants can be carried out very conveniently.

Ceramic Activity :

Sodium beta-alumina work was done in the regular manner-isostatic pressing of the powders and their sintering to theoretical density 3.30gm/c.c.; some tubes have been supplied to Karaikudi CECRI and Kalpakkam IQCAR, Madras for using in sodium-sulphur batteries.

A spray drier model DL-41 was purchased installed by us in the ceramic fabrication

shed. It was heated under varying conditions of the ceramic slip to produce regular size granules of (40-60 micron) beta alumina and also alpha alumina powder. The drier has the capacity of spraying approximately, 1 litre of slurry per hour.

Special Ceramics Activity - Porous alumina

Preliminary activities on porous alumina is under going by replica film of porous foam structures in alumina slurries, which is subsequently dried and burnt out. This porous alumina is being tried to be used as a filter for diesel engines. For permeability studies and actual emission filtering the equipments and fittings are being fabricated.

Interface and microstructure devices :

Work on metal/extrinsic dielectric/silicon structures for memory and sensor devices was extended. Work on post deposition annealing of electron beam deposited Y_2O_3 films shows the growth of SiO_2 below the extrinsic dielectric. This leads to the formation of stacked dielectrics with superior properties., in addition to providing insight into the SiO_2 growth process. Work on ferroelectric PZT films has been taken up. Preliminary results have demonstrated our ability to form films suitable for some electronic applications.

The electrochemical selenization technique has been refined and structural and optical investigations were performed on copper indium selenides and CdSe. The mechanism responsible for this selenization process has been identified thus improving our ability to optimize the process for preparation of solar cell grade semiconducting films

Utilizing the results of selenization of Cu and In films, the gas phase selenization technique has been extended to the preparation of high quality CIS films. The formation of single phase chalcopyrite structure in both $CuInSe_2$ and Cu (InGa) Se_2 has been confirmed by structural and optical investigations. For the first time plasma ionization has been introduced as a means of independently controlling the reactivity of the Se species and improve the selenization process. Results on the selenization of Cu films show the advantage of using the plasma enhance d process in formation of large grain highly textured films even with very small reaction times at low selenization temperatures. Work has been taken up to develop ZnSe window material as the replacement for CdS. This would lead to the *superstrate* structure for the CIS solar cell. Preliminary results confirm the possibility of performing a single selenization step for the formation of ZnSe/CIS layers. ZnSe films with suitable optical properties have also been prepared.

Formation of magnetic Yttrium Iron Garnet (YIG) films using MOCVD process has been demonstrated. Influence of cobalt doping on the magnetic properties of YIG has been investigated. For the first time, phase stabilization by charge compensation using Ce as a dopant has been demonstrated in Ce : YIG films.

LUMINESCENT MATERIALS

Electroluminescent Backlighting Panel:

Efforts were to develope Electroluminescent Backlighting Panel (ELBP) for use in backlighting of liquid crystal displays under sponsored programme from Raman Research Institute, Bangalore

Prototype ELB panel development:

EL Panels fabricated on conducting and transparent glass substrates were demonstrated in September 1993 at BEL in the presence of Prof. Chandrashekhar. The light output of ZnS electroluminescent phosphor was con-

sidered quite satisfactory. However, a change of configuration to the flexible plastic type was considered desirable by BEL engineers. Further work was continued to develope a prototype of such a plastic configuration.

This required an extensive R&D on materials and fabrication techniques. The immediate requirement was to develope an alternative to conducting glass, the conducting powder coating, to have adequate electrical conductivity and transparency to visible light. Extensive work was done to develope conducting tin oxide, indium oxide and zinc oxide powders with required crystallinity, particle size and conductivity.

The technique of layer application on Al-foil substrate remained essentially the same as for glass substrate. Large variety of organic binders and solvent combinations for the phosphor and conducting oxide layer were tried. A prototype developed consists of Al-foil on which phosphor in a plastic binder is spread followed by a layer of conducting oxide (tin or indium). The conducting layer is further coated with a peripheral Ag-paste electrode to improve upon the conductivity and the device is encapsulated between plastic sheets and the edges heatsealed. A prototype of this plastic ELBP was demonstrated in March, 1994.

Red Phosphor for Colour Picture Tube:

After having worked on different flux proportions, raw materials from different sources for preparing the red (Y_2O_2S:Eu) phosphor for colour picture tubes, characterisation was done for the light output, crystallinity and particle size distribution. A feasibility report of a red phosphor plant at 5 TPA capacity incorporating the project cost estimates and profitability analysis was prepared for consideration and support of the T.V. picture tube industry.

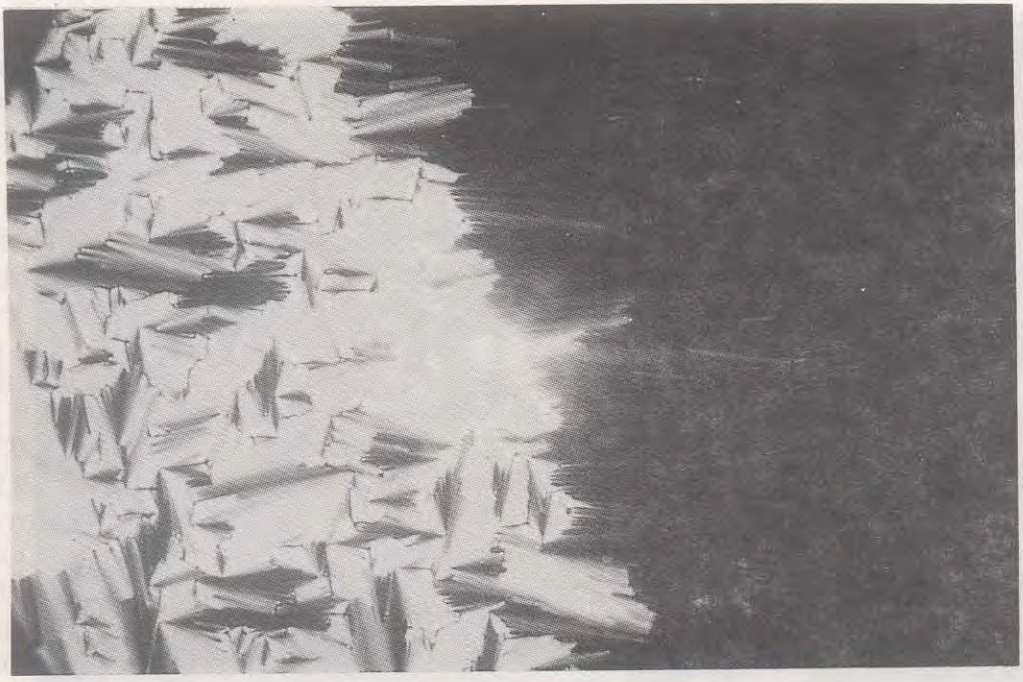
Display Devices

Bulk-induced alignment of nematic and Smectic liquid crystals by Photopolymerization:

A novel technique to produce uniform alignment of nematic and smectic liquid crystals has been developed. The technique is based on producing an anisotropic polymer network in the bulk liquid crystal by photopolymerizing a photoresist material by polarized UV light. Both uniform planner alignment and homeotropic alignment can be obtained depending on the curing conditions. In the case of planar alignment, the liquid crystal director orientation is governed by the direction of the polarization vector of the linearly polarized UV light; thus making it possible to produce a defined azimuthal orientation of the nematic director. This technique obviates the need to give any previous treatment to the bounding substrates and as such should be independent of the nature of the substrate. The micrograph shows the planar oriented chiral smectic C phase between crossed polarizers. The portions on the right is exposed with polarized UV light while the portion on the left was unexposed. (Photograph 1).

Prediction and experimental observations of gray-scale characteristics in ferroelectric liquid crystals:

In highly anchoring surface, the gray scale capability has been shown in polymer rubbed samples of high tilt angle ferroelectric liquid crystals possessing chiral nematic to smectic C* phase transition. In thick samples (10 microns) the gray-scale appears because of the strong anchoring effect on polymer rubbed surface due to the unwinding and winding of the smectic layer twisted structure. In thin samples (4 microns) the gray-scale characteristics appear due to the reorientation of



Micrograph of a planar oriented Sinc phase between crossed polarizers with preferred direction of the LC molecules lying along the x-axis.

the ferroelectric liquid crystal molecules linearly with applied electric field. This effect is observed in samples where the anchoring strength difference between two surfaces is very high. The anchoring strength has been controlled by means of rubbing strokes on polymer rubbed surface of the sample. Again in the same ferroelectric liquid crystal material the surface electroclinic effect in chiral nematic phase has been predicted by dielectric and optical methods due to surface anchoring effect.

Electronic applications of semiconducting polymers:

Basic properties and conduction mechanism in semiconducting polymers has been critically examined in view of the results of our investigations on the semiconducting polymers, polypyrole and polyaniline. A promising vacuum-deposited polymeric semiconducting device fabrication technique has been evolved and its possible applications are explored for light emissions, photo-voltaics and gas sensors.

Metal organic chemical vapour deposition technique for growing c-axis oriented ZnO thin films in atmospheric pressure air:

ZnO thin films have been grown in atmospheric pressure and ambient atmospheric air using zinc 2-ethyl hexanoate as zinc source by MOCVD technique. The films grown on glass substrates above 350° show c-axis orientation as seen from x-ray diffraction studies. The films were highly transparent and free from any visual defects. The growth rate and morphology of the film has been found to depend upon the substrate temperature. Auger electron spectroscopy has been employed to determine the nature of impurities present in the films.

Micrograph of the previous sample on rotating through an angle of 30°.

Sol-gel Processed Materials

(i) *Structural and microstructural evolution of barium titanate thin film deposited by sol-gel process :*

Barium titanate thin films have been fabricated by sol-gel technique from two different precursors, one using barium 2-ethyl hexanoate and other using barium hydroxide dissolved in methoxy ethanol as barium source. The films were examined at different curing temperatures using FTIR, SEM, optical transmission spectroscopy and x-ray diffraction techniques. The films prepared from ethyl haxanoate precursor were found to crystallize around 550°C into tetragonal polycrystalline form, where as those prepared from barium hydroxide precursor were crystallized into cubic form around 600°C. The films prepared from ethyl hexanoate precursor showed larger shrinkage during heat treatment and were more porous than those made from hydroxide precursor. The change in different temperatures were correlated with chemical modifications of the precursor film as well as structural and microstructural changes occuring during the formation of the final barium titanate thin film. FITR spectroscopy and electron microscopy were used to support these observations.

(ii) *Characterization of glucose oxidase immobilized with tetraethylorthosilicate derived sol-gel thin films.*

Sol-gel-derived glasses have emerged as a new class of materials well suited for the immobilization of biomolecules. As a consequence they are also finding

new applications as platforms for chemical sensors. Room temperature (or lower) processing conditions, chemical inertness, negligible swelling effects, tunable porosity, and the high purity of sol-gel derived glasses make them ideal for many types of sensor applications. A collaborative work between NPL and SUNY, Buffalo, N.Y. (USA) has yielded exciting results in this direction. We have recently reported our studies on the characterization of tetraethylorthosilicate (TEOS) derived thin sol-gel films, doped with glucose oxidase (GOX) was immobilized in/on a thin TEOS sol-gel film using physisorption, microencapsulation, and a new sol-gel : GOX : sol-gel Sandwich configuration. Amperometric and photometric detection modes are used to study the response profiles and in turn quantify glucose. The results clearly demonstrate that the sandwich configuration exhibit a fast response and high enzyme loading. This particular scheme has been optimized and is stable and reversible for a reasonable period of time.

(iii) *A novel protocol to immobilize active urease in a tetra ethoxy silane-derived sol-gel thin film architecture:*

Recently our Biosensor Group and the Sol-gel Processing Group at NPL in collaboration with the Photonic Group of SUNY, Buffalo, N. Y. (USA) have carried out basic studies on immobilizing active urease in a sol-gel processed films and its application for urea detection and quantification. To this end, urease is sandwiched between two thin sol-gel derived films. This novel architecture simultaneously allows the analyte (urea) access to the enzyme (urease) and permits high level of enzyme loading without any detectable leaching of the enzyme from the film. The analytical working curves of photometric signal verses Urea concentration are linear over the physiological concentration of urea found in blood (2 to 18 mm) and detection limits are 0.5 mm. The response time of this new sensing scheme is of the order of 10 sec. This represents two-order-of magnitude improvement in response time over previous sol-gel-derived sensor schemes. The protocol for enzyme immoblization is simple, relatively fast, and requires no chemical modification of the substrate or enzyme.

DEVELOPMENT IN XERO RADIO GRAPHY

The aim of the project is to develope indigenously the technology of xeroradiography for medical applications as an X-ray imaging technique in radiology for diagnosis of mammography (breast cancer detection), extrimities, etc. In this technology development programme the thrust of work during the year has been towards the development of high X-ray sensitive xeroradiography photoreceptors. We have developed these new photoreceptors and they are undergoing testing at LNJPN Hospital for their performance in actual clinical applications such as mammography, extrimities, etc,. These new photoreceptors have been prepared using the vacuum evaporation technique and made from chemically modified selenium, i.e., selenium doped with suitable dopants.

DEVELOPMENT OF BIOSENSORS

A hand-operated glucose biosensor (NPL GLUCOSENSE) comprising of a strip type glucose electrode coupled to an electronic circuit (fit. 1) has been developed at NPL in collaboration with the Centre for Biochemical Technology, Delhi and the Indian Association for the Cultivation of Science, Calcutta

under a project sponsored by Department of Science & Technology. A strip type glucose electrode consists of a working electrode (containing an immobilized glucose oxidase) and reference electrode (Ag/AgCl) screen printed on a plastic substrate. Amperometric method of detection has been employed. The calibration of strip type glucose electrodes has been carried out as a function of glucose concentration. The response time, sensitivity range and the self life of glucose strip has been measured as 40 seconds, 40 mg/dL to 600 mg/dL and 4 months, respectively. These glucose strip remain stable between 15° C and 40° C. A large number of blood samples drawn from various hospitals and pathological laboratories have been tested with NPL GLUCOSENSE. The technology for the manufacture of glucose biosensor has been assigned by National Research and Development Corporation, to the two companies.

A third generation glucose biosensor based on physically immobilized glucose oxidase (GOD) in p-toluene sulphonate (PTS) doped polypyrole films prepared electrochemically has been fabricated. Enhanced loading of glucose oxidase in polypyrrole films via manipulation of the polymer morphology has been studied. The exchange of bulky anions such as p-toluene sulfonate and ferricyanide present as dopant ions in polypyrrole with chloride ion in solution has been seen to impart greater porosity and resultant maximization of glucose oxidase (GOX) immobilization in polypyrrole. The polypyrrole GOX electrode thus prepared exhibits improved performance as an amperometric glucose sensor.

Glucose oxidase has been immobilized in solution cast films by physical adsorption such polyaniline-glucose oxidase electrodes exhibit better thermal stability. The response studies of polyaniline-glucose oxidase biosensor have also been systematically conducted.

Sol-gel derived glasses have emerged as a new class of materials well suited for the immobilization of biomolecules. As a consequence they are also finding new applications as platforms for chemical sensors. The characterization of tetraethylorthosilicate (TEOS) derived thin sol-gel films, doped with glucose oxidase (GOX), as a sensing platform for a prototypical biosensor has been done. GOX has been immobilized in/on a thin TEOS sol-gel film using physisorption, microencapsulation, and a new sol-gel: GOX: sol-gel sandwich configuration. Amperometric and photometric detection modes have been used to study the response profiles and in turn quantify glucose. The results have clearly demonstrated that the sandwich configuration exhibits a fast response and high enzyme loading. This particular scheme has been optimized and is stable and reversible for at least two months.

The study on immobilizing active urease in a sol-gel processed film and its application for urea detection and quantification has been undertaken, urease has been sandwitched between two thin sol-gel derived films. This novel architecture simultaneously allows the analyte (urea) access to the enzyme (urease) and permits high levels of enzyme loading without any detectable leaching of the enzyme from the film. The analytical working curves of photometric signal versus urea concentration are linear over the physiological concentration of urea found in blood (2 to 18 mM) and detection limits are 0.5 mM. The response time of this new sensing scheme is on the order of 10 s. This represents a two order-of-magnitude improvement in response time over previous sol-gel-derived sensor schemes. The protocol for enzyme immobilization is simple, relatively fast, and requires no chemical modification of the substrate or enzyme.

The traditional blood sampling method requires a diabetic patient to prick a finger sometimes more than four times a day to give a moment in time blood glucose level. Apart from being painful the test may cause a number of medical complications which may be fatal.

The development of non-invasive blood glucose sensor is of considerable importance. As a first step, a number of experiments have been carried out to get the near infrared spectra of D-Glucose in powder form and of the D-Glucose in solution of different concentratios. Partial least square (PLS) method is to be used to develope a multivariate calibration model relating to the spectral data to the glucose concentrations determined by reference method. The software for partial least squares method is in development stage.

CONDUCTING POLYMER

Under the EEC project entitled "Synthesis and Characterization and Application of some Conducting 'Polymers" in Colaboration with the Clarendon Laboratory, University of Oxford, U.K., a number of conducting polymers and their derivatives such as polyanilines, poly (O-toludines), poly (N-phenylenevinylenes), poly (N-tetradecyl aniline) have been synthesized using chemical and electrochemical techniques, respectively. Some of these conducting polymers have been characterized using Fourier Transform Infrared Spectroscopy, UV-Visible spectroscopy, gel permeation chromatography, electrical conductivity and differential scanning calorimetric (DSC) techniques, respectively.

Muon spin relaxation has been measured in longitudinal and zero field configurations for a number of conducting polymers as a function of temperature down to 11 K and in applied field up to 2000 G. Hyperfine parameters have been deduced for the coupling between muon and polaron spins and the spin dynamics model on the basis of polaron diffusion, which has one-dimensional character at low temperatures, becoming two-dimensional at room temperature.

Photoconductivity experiments using steady illumination with visible light have been carried out with emeraldine base to estimate the mobility of the photo excited charge carrier. The low value for mobility of 3.5 x 10^{-5} cm2/Vs obtained is ascribed to bipolaron formation. Photoelectro chemical measurements of charge decay with emeraldine salt electrode point out to the operation of polaron transport mechanism in this interesting conduction polymer.

Dielectric measurements have been carried out in polyemeraldine base (PEB) in A1-PEP-Al configuration, both as a function of frequency (5 Hz to 13 MHz) and temperature (77 to 380 K), respectively. An attempt has been made to understand the transport of charge in polymeraldine base in terms of polaron hopping model applicable to amorphous semiconductors. The analysis of the conductivity data indicates the operation of two relaxation mechanisms in this conducting polymer.

Dielectric relaxation studies have been systematically carried out on aluminum-polyaniline (emeraldine salt)-aluminium (Al-PANI-Al) capacitor configuration both as a function of frequency and temperature, respectively. The analysis of the results obtained for such a configuration shows interesting space charge phenomenon leading to interfacial polarization. The value of mobility, μ obtained as 9.6 x 10^{-6} ($cm^2/V.S$) at room temperature (300 K) using dielectric relaxation data is in reasonable agreement with the value (3.5 x 10^{-5}) $cm^2/V.Sec.$ reported in literature.

A number of experiments relating to a EMI

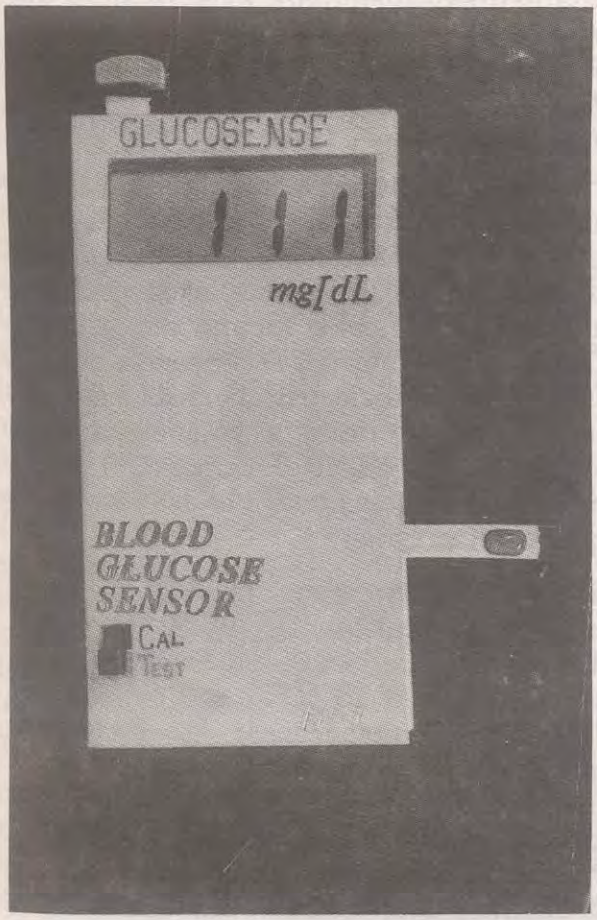


Fig. 1 Hand-operated Glucose Biosensor developed at NPL.

shielding in the frequency range from 100 kHz to 74 Hz using conductive polymers have been conducted. Studies pertaining to the effect of hazardous vapours like NH_3 and HCI on the electrical characteristics of polyaniline have been initiated.

LANGMUIR BLODGETT FILMS

The preparation and characterization of Langmuir Blodgett (LB) films of conducting polymers have been investigated. Monolayers of polyemeraldine base (PEB) have been successfully deposited on desired substrates such as glass, quartz and indium-tin oxide (ITO) glass plates, respectively. Pressure-area isotherm (Fig. 2) for polyemeraldine base have been obtained using Joyce-Loebl Langmuir Blodgett through installed at NPL. The characterization of such LB films has been carried out using UV-visible, FTIR and SEM techniques, respectively. It has been shown that the annealing of LB films of polyemeraldine base results in modification of their optical properties. The deposition of quasi-ordered Langmuir Blodgett films of preformed processable polyaniline has been described. It is possible to directly deposit films of emeraldine base by the Langmuir Blodgett technique without incorporating fatty acid tails in the molecule. However, the deposition of multilayers, irregularities begin to form in the film and the ordered nature of LB films is lost, leading to poor electrochemistry.

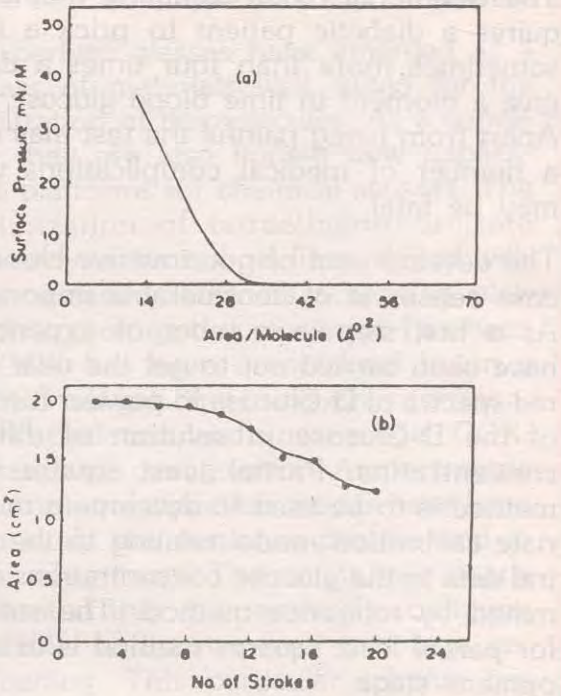


Figure 2. (a) Presure-area isotherm for polyemeraldine base at 22°C. (b) Area displaced from the LB through as a function of number of deposition storkes. Area of the ITO glass substrate used for deposition of LB films is 2 cm^2

Currrent-voltage (I-V) and capacitance-voltage (C-V) measurements of metal Langmuir Blodgett Layer (cadmium stearate) semiconducting polypyrrole devices have been conducted. Electrical characteristics such as work function, barrier height and ideality factor etc. in relation to such MIS devices have been experimentally determined. It has been shown that the passivation of semiconducting polypyrrole film by a Langmuir Blodgett layer (Cd stearate) results in the lower value of ideality factor for various metal Langmuir Blodgett layer (Cd stearate) semiconducting polypyrrole structures. The capacitance voltage measurements have been used to compute the value of the effective dielectric constant of insulating LB film.

CARBON PRODUCTS

I. Carbon Fibres :

Polyacrylonitrile precursor has been chemically impregnated with aqueous solution of KMnO4 under varying conditions of temperature and time. FTIR of the as-modified PAN fibres shows a clear peak at 2340 cm^{-1} corresponding to MnO4 -C=N conjugation. Such conjugation helps not only as catalyst for cyclization reaction, but also as plasticizer. Experimental results show that the tensile strength of carbon fibres prepared from chemically modified samples goes up to 4.2 GPa, compared to 2 GPa obtained from unmodified sample. More importantly, elongation to break for such carbon fibres is pushed upto 1.82% compared to 0.9% achieved with unmodified samples. Such carbon fibres will find applications in primary load bearing structures.

II. Intercalation studies :

Intercalation of PAN based as well as pitch based carbon fibres was carried out with Bromine in liquid phase as well as vapor phase under varying conditions of temperature and time. It was found that intercalation was next to impossible in non heat treated Ex. PAN fibres. Even after heat treatment at 3100C the bromine weight uptake is hardly more than a few percent. On the contrary the pitch based P-120 fibres show a bromine weight uptake of 20-25% and the resulting compound is quite stable at room remperature. X-ray diffraction studies of these fibres show the presence of bromine super lattice structure.

A new experimental set up has been devised which has enabled, to record insitu resistivity changes in carbon fibres during bromine intercalation. The technique has given direct insight into the intercalation kinetics of various carbon fibres.

- Plot of final/initial vrs. bromine partial pressure show the existence of an intercalation threshould below 15 Torr. It further shows that the reaction rate is not proportional to the vapor pressure.
- At least, a four fold increase in the electrical conductivity of P-120 fibre after intercalation is observed.
- It has been possible to intercalate flexible graphite foil. This has raised the possibilities of its various industrial applications.

III Characterisation of Carbon-carbon Brake Pad Materials :

Brake Pads for high speed vehicles such as aircrafts, trains and heavy lorries, is one of the most important applications of carbon-carbon composites. There is an indigenous programme of ADA to develop carbon-carbon brake materials

for aircrafts. "Evaluation and characterization of carbon-carbon brake pad materials", obtained from various sources has been carried out.

Carbon-carbon brake pad materials developed indigenously and imported one were characterised for their physical, mechanical and thermal properties, microstructure and oxidation resistance. The microstructural studies revealed that microstructure of the matrix which plays a vital role in the performance of carbon-carbon composites as braking material, is entirely different in the two. The processing route of the two carbon-carbon braking materials i.e. developed indigenously and that of imported one is also entirely different. in the two. The processing route of the two carbon-carbon braking materials i.e. developed indigenously and that of imported one is also entirely different. The indigenous carbon-carbon brakes have been developed by multiple liquid impregnation route whereas the imported ones have been developed by chemical vapour deposition route. Both the brake pad materials consist of two types of matrix carbon, one generated from coal tar pitch or deposited from organic vapours which is anisotropic in nature and the second one generated from thermosetting resin which is isotrpic in nature. The mechanical properties of carbon-carbon brake pads developed indigenously are somewhat superior to the imported brake pad materials whereas thermal properties, specifically thermal conductivity, and crystallite dimensions, degree of graphitisation and frictional properties (dusting) are somewhat inferior of the indigenously developed carbon-carbon brake pads.

IV. Special coal tar pitches :

A novel process involving state-of-the-art technology for the production of QI-free impregnation-grade coal tar pitch under a project sponsored by Graphite India Limited, Bangalore, was developed the optimisation studies of the various parameters were carried out.

The process know-how was transferred to the above industry. Besides this, consultancy was also rendered to this industry on the methods which can lead to low-QI (.2%) coal tar pitch, under a separate project from it.

V. Carbon bipolar plate for Phosphoric Acid fuel cell :

R & D work was continued under the MNES-sponsored project to study the corrosion resistance against hot (200 C) phosphoric acid and the air permeability of the graphite-reinforced phenol formaldeyhde resin carbon plates. A resin-graphite formulation with resin-to-graphite ratio at around 30:70 was found to be suitable for the carbon bipolar plate which leads to reasonably dense and strong (binding strength around 60 MPa) carbons having zero permeability and high corrosion resistance against 97% conc. phosphoric acid.

VI. High Density Isotropic Graphite :

R&D work was continued to improve the characteristics of the high density isotropic graphite. It has been found that the presence of some low amounts of quinoline insolubles in the precursor coal tar pitch generates large amount of the mesophase spherules of the desired size (5-15 microns) during the heat-treatment, and the calcination of the mesocarbon microbeads (mesophase

spherules) at around 285°C under a suitably reduced pressure leads to the isotropic graphite processing a bulk density of around 2.0 g/cm^3 which is higher than the value of 1.70 - 1.80 g/cm^3 obtained in case of the conventional high density isotropic graphite. A patent for this process has been applied for.

VII. High Temperature Oxidationresistance Materials

Synthesis of silican carbide by sol-gel technique was undertaken. The synthesis was carried out using alkoxide and different carbon source. Characterization of the above said meterials was carried out and it was reported that β-Sic with different crystallite and grain sizes are obtained by the method adopted. The densification of the product would yield SiC with theoretical density.

Synthesis of siliconoxycarbide using different alikoxides was carried out since these are high temperature resistant materials which can be amployed in the farbication of composites.

Efforts are made to synthesise SiC whisker's from rice husks and encouraging results are obtained.

THIN FILM SYSTEMS

During this year a comprehensive MOU was signed by the heads of NPL and Opto-Electronics Factory (OLF), Ministry of Defence, Dehradun. This MOU now makes it possible to use very modern facilities that have been created at OLF for volume production of sophisticated coated optics in the country. NPL's role has been identified as the designer of such coatings and R and D support for such activities. Under this arrangement development work of a Green Filter (Photo optic eye response filter) has recently been completed on a request from a pollution monitoring equipment manufacturer. Production of several other sophisticated coated optics are also to be taken up soon.

Under a similar arrangements with IDDC, Ambala (a division of HARTRON) fabrication of 20 numbers rear view prisms for HAL, Nasik division has been completed according to NPL released process for the same.

Looking into the considerable demand of IR filters in the 2-12 μm range for air pollution, Milk quality, Medical diagnostics and other instrumentation applications, NPL took, on request, design and feasibility study of these filters. Various user agencies and production facilities have since been identified and an implementation stragety has been evolved.

Amorphous thin films, devices and systems

Investigative Research : Efforts to grow amorphous hydrogenated films away from so called standard conditions was pursued in order to grow such films at low substrate temperatures, allowing use of polymeric substrates for such depositions. A RF asymmetric PECVD system was designed where substrates were kept on cathode and a finite amount of ion bombardment was deliberately induced. Hydrogen dilution of the feed stock (SiH_4) and application of high RF powers improved the photoconductivity of such films grown without any deliberate substrate heating dramatically ($>10^{-6}ohm^{-1}cm^{-1}$). Systematic IR absorption, PDS, hydrogen evaluation studies helped us to identify this process to be akin to chemical annealing.

Similarly in our continuing efforts to increase the deposition rate of basic amorphous silicon material, we conducted detailed experi-

ments on VHF-PECVD (100 MHZ) growth, involving both SiH_4 and Si_2H_6 as feed stock. Initial experiments on pulsed plasma growth of a Si:H were also completed.

Conditions leading to onset of photoconduction in DLC (Dimond Like Carbon) films were identified. Similarly a detailed study of Nitrogen dilution of the feed stock in the growth of stress relieved DLC films was completed.

Developmental Research

Under IRDE sponsored project, to improve the reliability of the large area growth process, we designed and fabricated, involving a private manufacturer, a sophisticated semiconductor laser based optical thickness monitor.

During this period NPL group worked very closely with BHEL amorphous silicon facility (ASSCP), Gwalphari and IACS group and rendered various technical assistance and consultation to help to stablise their large area a-Si module fabrication process. This interaction also provided important inputs to improve the design of substrate transport system for a large area multichamber prototype PECVD system being developed (under a MNES assigned project to NPL).

HIGH PRESSURE TECHNOLOGY

Graphitic form of boron nitride, when subjected to high pressures and high temperatures, is known to transform into harder phases of boron nitride such as cubic and wurtzitic structures. However, the behaviour of least ordered boron nitride or amorphous boron nitride under high pressures and high temperatures is not well studied. Since cubic boron nitride is a superhard material possessing superior mechanical properties which are exploited in machining ceramics, carbides and high speed ferrous alloys and our group has already been working on the problem of synthesising cubic boron nitride (c-BN) from hexagonal boron nitride (h-BN) employing the catalyst solvent process, the problem of study of least ordered boron nitride under high pressures and high temperatures was undertaken. To start with, turbostatic boron nitride (t-BN), to be used as the starting material, was prepared chemically and was subjected to high pressures and high temperatures in the presence of a catalyst ($Mg_3B_2O_4$).

Results of high pressure phase transformations in turbostratic boron nitride using $Mg_3B_2N_4$ as the catalyst showed that turbostratic boron nitride undergoes various structual changes accompanied with the formation of hexagonal, cubic and possibly wurtzitic modifications of boron nitride at high pressures and high temperatures. It was also found that the formation of these phases is sensitive to the pressures and temperatures prevailing in the reaction zone. At higher pressures (>40 kbar) and temperatures (>1300°C) cubic boron nitride was observed as the predominant phase.

A new project entitled "Amorphisation of Boron Nitride and Study of its behaviour under high pressures and temperatures" has been submitted to DST for funding in order to enable a systematic study of the process.

METALS & ALLOYS

Considerable amount of developmental efforts have been undertaken to develope light weight strategic materials using 500 tonne vertical hydraulic press and other associated equipments. The main achievements are highlighted below:

A *Metal Matrix Composites*

[Powder Metallurgy (PM) processed MMC Extruded tubes for Satellite Applications]

A project was undertaken to study the hot deformation behaviour of 2124 Al alloy reinforced SiCp having varying volume fractions (10, 15 & 20%) and using different particulate sizes (1.9 to 14 μm). The project has been undertaken as a collaborative effort between DMRL, Hyderabad and NPL, New Delhi.

Aluminium based particulate composites are now emerging as cost effective materials, providing designers with a unique combination of design features and properties such as high specific stiffness and strength, controlled coefficient of thermal expansion (CTE), improved elevated temperature properties and superior dimensional stability. Tubular struts for satellite is one such application where high specific stiffness, low CTE and reasonably high thermal conductivity play an important role. The performance indices for optimal selection of materials for the tubular strut application are both resistance to mechanical ($E^{1/2}/\rho$), as well as thermal (k/CTE) distortions, where ρ is the density; elastic modulus, E; thermal conductivity, k and CTE is the coefficient of thermal expansion. MMCS exhibit significantly higher figures of merit as compared to the corresponding unreinforced alloy as shown in Table 1.

The present weight saving which could be achieved by substituting conventional 2124 - Al alloy with Al-Li alloy or MMCs indicated in Table-II.

Table-II

Weight Savings by use of MMCs and Al-Li Alloys for structural application (Failure Mode: Bucking)

Material (Baseline - 2124 Al)	% Weight Savings
8090 Al-Li	13.7
2124 Al/15 v/o SiCp	17.6
2124 Al/30 v/o SiCp	19.6

Table-II indicates that the use of MMC tubular struts can offer significant weight savings which is a prime requirement for the satellite application.

Starting from a Powder Metallurgy route, billets of Al alloy + SiCp composite materials made by Defence Metallurgical Research Laboratory, Hyderabad, were supplied to NPL in the as hot pressed condition. These were hot pressed and hot extruded into thin wall tubes (Fig. 1), aimed at reducing tubular components for ISRO Space Application

Table-I

Figures of Merit for The Selection of Materials for Tubular strut Application

Material	E (GPa)	P (g/cm3)	Figures of Merit	
			$E^{1/2}$ (Mechanical)	k/CTE (Thermal)
2124 - Al	72	2.78	3.05	5.96
2124 Al/15 v/o SiCp	100	2.84	3.52	7.38
2124 Al/30 v/o SiCp	130	2.86	3.98	8.80

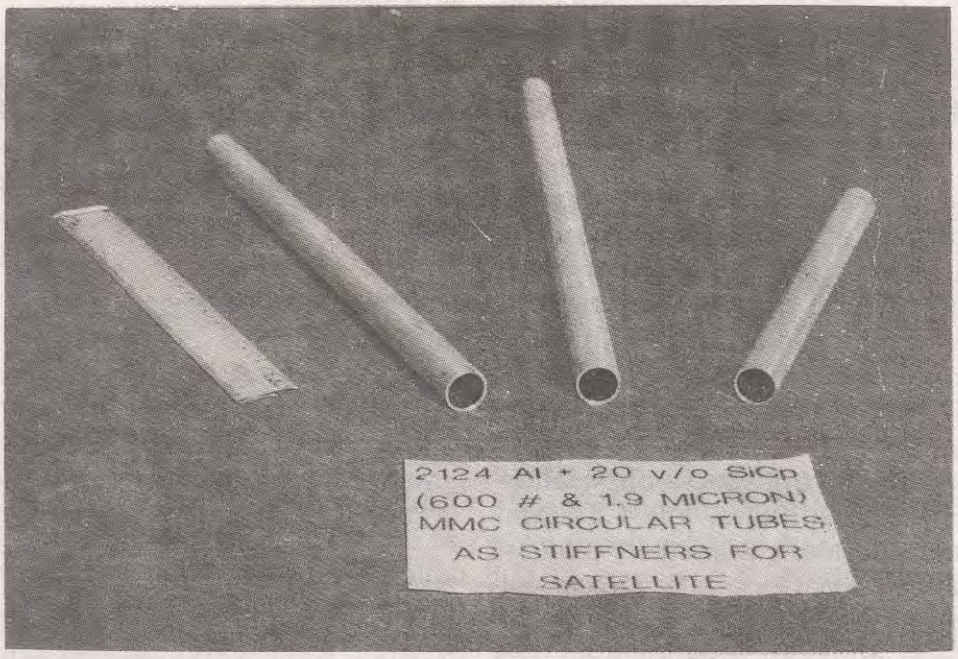


Fig. 1 - MMC Circular tubes as stiffners for satellige

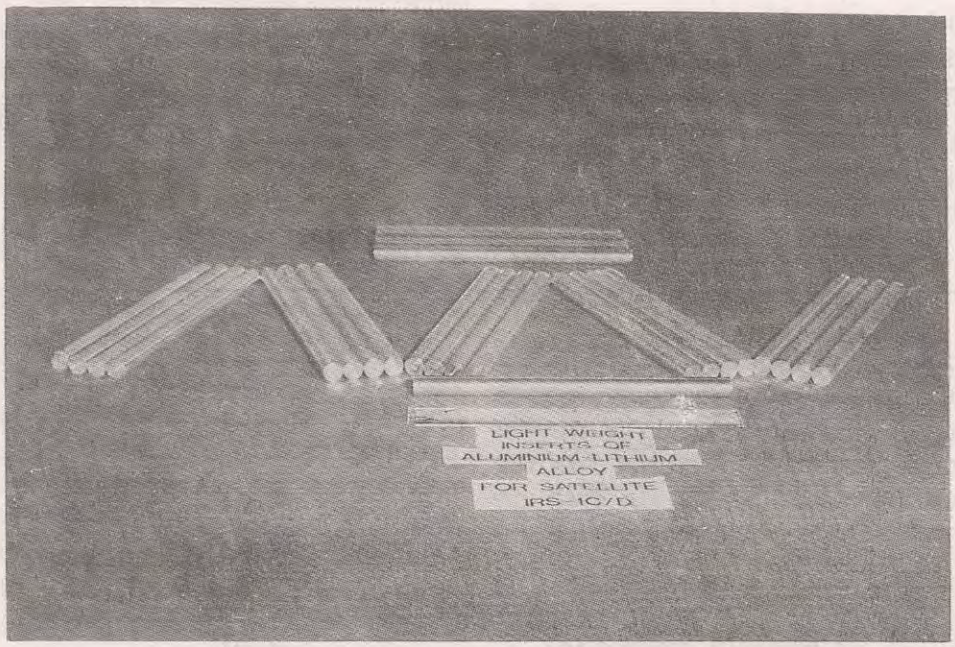


Fig.2 - Light Weight Inserts of Aluminium-Lithium alloy for satellite IRS - 1C/D

Centre, Bangalore. High quality tubes were obtained which exhibited the following properties as mentioned in Table-III:

Table-III

Property	Experimental	Target
0.2% YS (MPa)	380	380
UTS (MPa)	473	480
% Elongation	3.6	4.0
Modulus (GPa)	102	95

This is the first time that MMC tubes of this quality have been produced in India and closed to these required tolerances. With continued and large quantity handling, it is expected the properties will surpass all target very soon. Efforts are being made to modify the conventional PM process by avoiding a few expensive steps. This work was initiated and very encouraging results have been obtained. Efforts are being made to make PM route more economical. Detailed characterization is in progress.

Spray atomization & deposition unit was designed and the unit is under fabrication. This unit will be used to synthesize monolithic and MMC materials which will be further processed to make actual MMC components.

B. Aluminium - Lithium

Several strategic high strength Aluminium (Al) alloys with upto 2.5% Lithium (Li) additions have become hi-tech in character because of the need for special processing techniques.

The Metals & Alloys Group at NPL has successfully developed the processing of high strength Al-Li alloy of composition: Al, 4.5% Mg, 1.5% Li. This alloy was supplied in ingot form by Foundry & Forge Division, HAL, Bangalore and were hot extruded into 20 mm ϕ cylindrical rods (Fig.2) and supplied for the use by ISRO, Bangalore. Significantly properties achieved in this material were better than target properties indicated in parenthesis.

UTS	=	350 MPa	(300 MPa)
0.2% PS	=	260 MPa	(200 MPa)
% Elongation	=	5%	(3%)

MATERIALS CHARACTERIZATION

CHEMICAL METHODS

During the period under review 102 samples were received from different organizations including different sections of the laboratory for analysis.

About 200 samples collected from IARI, Pusa Campus rice field and Chilka Lake were analysed under the methane campaign programme.

Research & Development

Spectrophotometric method has been developed for the determination of phosphorus in high purity material like silica, germanium and other allied materials. The method is based on the formation of reduced bismuchophosphomolyb-date complex in perchloric acid medium and its extraction in methyl isobutyl ketone. The interference from matrix elements has been taken care of by using a mixture of HF, HNO3 and bromide. The sensitivity of the method is found to be 30 ppt.

Spectrophotometric method for the determination of traces of arsenic in high purity silicon and germanium by complexing with silver dithiocarbamate in morpholine chloroform system has been developed. Sensitivity of the method is found to be 5 ppb.

Indirect method for the determination of sulphate by atomic absorption spectrophotometry has been developed wherein sulphate is precipitated with excess of acidified barium chromate Liberating an equivalent amount of chromic acid. chromium is determined by AAS after removing excess of barium chromate with lime. The method is highly selective and sensitive.

A highly sensitive spectrophotometric method has been developed for the determination of nitrogen dioxide (Nitrite as NO_2) by reacting manganese dioxide in 1:20 perchloric acid. An amount of manganese dioxide (MnO_2) equivalent to the concentration of nitrogen dioxide becomes soluble due to the reduction of Mn(IV) to Mn (II) by nitrite in acidic medium. The soluble Mn(II) ion is filtered to remove excess of MnO_2 and is oxidized to permanganate ion by perchloric acid in the presence of phosphoric acid the violet coloured solution shows maximum absorbance at 525 nm. The sensitivity of the method is 0.08 ppm based on 0.0044 absorbance and Beer's Law is obeyed in the concentration range of 0.2 to 10.0 ug/ml of NO2. Molar absorbance is found to be 2442 at 525 nm.

Prepared high purity manganese oxide suitable for the manufacture of MnZn ferrites starting with indigenously available manganese salts prepared from ore. Characterization of the material has been carried out by X-ray diffraction, Electron Microscopy and impurities like silica, sodium, potassium and magnesium have been evaluated by instrumental methods. Material is found to be comparable to imported manganese oxide in purity as well as in assay 100 grams of material has been supplied to central Electronics Ltd. for trial purpose.

Methane Emission Studies:

In continuation to our earlier work on greenhouse gas emission studies, we have carried out the methane emission budget from paddy fields, wetlands and peatlands. Methane emission data collected during 1993 kharif

season from major paddy growing regions of India has been processed and methane budget from Indian paddy fields is estimated to be 3 to 6 Tg per year.

Under the development programme on methane emission studies from agricultural waste under the project entitled "utilization of agricultural wastes for energy" we have studied the biodegradation of various leaves under enerobic condition and the methane emission studies were carried out by G.C. method. The same work has been applied to various other agricultural wastes including rice straw etc. The work is under progress. Studies on muncipal solid waste (MSW) has been carried out at different sites of NPL and the work on incubation of MSW is under progress.

SURFACE AREA & POROSITY

Twenty nine samples received from various industries were tested for BET-surface area and porosity. The materials tested include precipitated silica (Sriram Institute, Delhi), zinc oxide (Punia chemicals, Rewari) and Upper India Smelting and Refinery Works, Yamuna Nagar, Haryana and catalyst for carbon nonoxide oxidation (Defence Laboratory, New Delhi).

For providing assistance to other projects in NPL two samples of manganese oxide (Analytical Chemistry) and one sample of copper powder sintered disc (Cryogenics Group) were tested for BET-surface area.

Under (NPL-IIT, Delhi joint research project):

59 samples of activated carbon fibres as well as cloth were prepared mainly for making pollution control devices. and out of these 20 samples were characterized to understand the formation of pore structure. The results of these investigations were presented in CARBON "94" Indian scenario, held at Bhopal.

FTIR SPECTROSCOPY

Infrared spectroscopic characterisation of different materials received from NPL and outside agencies was carried out. This includes phosphosilicate glass films on silicon wafers from CEERI, Pilani, amorphous silicon deposited over silicon from Thin film project of NPL, silicon wafers from Materials. Characterisation Div. and silicon dioxide film on silicon wafer from I.T.I. Banglore.

Studies on infrared absorption at 1127 cm^{-1} in silicon, were carried out to distinguish between multiphonon infrared absorption and impurity absorption in silicon. Far infrared spectra of neodymium sulphate and its deuterated analogue crystals were studied in the region 400-50 cm^{-1} at ambient and at different low temperatures.

Fourier transform infrared (FTIR) spectroscopic studies have been performed to analyse the coordinated water and lattice water vibrations in neodymium sulphate and its deuterated analogue at ambient and low temperature. IR absorption librational bands due to lattice water and *coorinated* water are obtained in the region 850-400 cm^{-1}.

Infrared absorption spectra of lanthanum sulphate nonahydrate crystals was studied over the range 4000-50 cm^{-1}. Emission spectroscopy characterisation was done for a number of samples, for their elemental constituents. These samples were drawn at various stages of their purification.

A study on collision-induced non radiative transitions in neon plasma has been carried out using high intracavity radiation field of 633 nm He-Ne laser beam. We have calculated the values of certain constants, like rate of excitation transfer per particle, probability of excitation transfer from one level to another etc., of electron-atom collision process between $3s_2$ level and close-by energy levels like $4s_1$ and $5s_1$ of neon.

EPR SPECTROSCOPY

Research investigations were continued on different materials. Preliminary investigations on Ge+ ion implanted followed by BF2 implanted Si wafers were undertaken in collaboration with CEERI, Pilani to understand the formation of ultra shallow pn junctions. Structural studies of vanadyl ions doped ternary borate glasses xLi2O.yBaO. (1-x-y) B_2O_3 prepared over wide range ($0 \leq x \leq 35$, $o \leq y \leq 35$) were made. Results showed that when the B_2O_3 content is reduced from 85 mole % to 65 mole %, the octahedral symmetry of the V_4+ site is improved but variations in Li2O:BaO ratio for constant (65%) B2O3 have no effect on the vanadium site. Apart from this, a number of samples from different projects of the laboratory were also characterised.

X-RAY DIFFRACTION

X-ray diffraction and fluorescence techniques were used for the characterization of materials of various projects of NPL, research institutes and private industries. More than 500 samples have been analysed. Assistance was provided to CEERI, Pilani; M/s. Beauty Art India, New Delhi; M/s. Polyplex Corporation Ltd., New Delhi and M/s. NTPC, Noida regarding the crystalline phase and elemental analysis of their materials.

Effect of calcination temperature on the Sb-doped BSCCO high Tc system was carried out by X-ray diffraction and found that Sb has oxygen-incorporating role in this system, necessitating a particular calcination temperature (830°) for the formation of the maximum volume fraction of 2212, which is a prerequisite to realize a high Tc (zero). The XRD analysis on the effect of exchange of Ca and Bi ions in this system was also done. Similarly effect of thallium concentration on the nominal composition $Tl_xBa_2Cu_2O_6$ (x=0.5 to 3.0), prepared by flash sintering process, was studied. XRD results showed that in all the cases, low Tl concentration as well as high Tl concentration, there is transformation of the nominal phase to 2201 superconducting phase with cell parameters a=3.86A°, c=23.18A° having only slight variations. The over all symmetry is tetragonal and all the lines are indexible on the I4/mmm space group. Samples with Tl content 1.5-2.0 sintered at 930-950°C, show the best superconducting properties.

Electrochromic WO_3 films, prepared by e-beam depositions, were found to be amorphous whereas on coloration they become crystalline with tetragonal structure. Thin selenide films of Cu and In prepared by a new electrochemical selenization technique have been characterized for phase analysis. In collaboration with CEERI, Pilani, degree of preferred orientation was determined on rf-sputtered AlSi films on glass and silicon wafer substrates and found that there is a gradual increase in the degree of preferred orientation with increase in the target voltage and substrate bias conditions.

The crystallite sizes L_c, L_{aI} and L_a and degree of graphitization were determined for carbon-carbon composites of different Brake pad materials from Mirrage, Dunlop and DRDL (different variety). The crystallite size was found to vary between 100 to 400A° and the d_{002} varies from 3.381 to 3.436A°. The degree of graphitization for mirrage and Dunlop Brake pad material was found to be 82% and 68% respectively while for the different varieties of DRDL materials it varies from 7 to 40%. Apart from above, silicon carbide synthesized from silicon alkoxide and different carbon sources was characterized using XRD technique. The product was found to be βSiC with different crystallite and grain sizes. This difference was attributed to the nature of carbon sources.

A project on the Development of Powder X-ray Diffractometer with the financial support of DST has been undertaken and the work is in progress for its fabrication. Recently, work on the development of grazing angle incident attachment for thin film studies has also been started. Also, development and preparation of silicon powder X-ray diffraction standard reference material, initiated last year, has been continued. It was observed that the crystallinity of high purity silicon powder is poor and the work is under progress to achieve the desired crystallinity by annealing at various temperatures.

Electron Microscopy

(a) Pure and Pb doped (1112) and (2223) compounds of Bi system have been synthesized and characterized in details for the surface morphology and elemental analysis by using scanning electron microscopy and electron probe microanalysis techniques respectively, The study led to the conclusion that the nucleation of (2223), (1112), (2212), (2201) and other phases takes place in these compounds irrespective of the starting composition. Further growth of different phases depends on the calcination and sintering conditions adopted for the preparation of the compounds. The study revealed that the material calcined at 800°C and sintered at 845 - 850°C the rate of growth of high T_c phase is seriously affected as the rate of diffusion of right type of atoms under these conditions is not adequate. However the material calcined at 830°C with partial melting during sintering process showed higher volume fraction of high T_c phase indicating that the calcination temperature and partial melting during sintering play an important role in the formation of high T_c phase.

The microstructure of Pure and Pb doped (2223) compounds of Bi system has been investigated with transmission electron microscope by using lattice imaging technique. The lattice spacing between c planes of (2212) and (2223) phases has been resolved and the values of c parameter have been determined as 30.6A° and 36.8A° respectively. Isolated dislocations could also be clearly seen in (2223) phase. The intergrowth of (2212) and (2223) phases has been observed at certain local regions of the sintered material.

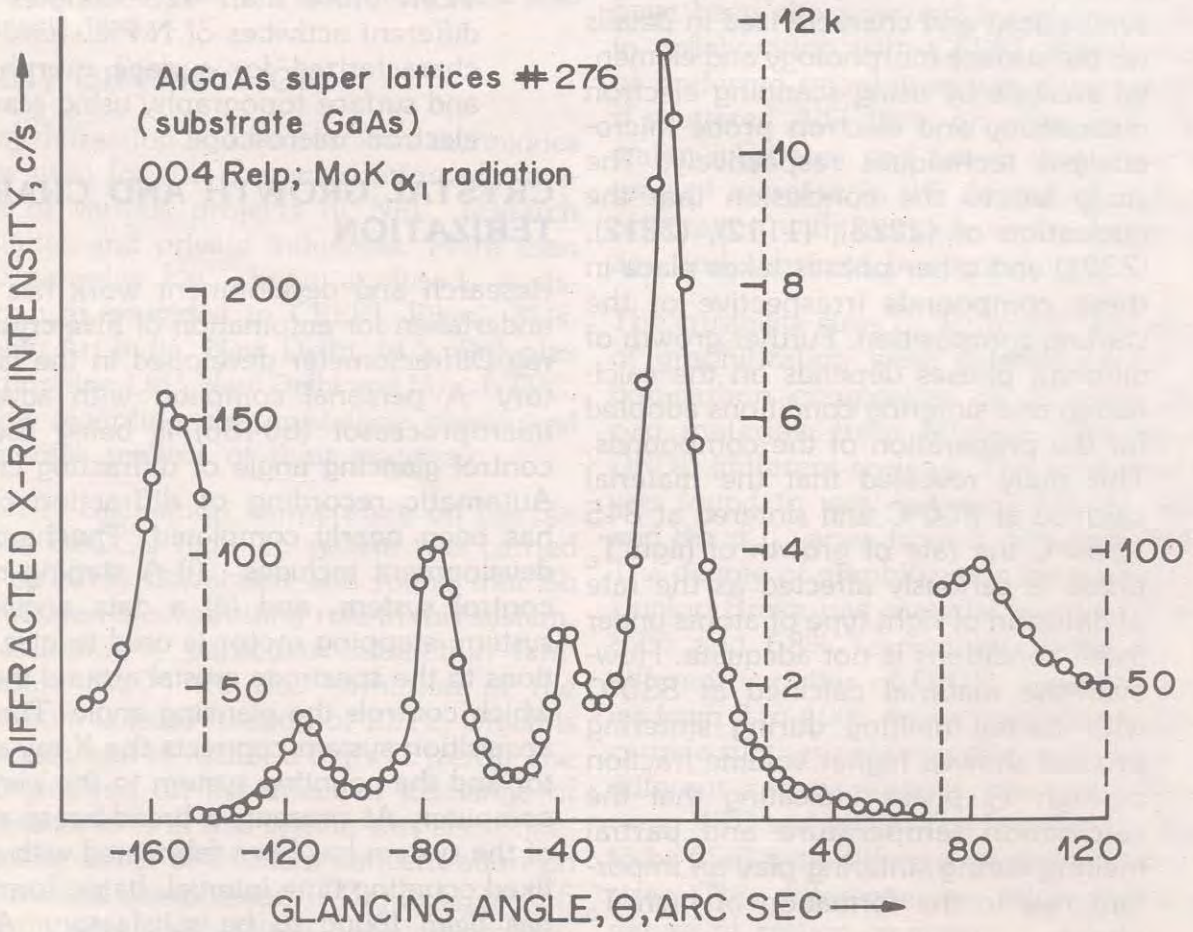
A total of 46 samples from within N.P.L. projects/activities and outside parties have been examined with the help of TEM. More than 425 samples from different activities of N.P.L. have been characterized for surface morphology and surface topography using scanning electron microscope.

CRYSTAL GROWTH AND CHARACTERIZATION

Research and development work has been undertaken for automation of Five-crystal X-ray Diffractometer developed in the laboratory. A personal computer with advanced microprocessor (80486) is being used to control glancing angle of diffracting crystal. Automatic recording of diffraction curves has been nearly completed. The hardware development includes : (i) A steping motor control system, and (ii) a data acquisition system, stepping motor is used to give rotations to the specimen crystal around the axis which controls the glancing angle. The data acquisition system connects the X-ray detector and the counting system to the personal computer. At present, a bread-board model of the system has been fabricated with a one fixed counting time interval. Its performance has been found to be satisfactory. A few

diffraction curves have been recorded successfully with silicon single crystals. The softwares for system control and data analysis have been developed within the group.

Investigations on biaxial stress induced by thin deposits in semiconduciting crystals have been carried out. The following two systems have been investigated : (i) Photo-CVD deposited SiO2 and SiON films on silicon single crystals; and (ii) cosputtered $MoSi_2$ films on silicon wafers. The stress induced by silicon oxide films was found to be compressive in nature Its value was in the range : $2x10^9$ dyn cm2 to $3x10^9$ dyn/cm2. On the other hand, SiON films produced tensile stress lying in the range of 4×10^9 dyn/cm2 to 2.3×10^9 dyn/cm2, the stress value depended upon the percentage of N_2O gas in the deposition chamber. The magnitude of stress induced by MoSi2 films in silicon wafers and its dependence on initial bending of the substrate had been investigated earlier. To reveal whether the stress is plastic or *elastic* in nature, plasma etching of films was carried out. The etched wafer did not exhibit any



remarkable change in their curvature or degree of crystalline perfection. This shows that the stress produced by films is mainly plastic in nature.

A new asymmetrically cut monochrormator made of silicon single crystal has been fabricated and installed in the double crystal X-ray diffractometer used for stress measurement. The visible surface of the monochromator makes an angle of 5.7° with the (III) crystallographic planes. The surface was prepared after grinding, lapping and etching. An asymmetric factor of 0.6 has been achieved.

A new non-thermal technique for annealing implantation induced damage in silicon single crystals has been developed. It has been seen that by using this technique all the damage in crystals subjected to BF_2 implantation at a most commonly used dose level of $1x10^{15}$ ions/cm2 can be removed. Absolute values of integrated X-ray intensities for III reflection have been measured on specimens implanted at different dose levels. A detailed analysis of this data suggests that the top layer of these specimens is not completely amorphous.

For the experiments being set up for insitu measurement of biaxial stress due to thin deposits on semiconducting crystals, fabrication of all major parts and sub assemblies has been completed. Their integration will start soon.

High resolution X-ray diffraction studies of natural diamond crystals of Type II variety have shown substantially enhanced transmission of X-rays when the specimen is oriented at diffraction maximum. Quantitative studies have been carried out on crystals which are not only thin (μt values of 0.3 or even less) but also quite imperfect (diffraction curve width of more than 100 times the theoretical half width). Experiments have been performed with the following reflections : 220, 440, $\bar{1}11$, 224 and $\bar{1}\bar{1}3$. It was found that the decrease in absorption coefficient at peak position is higher for stronger reflections. The decrease is very substantial for example in the case of $\bar{1}11$ reflection, the value of μ decreases from normal value of 0.219 mm^{-1} to 0.075 mm^{-1} at the peak position. These results suggest a coupling between the diffracted and the forward diffracted beams as in the case of Borrmann effect. However, such a result is not expected on the basis of dynamical diffraction theory as these crystals are too thin and too imperfect to show such features.

Nearly perfect lithium niobate single crystals have been grown by the Czochralski technique on a pulling machine developed in this group. Single crystals of lithium niobate with 5N pure Fe_2O_3 as dopant were grown. Single domain crystals were produced by poling technique. Electrical measurements were carried out on $LiNbO_3$ single crystals and results are being analysed.

International Collaboration

Guests scientists were received from USA and Russia under Indo-US and Indo-Russian collaborative research projects. These scientists had sought access to the high resolution multicrystal X-ray diffractometers developed at NPL for specific experiments.

A young scientist from University of Maryland had brought with him GaAs crystals which had been implanted with silicon ions. High resolution X-ray diffractometric experiments could reveal a well resolved peak due to a separate phase produced by implantation. Its peak position relative to that of the substrate peak has enabled quantitative determination of the lattice mismatch between this and the substrate crystal.

A senior professor from Institute of Radio Engineering and Electronics of the Russian

Academy of Sciences visited with specific programme of experiments of AlGaAs superlattices prepared on GaAs substrates. A five crystal X-ray diffractometer was used in this investigation. The quality of some of the epitaxial layers was found to be excellent. The sharpest diffraction curve was obtained from a short period superlattice (number of layers=100; thickness=15mm). Its half width was about 6 arc sec in the (+,-,+,-, +) settings of the diffractometer. For the first time, the values of lattice mismatch and misorientation between the substrate crystal and the epitaxial layers of AlGaAs were determiend quantitatively. The analyser stage of the diffractometer was instrumental in enabling such a measurement. With this measurement, exact composition of the superlattices $Al_x Ga_{1-x} A_s$ could be determined. A typical diffraction curve of a long period superlattice is shown in figure 1.

Work on sponsored projects under Indo-US and Indo-Russian (ILTP) schemes was carried out. Also a project on Development of Powder X-ray Diffractometer has been sponsored by DST, New Delhi.

Institutional Counsultancy to the University of Waterloo, Ontario, Canada.

Consultancy was provided to the University of Waterloo, Canada regarding stress induced by polysilicon films in p-type silicon substrates. The experience gained in investigation of stress and its dependence of various parameters has been the primary reason for request for this consultancy. The imput has helped the sponsoring institute to find out combinations of films which produced maximum and minimum level of biaxial stress in their substrates.

Characterization facilities have been provided to outside institutions. These concerned characterization of as grown bulk crystals as well as epitaxial layers of technical importance.

LOW TEMPERATURE PHYSICS

SUPER CONDUCTIVITY

(i) Defects in C60 Molecules - STM Study

Molecules dynamics (MD) simulations have recently been extensively used by theorists to predict a variety of defects that can occur when 60 carbon atoms come close together forming a large spherical molecule of the fullerene C60. This way, a host of defect structures envisaged are two adjoining pentagons, a pair of distorted hexagons with two common bands (or an octagon with a lone atom at the centre) and heptagons (see,Fig. 1). For the first time we have been able to observe all these defects by STM technique and directly provide an observational evidence for the predicts of M.D. simulations. Our STS spectra on the fullerene samples show a drastically reduced energy gap in accord with the calculations made for imperfect carbon cage.

(ii) Pr and Ce substitution in Bi 2122

We have carried out a systematic study of Pr and Ce doping (at the Ca site) in Bi_2 $CaSr_2$ Cu_2O_Y. For both Pr and Ce substitutions T_C decreases with the dopant concentration. Results are interpreted in terms of the hole filling due to aliovalent substitution in the system. At a higher doping level a metal insulator transition is observed. Near the transition the localization length (-1) is calculated and the possibility of having local pairs in the insulating phase is invoked. Around the transition region a dimensional changeover from two to three dimensions is observed in the variable-range hopping (VRH) regime and its consequence on superconductivity is discussed. The lattice parameters have been estimated through X-ray diffrac-

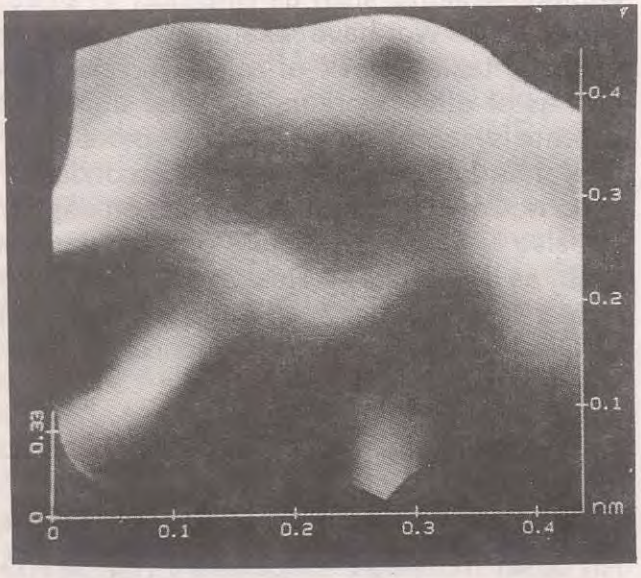


Fig. 1 : STM 3D image of a heptagon, occurring as a defect in fullerene C-60 carbon cage.

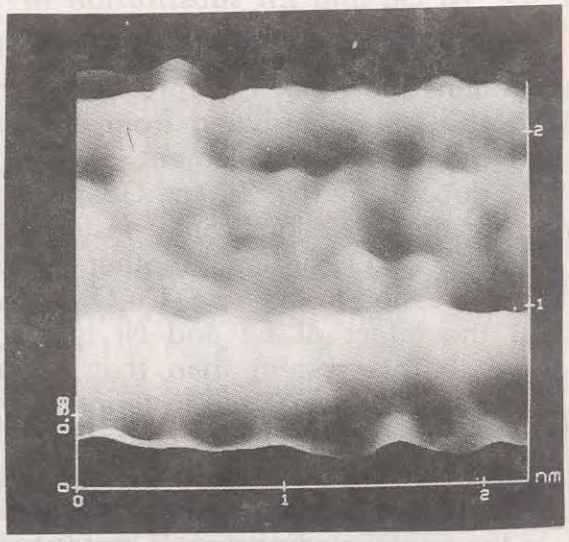


Fig. 2: STM image showing molecules of NiP_C intercalated in Bi-O layers of Bi-2122 cuprate.

tometry and the possibility of Pr and Ce existing in more than the 3 oxidation state in the system is inferred. Results are also compared with the existing data on other rare-earth dopings (at the Ca site) in the same system.

(iii) Role of Ca in supressing T_c of YBCO:

Partial subsititution of Ca^{2+} at Y^{3+} -site in Y-123 system shows several interesting features, namely 1. Creation of oxygen vacancies without any change in the lattice parameters, 2. no change in the effective copper valence, and 3. decrease in the critical temperature T_c with substitution, accompanied by decrease in the normal state conductivity. Host of measurements like low temperature resistivity, magnetic susceptibility, XRD, oxygen stoichiometry and the effective copper valence, reported here, suggest that T_c depression with Ca substitution is unlikely to be due to over-doping effect. An alternate explanation, which takes stock of the above observations, involving creation of disorder in CuO_2 planes is invoked.

(iv) Fe, Ni Ga and Zn substitution in Y-124 system :

Observations show that T_c depression of the $YBa_2 Cu_4O$ system resulting from disorder caused by partial replacement of Cu by metallic dopants Fe, Ni, Zn and Ga, in small concenterations, is significantly faster than in the $YBa_2 Cu_3O_7$ system. Another feature of T_c suppression in the $YBa_2 Cu_4O_8$ system is that the effect of Fe and Ni is much stronger in this system than that of Zn. These features are analyzed in terms of the hole occupancy of the doubly charged impurity atoms in two circumstances - first when the impurity is isolated, and the other when it is in the crystal environment. On this basis the observations support a mechanism of Tc suppression wherein the moments of the impurity acquire effectively more isolated atom like character in the $YBa_2 Cu_4 O_8$ system and wherein the pairing interaction is also suppressed directly.

(v) Thermoelectric power of Bi-2223, based on two band model:

A two-band model has been applied to explain the observed behaviour of the thermoelectric power of Bi-2223. The model invokes the Cu-O planes, which contribute to the metallic conduction of holes, while Bi-O planes contribute to the semiconductor like behaviour of electrons. The results indicate a good fit to the observed data and are consistent with the recently reported scanning tunneling spectroscopy studies of Bi-O layers in Bi cuprates.

(vi) Question of universal relationship between T_c and hole concentration

La(Sr)-214 system shows superconducting behaviour with T_c exhibiting a peak for an optimum carrier concentration. Several authors have been attempting to fit this kind of behaviour in a universal way to other cuprate systems, such as Bi-2122, Tl-2122, Y(RE)-123. We have examined this issue critically taking stock of our own results as well as of other workers. We find that most cuprate systems are in general, more complex than La(Sr)-214 in that superconductivity is not only controlled by holes on copper but also by the valence state of other cations such as Bi and Tl. This apart T_c is also influenced by interlayer coupling between CuO networks. As a consequence, no relationship between 2 T_c and hole concentrations on copper is to be expected.

SUPER CONDUCTIVITY AND MAGNET SYSTEMS

An onset transition temperature (T_c) of 135 K and a zero resistance T_c of 114 K has been observed in $Bi_{1.7}Pb_{0.3}Sr_{2-x} Hg_xCa_2Cu_3O_y$ com-

position for x = 0.3. Surprizingly XRD spectra shows the presence of only 2212 phase. No mercury is found to be incorporated in the system. Addition of HgO in this system enhances the oxygen partial pressure during sintering and perhaps raises the oxidation state of Cu which may be responsible for high T_c.

Magnet Applications

NPL provided consultancy to BHEL (Corp. R&D) Hyderabad on the development of a laboratory model of 200 KVA superconducting generator. NPL scientists remained associated with this project during the fabrication, vacuum leak testing, cryogenic thermal shocking, testing of the superconducting rotor at 4.2K, field profiling, installation of liquid helium and liquid nitrogen plants and the final trial operation of the generator. The generator ran successfully upto a speed of 1560 RPM. The open current phase voltage of stator was 50V at 1500 RPM and 200A field. The wave form was sinusoidal without noticeable harmonics. All the three phase voltages were equal.

Significant progress has been made in the DST sponsored 22.79 lacs project on the development of high homogeneity superconducting 3T magnet and a long hold liquid helium dewar for a 100 MHz NMR spectrometer. Three numbers of sixth order compensated magnets with bore dia. up to 105 mm and a winding length of 380 mm have wound using multifilamentary as well as single strand conductors. Axial correction has been applied by a set of six coils and radial corrections by a set of thirty two saddle shaped coils. Impregnation of coils has been carried out using Bees Wax as well as epoxy. A large long hold LHe dewar has been designed and is under fabrication.

Superconducting Thin Films

Parameters for insitu deposition of superconducting YBaCuO thin films by dc magnetron sputtering were optimized to enhance the J_c of the films. Micro-bridge structures of 50 μm width were patterned on the film by photolithography to measure transport J_c which was found to lie between $(1\text{-}3)\times10^6$ A/cm^2 at 77K, zero field and $(4\text{-}8)\times10^5$ A/cm^2 at 77K and 8000 Gauss field applied perpendicular to the substrate.

Low Frequency Conduction Noise Studies in HTSC

Experimental set up for measurement of low frequency Conduction noise in high-T_c superconductors was established. A systematic study of low frequency voltage noise in several YBaCuO ceramic samples of different quality was carried out in the temperature range 77-300K. The magnitude of noise in the normal state was found to be several orders of magnitude higher than that of metals and a pronounced peak near the superconducting transition temperature was usually observed. As the quality of the sample improved both the magnitude of noise in the normal state and the amplitude of noise peak (near the transition temperature) decreased.

HTSC SQUIDS

A detailed study to understand low frequency flux noise in HTSC rf-SQUIDs based on natural grain boundary weaklinks, was carried out. It was found that the flux noise in SQUIDs fabricated from c-axis oriented films is lower than those fabricated from unoriented films. The lowest noise energy $\approx 6.8\times10^{-28}$ J/Hz at 100 Hz and 77K was achieved. The SQUID was successfully used to detect and measure low frequency (1Hz to 10 Hz) square wave magnetic signals of 1.3 nano Tesla peak to peak amplitude.

Microwave Properties of HTSC

A systematic study of surface resistance (R_s)

of $YBa_2Cu_3O_{7-X}$ ceramic samples of different density has been carried out as a function of temperature, frequency, rf and dc magnetic fields. The R_S of 50 mm diameter samples has been measured by cavity and plate replacement method in the frequency range 10 to 22 GHz using high Q TE_0 in mode cylindrical resonators. A definite correlation in the value of R_S as well as its frequency, rf and dc magnetic field dependence with density of the samples has been found.

High-T_C YBaCuO and BiSrCaCuO superconducting microwave TE_{011} mode cavities for 17 GHz frequency were designed and fabricated. The highest Q obtained for a YBaCuO cavity at 77 K was 17000

High temperature superconducting tape

Compositions of Bismuth compounds 2212 and 2223 superconducting tapes have been prepared by using doctor blade tape casting technique. The fabrication of 2212 tape was carried out by melt texturing technique and of 2223 tape was carried out by intermediate pressing and sintering technique. The thermal treatment was optimized for high JC. maximum JC obtained so far for 2223 tapes is 6000 A/cm2 and for 2212 tapes is 8000 A/cm2, at 77 K and zero magnetic field. The critical current density JC has been investigated as a function of transverse magnetic field (0-IT) and temperature (60-77K) for both type of tapes. Critical current density dropped with increase in magnetic field, at 1 T JC measured was 103 A/Cm2 for both types of tapes when magnetic field was applied parallel to b-plane.

D C magnetization studies under different magnetic fields were carried out to distinguish inter and intragranular properties of these materials. Both inter as well as intragranular critical current density showed upward trend with texturing.

High temperature superconductivity-processing

High-Tc phase Bi-2223 bulk polycrystalline samples from nominal composition having molar ratio of Bi:Pb:Sr: Ca:=1.7:0.3:1.9:2.1 with increasing cu-content: Cu=3.3, 3.5, 3.7 and 3.9 have been synthesized and characterized. Three different chemical routes : (i) Co-precipitation, (ii) sol-gel and (iii) spray drying having been employed in order to get single phase Bi-2223 samples (synthesized under identical conditions of calcination and sintering in air) in relatively short time. The best results were obtained from spray drying method which produced single phase Bi-2223 samples (from nominal composition: Bi1.7 Pb0.3 Sr1.9 Ca2.1 Cu3.5 O10+x) in 48 hrs only, with TC (R=0)~106 K and density more than 90%.

For further improvement, studies of these samples sintered under reduced O_2 partial pressure are underway.

Besides these studies, on high TC Bi-2223 samples, some of the studies have also been carried out on the low-TC. Bi-2212 samples. Effects of quenching and slow cooling on the superconducting and structural properties of both the Pb-free as well as Pb-substituted Bi-2212 samples have been studied as a function of sintering duration.

THEORETICAL STUDIES

The vibronic interaction in low lying T1u and T1g states of fullerine ion C60 is studied in view of a recent suggestion that the proximity between the two levels is responsible for superconductivity in M3 C60 systems. The two levels are mixed under an odd parity vibration and are also susceptible to Jahn Teller interaction. This Complex vibronic problem is analysed and compared with the experimental spectroscopic results on C60 radical.

RADIO SCIENCE

RADIO SCIENCE INTERNATIONAL GEOSPHERE BIOSPHERE

Solar UV-B radiation and aerosol measurement

The solar UV-B radiation data at Delhi for the period 1981 to 1991 were analysed along with changes in ozone values for the same period. Correlation of ozone with UV-B radiation, surface temperature and solar activity were studied. It was found that 30% decrease in ozone will lower the surface temperature by about 0.3 K which will affect the climate significantly.

During the Indian middle atmosphere programme (IMAP) a network of ground based passive multi-wavelength solar radiometers (M W R) were established covering different geographic locations in the country. The Temporal, Spatial and spectral characteristics of atmosphere aerosols were studied using the spectral extinction measurements at eight wavelengths of the network lying in the visible and near IR range. An attempt has been made to explain the observed features on the basis of natural and anthropogenic effects which are synoptic as well as of meso - scale nature.

Measurements are continuing of solar UV-B on clear days at local noon. The measurement involves global, diffused, direct and the vertical components by Erythemal Probe at 297 nm as also the spectral measurements from 280 nm to 340 nm.

Solar Infrared Spectroradiometer

Analysis has been made of spectroscopic measurements of atmospheric water vapour over Delhi using a solar infrared spectroradiometer. The water vapour content obtained from solar infrared spectroradiometer has been compared with the water vapour content obtained from radiosonde observations and the tropospheric and stratospheric water vapour content deduced.

Ozone Trend Analysis

Recent study of ozone decrease over the Antarctic region has brought about the importance of knowing the rate at which our environment is undergoing change. It is more or less established that the manmade chlorofluorocarbons are the major cause of ozone depletion in polar and higher latitude stratosphere. But over the past few decades an increase in tropospheric ozone is being detected over the globe. This is due to the oxidation of agriculturally produced methane in the presence of sunlight. These two opposite effects influence total ozone in varying degrees at different latitudes.

Trend analysis of ground based dobson ozone values over three representative Indian stations namely: Srinagar (39°N), Delhi (28°N) and Kodaikanal (10°N) have been studied. The data series extends over the period 1965-91 except for Srinagar for which the data is available only up to 1988. A statistical model having terms for different variabilities such as linear trend, six monthly, seasonal and biennial oscillations, as well as, long term solar variability have been used. It is found that the trend near the equator, though small, is positive, decreasing to negative values at higher latitudes.

INDIAN ANTARCTICA RESEARCH PROGRAMME

Measurement of ozone over antarctica

The laser Heterodyne spectrometer using wide band 1 GH_z acousto-optic spectrometer designed and developed at NPL to monitor ozone and other minor constituents was taken to the Antarctica in 13th Antarctica expedition. The observations have been taken and the data so obtained is currently being analysed.

The millimeter wave ozone radispectrometer, which has been under development at NPL under a sponsored project funded by Deptt. of Ocean Development, was taken to Antarctica during the 13th Indian Antarctica Expedition. The observations have been taken for a period of about a month and the ozone data so obtained is currently being analysed.

RADIO COMMUNICATION

Short term forecasting and consultancy services

Short term forecasting and consultancy service, RWC (New Delhi) being operated from NPL continued to provide short term forecasts on solar and magnetic activities to a variety of users in India which include among othersISRO, Bangalore, PRL, Ahmedabad, VSSC, Trivandrum. Rajasthan state electricity board was provided with ionospheric predictions for planning of several HF communication networks in Rajasthan state linking.

Ionospheric prediction were also provided to Army signals to aid in setting up a reliable HF link between India and Somalia for round the clock operation.

Studies on HF Fading

Considering the importance of fading of radio signals in the estimation of transmitter powers for a specified reliability of service, a study has been made on various aspects of fading of HF radio signals. It was observed that the most probable values of fading range vary between 12-14 dB in 6-17 MHz bands. Speed of fading is found to vary between 8-15 fades per minute depending on the frequency, higher values occurring at higher frequency bands. Based on this study a fading allowance of 9 dB is proposed on short term basis to ensure stable condition of signal for optimum signal to noise ratio for communication purposes. A special campaign was conducted at Calcutta to monitor several HF Broadcast transmision originating in the Eastern region of India to study Various aspect of HF field strength Variation in that region..

Effects of Rain on Radiowave Propagation

Effects of rain on microwave and mm-wave radio propagation in selected regions in India-a project sponsored by DTSR, DRDO, Ministry of Defence has been completed during this period. The basic thrust was to study the attenuation of radio waves due to rain at various frequencies for both terrestrial and earth-space paths over selected sites/regions. In addition a detailed rain height characterisation over India has been mapped.

Long Term Solar and Ionospheric Predictions

Regular prediction of sunspot numbers six months in advance continued. Also work continued on the ATLAS of Ionospheric Communication parameters over the Indian subcontinent which gave average values of the parameters to find the day-to-day variability. This included plotting of contour maps of coefficient of variation of the two main communication parameters for F2 and

MUF (4000) F2 over a Solar Cycle. Two diagrams for each year for each station were drawn. These depicted the local time and seasonal changes in the coefficient of variation. For a few Indian stations eleven years of data have been processed. The expected deviations from the monthly medians during magnetic storms are also included. This coefficient of variation determines the extent of the deviations from the monthly median and is used to derive working frequencies in the HF-circuits for given time availability (90 percent for most of the circuits) while planning efficient communication links.

Anomalous long distance TV signals

The monitoring of anomalous long distance TV signals continued with field strength measurement at Delhi during 1993-94.

The monitored data of anomalous long distance TV reception at Delhi in the Band I has identified possible modes of propagation. The afternoon and late night peaks were mainly due to normal F-layer and artificial spread-F during equinoxes and winter of high solar activity. However, summer noon and late evening peaks were mainly due to sporadic-E layers and artificial Spread-F respectively for low to high solar activity periods.

Cosmic Radio Noise

The manifestation of solar activity on the cosmic radio noise records has been studied with special emphasis on Type-I noise storms and the associated coronal magnetic fields above the active regions on the sun. An improved empirical equation has been suggested for the observed magnetic field at the source which is written as

$$B=41.26 \exp(-2.56\ R/R_0)$$

Thus estimation of coronal magnetic fields and localisation of the release of non-thermal energy in the solar corona give valuable insight into the physics of the sun.

The sun's enhanced radiation during the disturbed period has successfully been made use of to validate the riometer, Radar antenna power patterns to make it simpler.

Riometer quiet day curve (QDC) using sky brightness survey has been developed to behave better than any other technique deriving the QDC.

Microwave/mm Wave Radio-metery

The 22.235 GH_z data from SAMIR on board orbiting Bhaskara II satellite were used for estimating water vapour content over oceans and land. The average values of land emissivity (~0.85) and ocean surface emissivity (~0.408) were used based on model using average value of wind speed in the absence of daily wind speed values. The water vapour content so retrieved has been used to develop water vapour contours over land and sea based on SAMIR coverage over India. Comparison was also made between the water vapour content measured using ground based microwave radiometer operating at 22.235 GH_z and SAMIR measurements for New Delhi. The correlation coefficient between the two measurements was 0.85.

Attenuation measurements were obtained using the microwave radiometric measurements of atmospheric attenuation at 19.4 GH_z under clear, cloudy and rain events. The attenuation measurements under clear weather condition varied between 0.2 dB to 1.1 dB at 19.4 GH_z. The cumulative distribution showed for 1% of time attenuation exceeded 0.9 dB whereas for 50% of time it exceeded 0.5 dB. In the case of clouds, for 50% of time attenuation exceeded 0.28 dB whereas for 80% of time it exceeded 0.15 dB. The values of attenuation versus rainfall

rate measured by a 10 seconds opto-electronic raingauge at 19.4 GHZ varied between A=0.01 + 0.18 R at the minimum and A=0.01+0.25 R at the maximum. Microwave radiometric measurements at 19.4 GHZ gave a set of attenuation values for clear weather, cloudy and rainy conditions useful for reliable communication systems in the microwave/mm wave regions.

RADIO AND ATMOSPHERIC PHYSICS

Variability of Dayside Electron Temperature at Venus:

Langmuir probe measurements on Pioneer Venus Orbiter show that electron temperature (Te) increases slowly with altitude in the ionosphere whereas it rises sharply with altitude in the ionopause region. This rise in Te has generally been attributed to solar wind heating. We have shown that this sharp rise in the Te is primarily due to the steep fall in electron density, Ne. Large orbit to orbit variations in Te have been observed in the ionopause region and these are found to be inversely related to changes in Ne (Fig.1). The variations in solar wind dynamic pressure do not seem to have a direct effect on Te, rather the effect is indirect coming through the sharp decrease in Ne.

Comparison of Langmuir Probe based EUV index with Lyman-alpha and F10.7:

For ionospheric studies, solar radio flux at 10.7 cm (F10.7), has often been used as a proxy for solar EUV flux. This is quite adequate if F10.7 is averaged over one or more rotations. The daily F10.7, on the other hand, could lead to wrong conclusions, since day-to-day variability in F10.7 is basically due to solar rotation and is caused by short-lived boosts from coronal emissions, and these emissions do not contribute significantly to the F2 region ionization. Comparison of the relationship between F10.7 and EUV flux on daily as well as long term basis have been studied. EUV flux was evaluated in terms of the photoelectron current, ipe, measured by Langmuir probe on the pioneer Venus Orbiter. An analysis of ipe and F10.7 over the 13 year period from January 1979 to December 1991, shows that daily F10.7 is a poor proxy for EUV flux on short-term basis. The 81-day averaged F10.7 (Viz. F10.7A), on the other hand, shows a linear relationship with 81-day averaged ipe upto about 160 flux units, above which the relationship breaks. The relationship of ipe with solar Lyman-alpha and solar magnetic flux were also studied and it was found that both these parameters are linearly related to ipe at all levels of solar activity. It is thus concluded that the daily F10.7 should not be used as a proxy for the EUV flux for ionospheric thermospheric studies. Further, F10.7 may only be used as a proxy for EUV flux for low and medium solar activity conditions.

O^{++} Ions at Venus:

Measurements of O^{++} concentration made by the orbiter Ion Mass Spectrometer were analysed for studying its temporal and spatial distribution in the Venus ionosphere. The diurnal analysis shows a high abundance of O^{++} around midnight. In the nightside, O^{++} densities are highly variable but show positive correlation with the variations of O^{+} densities. Model calculations of O^{++} in the nightside, first by assuming impact ionization by precipitating electrons and then by transport of ions from dayside as sources of O^{++} ions were made. In-situ ionization by precipitating electrons is found to contribute very little, whereas a downward O^{++} flux of 1.7×10^{5} cm-2 s^{-1} can account for the measured O^{++} densities. The high abundance of O^{++} near midnight is related to the special characteristic of multiple charged ions, where the upward forces due to thermal diffusion

and polarisation field contribute significantly in the momentum equation for O^{++}. As a result, the downward velocity for O^{++}, as compared to other ions, is small. Since more O^{++} is added through transport from dayside in this region than is lost, this mechanism can increase the O^{++} concentration in the deep nightside. It has also been found that orbits having high O^{++} density correspond to orbits with low Psw, which supports the transterminator mechanism for the source of O^{++} ions near the antisolar region.

Liquid Water on Mars and Solar Models with Mass Loss

There are strong geological evidences that liquid water was present on the surface of Mars around 3.8 billion years ago. This evidence has been used as a boundary condition to constrain the new solar models in which the solar flux was initially higher (contrary to standard models) during the early days of the solar system and then declined. It is concluded that the surface temperature on Mars could be maintained at or about 273° K around 3.8 billion years ago, only if the initial solar flux variation (resulting from solar mass loss) took place with a time scale of about 10^9 years, and if the initial surface pressure on Mars was around 5 atmosphers or more.

MST Radar Measurements

The Indian Mesosphere-Stratosphere-Troposphere (MST) radar, installed at Gadanki (13.47°N, 78.18° E), near Tirupati, Andhra Pradesh, was operated in the ST mode during February-March, 1992, with the antenna beam pointing vertically toward zenith and the observations taken with 150 m range resolution for two hours (1430-1630 hrs IST) of radar time daily for five days (24-26 February and 23-24 March 1992). Vertical wind velocities were obtained from the Doppler shift and the Spectral analysis showed that in the lower troposphere, the dominant period lies in 4-8 min or 14-24 min. However, in the upper troposphere (14.0-19.0 km), waves with 4-7 min periodicities are dominant. The Brunt-Vaisala (BV) period computed from the radiosonde showed wide fluctuations in the lower troposphere, whereas in the upper troposphere, it was in good agreement with the radar measurement. Doppler power spectra in the six beam positions, i.e. East, West, Zenith-Y, North, South, and Zenith-X were also obtained. These spectra showed the zonal, meridional and vertical wind components in the lower troposphere (3.6 to 7.2 km). The Fast Fourier Transform (FFT) analysis of time series showed that the waves of 5-10 and 16-20 min periodicities dominate in the lower troposphere and the amplitude varied between 0.3 and 3.0 ms-1. The measurements were also used to study the wind shears, and significant shears were noted only above 6.0 km.

The variability of the tropopause and the stable layers in the atmosphere were also studied, and it was observed that the multilayered structures (3-4 layers) exist below and above the tropopause. In addition, one or two layers were always seen in the lower atmosphere in the region of 6.5-8.5 km height. The layer in the lower atmosphere can be turbulent or stable and further experiments are needed to verify the nature of the layers.

Thickness Parameter for IRI (International Reference Ionosphere):

High resolution electron density profiles, measured with the Arecibo incoherent scatter radar have been used to derive the half density point on the Ne-h profile for specifying the shape of the bottomside F-region. More than 2400 profiles, for the period August 1974-May 1977, have been used to study behaviour of this parameter. Our analy-

sis shows that during the night, h0.5 varies mostly between 200 and 350 km, but during the day, the excursion is larger and values lower than 150 km are also seen. These lower values are often coincident with the presence of F1-lyer and when h0.5 is less than hmF1. We also find that most of the variability in h0.5 is due to the variability in hmF2 and a linear relationship between h0.5 and hmF2 is seen.

IONOSPHERIC HEATING

A critical examination was made of records of some experiments that were made in 1980-81 to find out, if Spread F could be produced by high power transmitters modifying the F-layer. The heating transmitter of 250KW was at Aligarh and the monitoring ionosonde at Delhi. It is concluded that, with a transmitter power of the above order, enhanced spread F condition may be produced, if some irregularity structure is already present in the F-layer and also if the heater frequency is within ± 0.1 MH_z of foF2.

MICROBAROGRAPH

Infrasonic pressure variations during 1991 at Maitri, Antarctica were studied. In addition to the normal infrasonic pressure variations which are observed in the Mainland also, some continuous infrasonic waves were observed during the month of Oct. 91. A possible linkage of these infrasonic wave motions with the stratospheric temperature changes at Antractica in the month of October, is suggested.

SATELLITE BEACON STUDIES

The VHF signals of geostationary satellite Fleetsat at 250.35 MH_z recorded earlier at Delhi, Bhopal and Hyderabad were extended to cover Dibrugarh. Scintillation data campaigns were held under AICPITS during June and Dec. 1993. Also a study of coordinated multi-station VHF scintillation observations were carried out under AICPITS data campaign during Sept-Oct. 1991. It was observed that the scintillations occur continuously throughout the night in the equatorial zone while it breaks up into more discrete patches at anomaly peak and beyond. The occurrence patterns of scintillation and spread-F are well correlated in the equatorial as well as anomaly crest latitudes. However, if the irregularities are patchy at the equator itself, then scintillations are less likely to occur at the crest latitudes and beyond.

Analysis of amplitude data at Delhi for the period 1979-80 shows that daytime scintillation occurrence is maximum in summer and minimum in winter months. They peak around mid-day and show negative types class I and class II. Class I type scintillations show maximum occurrence in equinox and class II in summer. Class I and Class II show positive and negative correlation respectively with solar activity.

A computer simulation has been under taken to solve a two dimensional parabolic equation to obtain complex wave field distribution of GPS (Global Positioning Satellite) L 1 (1575.52 MH_z) and L2 (1227.6 MH_z) signals after scattering by a model phase screen at the ionospheric heights. It has been shown that the correlation peaks of strong scintillation features might actually mask or blur the correlation peak due to ionospheric group delay, and hence the real time ground delay correction at L1 may become erroneous or superficial in the presence of strong scintillation producing ionospheric structures.

A study of IEC at mid latitude stations Tokyo, Osan and Athens for the year 1980 shows that IEC and IEC max show good correlation and that the later could be used as an indicator of depolarisation of communication signals.

An empirical model based on harmonic analysis approach for IEC has been evolved for all levels of solar activity. The model requires only the precalculated set of co-efficients as input, eliminates the necessity to integrate the electron density profile and enables first order correction of the time delay and refraction errors.

TECHNICAL INFRASTRUCTURE

LIBRARY

315 new titles in physics and related areas were added to the current library collection of which 10 were in Hindi. It subscribed to 177 journals out of a total of 252 journals listed for the current year.

The library continued to provide as usual library, documentation and reprographic services. 4036 publications were issued from the library. It also includes items given to libraries on interlibrary loan. 151849 photocopies were made on photocopying machines. 1097 visitors from academic and scientific institutions in Delhi and outside visited the library during the period. Selective. Dissemination of Information service was rendered to 25 research projects in the Laboratory on regular basis.

CD-Search facility was started in Jan 1994. It offers information retrieval facility from INPSEC (Physics) database covering the period from 1990 to date. This facility was estabilished under the project sponsored by NISSAT.

The Library started information services on commercial basis from this year with a view to provide access to users across the country. It now offers ACLIPS (Access to Literature in Physical Sciences) service.

GLASS WORKSHOP

This unit has continued its activities in the field of development, fabrication and repairing of scientific Glass, Quartz Apparatus and Equipments for the uses with in the Laboratory as well as for out side Institutions, Industries, R&D Organisation, Medical and Educational Institutions and Government Institutions/Organisations.

The following are the main representative organisations benefited by the work carried out for them in their Research and Development works:-

Central Road Research Institute, New Delhi

Deptt. of Physics, Indian Institute of Technology- Kanpur.

Aligarh Muslim University-Aligarh.

Deptt. of Atomic Energy-New Delhi.

M/S Ranbaxy Laboratories, New Delhi.

M/S Gupta Scientific Industries, Ambala Cantt.

M/S Industrial Carbon - Calcutta.

Kurukshetra University - Kurukshetra.

Geological Survey of India, Faridabad.

University of Allahabad.

L.N. Mithila University - Darbhanga.

Guru Nanak Dev University, Amritsar.

During the year 409 Internal Jobs were undertaken of various Division/Projects of our own Laboratory-NPL.

INSTRUMENTATION SERVICE FACILITIES

224 instruments were tested and evaluated for checking their workability and performance before return to Central Stores. The major repairs undertaken are calculating machine, colour photometer, tape Recording systems, voltage Stablizers temperature Controllers, portable gas chromatographs etc.

Technical assistance has also been rendered to various in house projects in the design of circuit. Inward inspection has been made for Electronic and Electrical Stores at time of procurement in Central Stores. More than 20 test reports were prepared and submitted to the Central stores for various electronic components, ICs and devices.

PUBLICATIONS

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STANDARDS

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APPENDICES

SPONSORED/SUPPORTED PROJECTS

Sr. No.	TITLE	AGENCY	AMOUNT RECEIVED (Rs. in Lakhs)
NEW			
1.	Investigation of materials under ultra high pressure metrological applications.	DST	5.871
2.	Studies on reliability and availability of GPS signals in India (SARGI)	DOE	8.00
3.	Development of high critical current high Tc superconducting thin films for fabrication of squids and infrared detectors.	INDO-FRENCH	12.646
4.	Development of a vapour compressor based refrigerator for storage of life saving vaccines like DPT etc. for national immunization programme.	DST	1.50
5.	Use of the laser heterodyne system with acousto optic spectrophoto meter for atmosphere studies over tropics.	INDO-FRENCH	9.00
6.	Development of powder X-ray diffractometer	DST	20.00
7.	Laboratory level technology of some biosensors and related materials.	DST	13.00
8.	Fabrication and supply of underwater pinger unit.	NSTL	0.993
9.	Development of two dimensional steps package diffusion module.	DOE	7.00
10.	Development of ultrasonic transducer for the development of a portable low cost ultrasonic scanner.	CSIO	0.25

CONTINUING

1.	A ground based millimeter wave technique for ozone observations at Antarctica.	DOD	7.50
2.	Development of graphite reinforced carbon bipolar plates for fuel cells.	DNES	0.75
3.	Preparation and characterization of halogen intercalated carbons.	INDO-FRENCH	6.91
4.	Development of high strain to failure and high modulus carbon fibres.	ARDB	13.08
5.	Design and fabrication of plasma CVD Based system for deposition of diamond like carbon (DLC) films on Ge substrate.	IRDE	2.00
6.	Design & Development of plasma CVD based system for deposition of a-Si films on large area.	DNES	4.50
7.	Development of a semiconductor processing equipment.	CEERI	0.25
8.	R&D in laser frequency standards.	INDO-RUSSIA	—
9.	Volatile metal organic compounds.	INDO-RUSSIA	—
10.	National superconductivity fellowship (National superconductivity programme).	DST	—
11.	Electroluminescent panel for backlighting of crystal displays.	TIFAC	—
12.	Establishment of surface analytical facilities	UNDP	—
13.	Augmentation of national standards of measurement at NPL under the programme of technical collaboration with PTB Germany-Extended phase for consolidation and completion.	INDO-GERMAN	—
14.	Interaction of small gas molecules with semiconductormetal interfaces as studied by surface analytical techniques.	INDO-US	—

15.	Establishment of transfer leak standards in vacuum metrology.	INDO-US	2.73
16.	Deformation behaviour of composite materials (Aluminum alloy matrix composites).	DST	—
17.	Calibration service programme under the NABL programme.	DST	12.00
18.	Development of stirling engine for power production.	DNES	—
19.	Charge carrier transport in crystalline materials matrological application.	INDO-US	—
20.	Simple technology development for a heat pipe room heaters from ground heat.	DST	—
21.	DOE-NPL centre for characterization of materials for electronics.	DOE	—
22.	Growth of nearly perfect crystals of oxides like lithium niobate.	INDO-RUSSIA	—
23.	High resolution X-ray diffraction imaging for materials characterisation.	INDO-US	—
24.	Development of ionospheric models for high reliability if system.	DRDO	—
25.	Synthesis, characterisation and application of some conducting polymers.	INDO-EEC	15.385
26.	Hydrogen maser for vlbi studies.	NGRI	—
27.	National methane campaign for actual methane measurements.	MEF	—
28.	Design, Development & fabrication of doppler Mini-Acoustic sodar (MINI SODAR) for studies of the atmospheric boundary layer over the sea surface.	DST	—
29.	Environmental impact assessment studies of noise pollution.	MEF	0.275

30.	Indigenous development of ultrasonic transducer for seismic physical modelling studies.	ONGC	0.843
31.	Development of ultrasonic transducer for the development of a portable low cost ultrasonic scanner.	CSIO	0.25
32.	Ultrasonic standard for support to industries (Phase-II)	BRITISH COUNCIL	—
33.	Development of a superconducting magnet system with a long hold devar for a 100 KHz NMR spectrophotometer.	DST	8.77
34.	Development of process for fabrication of 15% efficiency single crystal and multicrystal solar cells.	DNES	15.00
35.	Mointoring of solar ultraviolet radiation at the ground in the UV-B region (Project completed equipment maintenance work only).	ISRO	0.188
36.	Development of high X-ray sensitive photoreceptors for dose reduction in xeroradiography.	DOE	—
37.	Laser heterodyne system for the study of ozone and other minor constituents in Antractica.	DOD	29.50

COMPLETED

1.	To monitor solar infrared radiation for studying minor constituents in atmosphere using infrared spectrometer.	DST	—
2.	Development of warm forging & hot extrusion processes for metal matrix composites (jointly with DMRL, Hyderabad).	ARDB	—
3.	Preparation, Characterisation & precise measrements of semiconducting materials.	INDO-US	—

4.	Metrological studies on standards of measurements	INDO-US	—
5.	Studies of high temperature superconductivity (coordinated by II Sc Bangalore)	INDO-RUSSIA	—
6.	Syethesis of high Tc superconducting materials through eutectic melt.	DST	—
7.	Scientific programmes relating to Indian Antaretic scientific research of various laboratories of CSIR.	DDD	—
8.	Development of software packages on rain effects in the microwave & mm wave bands in selected regions over India.	DRDO	—
9.	Study of the tropical boundary layer metrology at Jodhpur using monostatic acoustic sounder and instrumented tower.	DST	0.65
10.	Monitoring of monsoon circulations.	INDO-RUSSIA	—
11.	Development & decay of scintillation producing irregularities and gravity wave propagation in low latitude.	DST	0.30
12.	Establishment of CD/ROM based information services (INFPHS) on physics at NPL.	DST	—
13.	Technical feasibility and concept proving in the area of biomolecular electronic devices.	DST	2.45
14.	Comprehensive programme of manpower development associateship/fellowship programme.	DOD	—
15.	Development of aerospace quality carbon fibre.	DST/TIFAC	—

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

All India Institute of Medical Sciences, New Delhi. (Instrumentation)

Aichi Instt. of Technology for development of mask aligner. (Length)

Agra University, Agra. (Instrumentation)

Bharat Heavy Electricals Ltd., Hyderabad (Carbon)

Banaras Hindu University.

BHU, Varanasi, PRL, Ahmedabad & NMRF, Tirupati. (RSD)

Birla Institute of Science & Technology, Pilani. (EPR spectrocopy)

Central Arid Zone Research Institute, Jodhpur. (Acoustics)

Central Electronics Engineering Research Institute, Pilani. (Characterization, Instrumentation & Spectroscopy)

M/S Central Electronics Limited, Sahibabad (U.P.)

Centre for Liquid Crystal Research, Bangalore. (Electroluminescent Panel)

Central Scientific Instruments Organisation, Chandigarh. (Ultrasonics & Instrumentation)

Delhi College of Engineering, Delhi.

Department of Environment, New Delhi.

Defence Metallurgical Research Laboratory, Hyderabad, HAL, Bangalore,

Regional Research Laboratory, Trivandrum.

Indian Institute of Science, Bangalore. (Metals & Alloys)

DRDL, Hyderabad & IIP, Dehradun. (Carbon)

Department of Science & Technology, New Delhi. (Acoustics, Josephson Voltage & RSD)

Delhi University, Delhi (Charaterization, Instrumentation)

Dibrugarh University (Scintillation)

Graphite India Limited, Bangalore (Carbon)

Guru Nanak Dev University, Amritsar.

Hindustan Aeronautics Ltd., & Air Force Head Quart, Nasik

Indian Association for the Cultivation of Science, Jadavpur.

Indo-French Centre for Promotion of Advanced Research, New Delhi.

Indian Institute of Technology, New Delhi. (Josephson Voltage, Instrumentation & Surface Area & Porosity)

Indian Institute of Technology, Bombay.

Indian Institute of Science, Bangalore, Indian Statistical Institute, Calcutta & Indian Institute of Tropical Meteorology, Pune.

ILTP programme of cooperation between India and Russia on R&D in Laser Frequency Standard. (Length)

Industrial Toxicology Research Centre, Lucknow.

Institute of Radio Physics and Electronics, Calcutta. (RSD)

Jamia Milia Islamia University, Jamia Nagar, New Delhi.

Jawaharlal Nehru University, New Delhi.

Kurukshetra University. (Josephson Voltage & Instrumentation)

KD Malviya Institute of Petroleum Exploration, Dehradun.

Meerut University, Meerut.

National Environmental Engineering Research Institute, Nagpur.

Nuclear Science Centre, New Delhi.

Opto Electronics Factory, Ministry of Defence, Dehradun. (Thin film)

Physics Department, M.D. University, Rohtak. (Charaterization) Punjabi University, Patiala.

Regional College of Education, Bhopal (Scientillation) & Osmania University, Hyderabad.(Scintillation)

R&D Unit for Navigational Electronics, Osmania University. REC, Warangal.

S.V. University, Tirupati.

Thapar Institute of Engineering and Technology, Patiala.

University of Roorkee, Roorkee.

OVERSEAS

BELGIUM

Katholieke University, Kortrijk Campus and Leuven Campus. (Instrumentation)

FRANCE

Centre de Research Paul Pascal, CNRS, Bordeaux. (Carbon)

CNRS, Laboratoire de Physique des Solides de Bellevue. (Josephson Voltage)

Laboratoire de Genie Electrique de paris. (Josephson Voltage)

GERMANY

P.T.B. Braunschweig. (Acoustics)

P.T.B. Collaboration for coaxial microcalorimeter. (Standards)

P.T.B. Collaboration programme (Phase II).

P.T.B. Cooperation for augmentation of Length Standard and Calibration facilities. (Length)

INDO-US

Charge carrier transport mechanism in crystalline materials : Application of Metrology (Pressure)

Establishment of Transfer Leak Standards in Vacuum Metrology. (Pressure)

"Intercomparison of small gas molecules on metal/semiconductor interfaces". (Pressure)

NETHERLAND

Delft University of Technology, Delft. (Instrumentation)

RUSSIA

Institute of atmospheric Physics, Moscow. (Acoustics)

VNIIFTRI, Moscow Region. (Acoustics)

SWEDEN

Agreement on joint Indian/Swedish research project on atmospheric chemistry. (Chemistry)

(I) Precipitation and aerosol measurement and
(II) Greenhouse gas emissions.

THAILAND

Assessment of biomass as a source of energy and technical option for green house gas emission reduction. (Chemistry)

UK

University of Aberdeen British Council Project on Acoustic Tags. (UltraSonics)

USA

M/S Crystal Systems Inc., directional solidification of multicrystalline silicon. (Silicon)

PTB Germany, University of Rochester. (Optical Radiation)

University of California, Irine. (Metal & Alloys)

University of Wsiconsin, Milwaukee. (Metal & Alloys)

CALIBRATION/TESTING CHARGES
(Realised during 1993-94)

ACTIVITY	AMOUNT (Rs)	REPORTS (No.)
PHYSICO MECHANICAL STANDARD		
Force & Hardness	14,45,485	797
Dimensional Metrology	13,90,825	523
Optical Radiation	7,01,700	188
Pressure & Vacuum	7,48,500	145
Temperature	6,23,300	393
Mass, Density, Volume & Viscosity	4,05,300	408
Acoustics	3,30,800	98
Length	1,02,200	17
Ultrasonics	5,050	2
ELECTRICAL STANDARDS		
AC & LF Standards (Up to 1kHz)	3,71,450	91
LF & HF Impedence Standards	1,58,050	132
DC Standards	3,80,050	201
HF & MW Power, Voltage, Freq. & Noise	3,55,650	64
HF & MW Attenuation & Impedance	1,03,675	37
Time & Frequency	67,150	34
Total	71,89,185	3130
MATERIAL ANALYSIS		
Material characterisation	3,27,145	32
Chemical analysis	56,800	28
Total	3,83,945	60
Grand Total	75,73,130	3190

PROCESS RELEASED

PROCESS	LICENCEE	TERMS & CONDITIONS
Liquid Nitrogen Containers	M/S Hi-Tech Industries Manjal Pur, Baroda.	Premium-Rs 25.000/- Royalty - 3% Licence Period - 7 Years
Blood-Glucose Biosensor	M/S Gamma International Private Limited, 16/6 Mathura Road, Faridabad.	Premium - Rs. 3.00 Lakhs Royalty - 5% on sales Licence Period - 10 Years

CONSULTANCY

Nature of Consultancy	Party	Amount (Rs. in lakhs)
1. Consultancy on 5 MVA super conducting magnet.	Bharat Heavy Electricals Ltd., Hyderabad.	3.000
2. Supply of Acoustic Sodar for generation of Data on mixing *might* for DSP(Steel Plant) Durgapur.	Steel Authority of India Ltd., DORANDA, Ranchi.	3.000
3. Acoustic Sodar for Generating data on mixing height.	Steel Authority of India (SAIL), R & D Centre for Iron and Steel, Ranchi	2.675
4. Characterisation of brake pad samples.	Defence Research and Development Laboratory, Hyderabad.	1.950
5. Low quinoline insoluble impregnating coal tar pitch for graphite electrodes.	M/s Graphite India Ltd., Calcutta.	1.750
6. Acoustic treatment of various areas of Terminal II of the Indira Gandhi International Airport, New Delhi.	International Airport Authority of India, New Delhi.	0.610
7. Feasibility Study on the flexible Graphite sheets.	M/s Universal Ferro & Allied Chemicals Ltd., Bombay	0.400
8. Inspection & detecting defects faults in the laser systems.	Inkram Sakrbai space centre research Unit-V, Thiruranantta-puram.	0.198
9. Acoustic treatment of Auditorium complex at NIO., Goa.	National Institute of Oceanography. Goa.	0.126
10. Improvement of performance of microwave absorption materials.	M/s K.V. Microwave Materials, Sahibabad.	0.100
11. Advisory Consultancy related to coater.	M/s Modi Xerox Ltd., Kanpur.	0.100
12. Optimisation of performance Parameters of electronic SPST, DPST & liner potentiometer.	M/s Super Shine Industries, Faridabad.	0.096

13. Optimum performance evaluation of electronic potentiometer volume control and presets.	M/s Sun Shine Industries, Faridabad	0.086
14. Stabilizeo cubic zirconium.	M/s Shreyans Enterprises, Jaipur.	0.052
15. Performance Evaluation of V-belt guaging Machine.	Technical hilton roulands Ltd. Sonepat, (Haryana).	0.052
16. Consultancy related to formation of chrysoberyl crystals.	Rattan Chand Jain K-29 NDSE Part-2, New Delhi.	0.050
17. Acoustic treatment of the central air-conditioning plant room at Rashtrapati Bhawan.	President Estate, Rashtrapati Bhavan. New Delhi	0.050
18. Design of 3-D surface lifting software.	M/s Samtel Colour Ltd., Distt. Ghaziabad	0.020

HUMAN RESOURCES

SCIENTISTS OFFICERS

(In order of Gp. IV to Gp. III as on 1.4.94)

DIRECTOR
ESR Gopal

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

VD Dandawate, Sc EII
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, TOB
A. K. Kanji Lal, TOB
BK Roy, TOB
Ram Narain, TOB
SL Thind, TOB
VD Sharma, TOA

MASS

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

FORCE

JR Anand, Sc F
RS Sharma, Sc EI
JK Dhawan, Sc EI
MK Chaudhury, Sc EI
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
Pardeep Mohan, Sc EI'
SM Sivaprasad, Sc C
R.K. Kulshrestha, Sc C
Arun Vijaykumar, Sc B
SP Sharma, TOA

TEMPERATURE

RK Luthra, Sc EI
NK Srivastava, Sc C
TK Saksena, Sc C

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

OPTICAL RADIATION

KC Joshi, Sc F
JS Vaishya, Sc EII
S Manrai (Smt), Sc C
HC Kandpal, Sc C
TK Chakraborty, Sc C
Jai Bhagwan, TOA

INFRARED RADIATION

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

ULTRAVIOLET RADIATION

RS Ram, Sc EI
Om Prakash, Sc EI
NN.Swamy, TOB
Jagdish Lal, TOA

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

TK Saksena, Sc F
Janardan Singh, Sc EI
Ashok Kumar, Sc EI
SK Jain, Sc EI
RP Tandon, Sc EI
Ved Singh, Sc EI
Harish Bahadur, Sc EI
Mukesh Chandra, Sc C
Subhash Chandra, TOB
Reeta Gupta (Smt), TOA
NC Soni, TOA

FLOW MEASUREMENT

MK Dasgupta, Sc F
JN Som, Sc EI
Raj Singh, Sc C
Virendra Babu, TOC

ELECTRICAL STANDARDS

TIME & FREQUENCY

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

JOSEPHSON VOLTAGE

Ashok K Gupta, Sc F
VS Tomer, Sc EI
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 C
AK Saxena, Sc C
Kewal Krishan, Sc C
Naib Singh, Sc B
JC Biswas, Sc B
AR Kaushik (Smt) TOB

HF & MW VOLTAGE, POWER FREQUENCY & ATTENUATION

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

MAGNETIC STANDARDS

PC Kothari, Sc EII
HM Bhatnagar, Sc C

TESTING & CALIBRATION SERVICES PROGRAMME

Mahesh Chandra, Sc EII
HS Dahiya, Sc EI
Sudarshan Kumar, Sc EI
NS Natarajan, Sc EI
CP Singh, TOC
SD Bahl, TOB
GK Kapoor, 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
Balbir Singh, Sc EI
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 C
ML Sharma, Sc C
RK Kotnala, Sc C
Kiran Jain (Smt), Sc C
Ram Kishore, Sc C
PK Singh, Sc C
S Singh (Smt), Sc B
NS Bangari, TOC
SM Khullar, TOC
HS Kalsi, TOC
RC Goel, TOC
Ravi Kumar, TOB
BS Khurana, TOB
SK Sharda, TOB
HP Gupta, TOB
Prem Prakash, TOB
KS Balakrishnan (Smt), TOB
MK Bajerjee, TOA
T Podikunju, TOA
TR Pushpangadan, TOA

LUMINESCENT MATERIALS

PK Ghosh, Sc F
HP Narang, Sc EII
V Shankar, Sc EI
Harish Chander, Sc EI

DISPLAY DEVICES

Subhas Chandra, Sc F
SC Jain, Sc EII
SS 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
KK Saini, Sc C
NS Verma, Sc C
VS Panwar, Sc C
BD Malhotra, Sc C
Ranjana Mehrotra (Ms), Sc C
RK Sharma, Sc C
SK Dhawan, Sc B
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 EI
A Basu, Sc EI
BS Verma, Sc EI

M Kar (Smt), Sc EI
PN Dixit, Sc EI
OS Panwar, Sc C
C Anandan, Sc C

HIGH PRESSURE TECHNOLOGY

MM Bindal, Sc EII
AK Aggarwal, Sc EII
BP Singh, Sc EI
SK Singhal, Sc EI
Rajeev Chopra, Sc C
RK Nayar, TOC
KD Sharda, TOA

METALS & ALLOYS

Anil K Gupta, Sc EII
RC Anandani, Sc EI
Ajay Dhar, Sc C
IA Malik, TOC
Rajiv Sikand, TOB
HB Singh, TOA
Jaswant Singh, TOA

MATERIALS CHARACTERIZATION

CHEMICALS & POROSITY

DC Parashar, Sc F
PK Gupta, Sc F
JN Bohra, Sc EII
VK Amar, Sc EI
JC Trehan, Sc EI'
R Ramchandran (Smt), Sc EI
AK Sarkar, Sc EI
AK Aggarwal, Sc EI
PK Gupta, Sc C
Mewa Singh, Sc C
RC Sharma, TOA

IR & EPR SPECTROSCOPY

MM Pradhan, Sc EII
SK Gupta, Sc EI
RK Garg, Sc C
S Parthasarathi, TOC
MK Dasgupta, TOA

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
Ranjan Kothari, Sc B

LOW TEMPERATURE PHYSICS

SUPER CONDUCTIVITY

AV Narlikar, Sc G
RG Sharma, Sc F
YS Reddy, Sc EI
BV Reddi, Sc EI
BV Kumaraswami, Sc EI
PK Dutta, Sc EI
UC Upreti, Sc C
Ratan Lal, Sc C
SK Aggarwal, Sc C
PL Upadhyay (Km), Sc B
SB Samanta, TOB
VS Yadav, TOA

CRYOGENIC SYSTEMS

AP Jain, Sc F
S.C. Gera, Sc EI
RS Khandekar, Sc EI
RB Saxena, 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

BM Reddy, Sc G
KK Mahajan, Sc F
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
SK Singhal, Sc C
VK Pandey, Sc C

CB Tandel, Sc C
Jayanta Kar, Sc C
VK Vohra, Sc C
P Subrahmanyam, Sc C
BC Arya, Sc C
NK Sethi, Sc C
SS Rajput, Sc C
P Chopra (Smt), Sc C
HK Maini, Sc C
VP Sachdeva, Sc C
MVSN Prasad, Sc C
John Thomas, Sc C
Risal Singh, Sc C
Meena Jain (Smt), Sc C
SK Shastri (Smt), TOB
ARS Vashisht, TOB
Abdul Hamid, TOB
Didar Singh, TOB
RS Tanwar, Sc A
Raksha Marwah (Smt), TOA
KL Gulati, TOA
DB Sharma, TOA
Vishram Singh, TOA

TECHNICAL INFRASTRUCTURE

PLANNING & COORDINATION

GK Arora, Sc F
RS Khanduja, Sc EII
G Govindaswamy, Sc EI
FC Khullar, Sc EI
PK Kohli, Sc EI
Satbir Singh, Sc EI
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
Sawanti Lal, TOA
Hasan Haider, TOA

COMPUTER

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

INSTRUMENTATION

VR Singh, Sc EII
IJ Banaudha, TOC
DS Sachdeva, TOB
YPS Negi, TOA

WORKSHOP

HNP Poddar, Sc EI
Ravi Khanna, TOB
MK Chibber, TOB
Kewal Krishan, TOB
Dharam Chand, TOB
Ram Swarup, TOA
JP Sharma, TOA

GLASS WORKSHOP

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

SERVICES

CSP Kumar, Sc EII
S Dwivedi, Sc C
JC Sharma, Sc C
OP Tagra, TOC
KV Krishnamurty, Asst. Exe. Engineer
RS Singh, TOC
SL Sharma, TOB
SS Kapur, Asstt. Engineer
KL Ahuja, TOA
JS Dhama, TOA
BS Negi, TOA
Damodar Prasad, TOA

STAFF ON DEPUTATION

AR Jain
Ranjit Singh
K. Vardan (Smt.)

SCIENTISTS, FELLOWS, RESEARCH ASSOCIATES & POOL OFFICERS

RN Chaudhury, Sc (DST)
S Govindarajan, Sc (DST)
SK Gupta, Sc (UGC)
V Soni, Sc (UGC)
TR Anantha Raman, Emer Sc
B Buti, Emer Sc
AP Bhatnagar, Fellow
VV Janki (Smt), Fellow
PK Singhal, Fellow
TAN Suthan, Fellow
Manju M Vergheese (Km), Fellow
Ravindra Agarwal, RA
Tinku Basu (Smt), RA
G Beig, RA
S Bhattacharya (Smt), RA
S Chauhan (Km), RA
Archana Garg (Km), RA
Chetana Kachroo (Smt), RA
S Khare (Smt), RA
J Mittal, RA
Rashmi Mitra (Km), RA
KC Nandi, RA
AK Padama (Km), RA
GK Padam (Km), RA
Rashmi Paul (Smt), RA
Renuka Rajput (Km), RA
Ramesh Chandra, RA
Biswanath Sarkar, RA
Kanchan Saxena (Km), RA
Sanjay Sengupta, RA
Hari Om Upadhyay, RA
Manoj Gupta, PO
Jaivir Kaudinya, PO
RM Krishna, PO
GS Reddy, PO

C Sharma, PO
NS Sunderason, PO

ADMINISTRATION, ACCOUNTS, STORES/PURCHASES

MM Sharma, Sr. COA
HR Mehta, SFAO (SG)
CS Chohan, COA
JM Sardana, SPO
OP Kakar, FAO
AK Ghosh, TOB
Anil Kumar, SO
BB Chopra, SPA
NK Bajaj, SO (F&A)
RK Bhasin, SPA
Dharam Raj, SO
SA Joseph (Smt), SPA
OP Meni, SO
Jitender Parasar, SO
Sardara Singh, SO
KG Sharma, SO (F&A)
RL Sharma, SO (F&A)
S Sharma (Smt), H. Offr.
RC Gupta, Dy. SPO
Brijesh Sharma, Dy. SPO
Jagdish Kumar, SPA
Prem Nath, SPA
DV Sharma, SPA
Sis Ram, SPA
Vijay Kumar, Sec. Offr.

RETIRED

HK Thadani, Sc EII, April
TR Marwah, TOA, May
SC Gupta, Sc EII, May
Jagdish Singh, Tech. VII, June
Kani Ram, TOB, June
OP Juneja, SFAO (SG), June
Mal Singh, Tech. VIII, June
Ram Din, Tech. VII, June
MNM Rao, Sc F, July
Harish Chand, TOB July
JP Sharma, Tech. VIII, Aug.
SK Kapur, Sc EI Sept.
PS Sharma, Tech. VIII, Oct.
VP Wasan, Sc EII, Oct.
JKN Sharma, Sc G, Oct.
SR Yadav, Tech. VII, Oct.
PS Bisht, Tech. VIII, Oct.
BN Srivastava, Sc EII, Oct.
SP Kansal, SPA Gr. VI, Oct.
CL Verma, Sc EI, Nov.
Mala Ram, W/Shop Asstt., Dec.
TR Arora, TOB, Jan.
KD Kundra, Sc F, Jan.
SL Dahake, Sc F, Feb.
SK Basu, Tech. VIII, Feb.
KN Bhatnagar, Sc EI, Feb.
MS Hegde, Sc EII, Feb.
MG Sehgal, TOB, Feb.
VU Uthuppan (Smt), Store & Purchase Asstt.
AS Bisht, Asstt., Feb.
Khazan Singh, SMA, March
Ghamandi Lal, Tech. VIII, March
SP Singhal, Sc F, March
RL Seth, Sc F, March
Majeed Khan, Tech. VIII, March

JS Rawat, LDC, Sec Asstt. II, March

OBITUARIES

Bishan Singh, Daftry, April 15

RS Saini, Tech..II, April 23

AP Gera, TOA, June 17

BD Vatsa, Tech. VIII, Jan 20

Ramesh Kumar, Canteen Bearer, Feb 1

STAFF STRENGTH
(as on 1.4.94)

Category	Grade	Number
SCIENTIFIC & TECHNICAL STAFF		
Scientific Staff	Group IV	288
Technical Staff	Group III	177
Engineering Cadre Staff	Group V	1
Supporting Technical Staff	Group II	384
Supporting Technical Staff	Group I	120
	Sub- Total	**970**
ADMINISTRATIVE & NON-TECHNICAL STAFF		
Administrative (Gazetted)	Group A	5
Administrative (Gazetted)	Group B	20
Administrative (Non-Gazetted)	Group C	147
Non-Technical	Group D	135
	Sub-Total	**307**
	Total	**1277**

VISITS ABROAD
(1.4.93 to 31.3.94)

Scientist	Country	Duration	Purpose
Prof. E.S.R.Gopal	Saudi Arabia	Jun 22-28	As a member of CSIR delegation.
	Germany	Sept 6-17	Under NPL-PTB (Phase-II) Programme.
	France	Sept 18-25	Attended CIPM meeting.
	Sri Lanka	Jan 17-24	Attended NAM-SMQC meeting at Colombo.
Dr. Krishan Lal	Belgium & USA	Jun 13-30	Under the on going INDO-US collaborative project "High Resolution X-ray diffraction imaging for advance materials characterization".
	China	Aug 21-23	Attended Congress and General Assembly of IUCr.
	Taiwan	Mar 10-12	Attended 6th CODATA/DSAO meeting.
Dr. D.C. Parashar	Netherlands	Dec 13-15	To attend International Symposium on Non Co_2 Green House Gases why and how to control.
	Thailand	Jan 31-Feb 1	To attend a workshop on Energy Environment Research in Asia.
	Philipines	Mar 14-18	Attended Intl. Symposium on Climate change and rice.
	Japan	Mar 19-29	GCTE-Rice Eco system and NIAES, Japan for technical discussions.
Dr. P.K. Gupta	Israel	Apr 18-22	Attended IGAC conference.
Dr. A.C. Gupta	USA	May 2-Aug2	To study and characterize different type of leaks used in vaccum metrology under INDO-USA collaborative project.
Sh. H.N. Poddar	Germany	Nov 20-Dec 19	Under NPL-PTB (Phase-II) Techl. Cooptn. Programme.
Dr. Ram Kishore	USA	Jan 7-Mar 7	To acquire knowledge on recent development in Si and Si solar cells at National Renewable energy.
Dr. V.T. Chitnis	Japan	May 17-23	Attended 7th International Seminar on precision engg. at Kobe and avail post

			of visiting Prof at AICHI Instt. of Technical.
Sh. M.K. Mittal	Germany	May 24-Jul 22	Under NPL-PTB (Phase-II) Techl. Cooptn. Programme.
Dr. R.B. Mathur	France	May 20-Jul 3	To work on Research Project on Halogens compounds under IFCPAR and to attend Biennial conference.
Dr. R.R. Chakraborty & Dr. D.R. Sharma	France	Jun 14-26	To take operation training on recording Ion Mass spectrum model No. M/Q 256.
Dr. S.P. Singhal & Dr. B.S. Gera	Moscow	May 23-Jul 3	Under ILTP programme in Science & Technology.
Dr. S.C. Jain	Germany	Jul 4-Jan 3	Under INSA-DFG Exchange Programme.
Dr. V.G. Kulkarni & Sh. B.K. Roy	Russia	Jul 15-Jan 14	Under ILTP Programme in the area of laser S & T Project on Laser Spectroscopy and Photometry.
Dr. P.K. Dutta	Japan	Aug 15-Feb 14	To do research in Gakushwin University under INSA-JSPS Exchange Programme.
Dr. V.N. Ojha	Japan	Aug 25-Sept 2	Attended URSI General Assembly.
Dr. K.K. Mahajan	USA	Aug 9-Sept 20	To accept short term assignment in Maryland.
Dr. B.M. Reddy	Japan	Aug 25-Sept 1	Attended URSI General Assembly.
Dr. Neeraj Khare	USA	Sept 6-Jul 5	Under Indo-US S&T Fellowship Programme.
Sh. G.K. Arora	Germany	Sept 6-18	NPL-PTB (Phase-II) Techl. Cooptn. Programme.
Dr. P.K. Singh	Germany	Sept 20-Nov19	Under CSIR-DAAD Exchange Programme

Dr. R.V. Ananthamurthy	Russia	Sept 29-Nov 28	Under INDO-RUSSIA Long Term Programme.
Dr. B.S. Mathur	Germany	Sept 30-Oct 1	Attended "Development Council" meeting at Berlin.
	USA	Oct 3-15	To visit NIST Boulder for Scientific discussions.
Dr. Chhote Lal	France	Oct 1-Dec 31	Under CSIR-CNRS Exchange Programme.
Dr. V.R. Singh	Malaysia	Nov 8-11	Attended and deliver a talk at 2nd ANAIC Conference at Kalalampur.
Mr. M.K.Das Gupta	Germany	Dec 8-21	Under NPL-PTB (Phase-II) Programme for inspection of 6MN Force Machine.
Dr. O.P. Bahl	France	Feb 26-Apr 15	To work on Bromination and Florination of carbon fibre from Vapour Phase and their characterisation under IFCPAR Project entitled "Studies on the Halogen/Halogen compounds.
Dr. J.N. Som	Germany	Feb 20-April 30	Under Project of fluid flow measurement under NPL-PTB (Phase-II) techl. Cooptn. Programme.

ACTUAL EXPENDITURE
(1993-94)

Budget Head	Rs. (Lakhs)
Salaries	787.039
Contingencies	137.163
Maintenance	16.096
Chemicals	76.791
Works etc.	33.176
Equipment	87.210
Other	46.961
Total	1184.436
Sponsored Projects	210.657

SPECIAL LECTURES

DATE	SPEAKER	TOPIC
06/04/93	Dr. A.K. Susheela, Indian Institute of Medical Sciences, New Delhi.	Flouride pollution in drinking water & health hazards : Prevention & control programme in India.
07/04/93	Prof. Pham V. Huang, University of Brodeaux, France.	Structural Studies of high temperature superconductors through Micro Raman measurement.
08/04/93	Prof. R. Mews, Institute of Inorganic & Physical Chemistry, University of Bremen, Germany.	Sulpur, nitrogen & fluorine compounds & their applications.
28/04/93	Prof. S.M. Bhagat, University of Maryland.	High temperature superconducting cuprates-dc magnetization.
05/05/93	Dr. Antonia Rotger, France (LEPESCNRS, Grenoble).	Review of heat pipe technology in CIS countries.
17/05/93	Sh. A.K. Sheth, Systron Donner, USA.	Magnetotransport in Quasi 2-D charge density wave compounds.
08/06/93	Prof. R.P. Sharma, Argonne National Laboratory, USA.	Studies of high temperature super-conductors.
15/06/93	Dr. Atit Bhargava, University of Queenland, Australia.	HTSC Products developed at the University of Queenland.
29/06/93	Prof. P.S. Ramanujam, Optics & Fluid Dynamics Deptt. Riso National Laboratory, Denmark.	Side chain liquid crystalline polyesters for optical storage.
12/08/93	Prof. A.K. Dutta, Calcutta University	Optical neural network.
14/09/93	Dr. Ivan Tomas, CSC of Institute of Physics Academy of Science of the Czech Republic.	The magnetic coercivity and hysteresis and their links to magnetic domain structure.
15/10/93	Dr. J.H. Futrell, Chemistry Deptt., University of Delware, USA.	Energy transfer in ion molecule collisions.

11/11/93	Prof. R.D. Verma, Deptt. of Physics, New Brunswick.	Spectroscopic research in optical region.
25/11/93	Dr. Sailesh. M.Merchant, AT & T Bell Laboratory, USA.	Metallization directions in semiconductor integrated circuit manufacturing.
01/12/93	Prof. P.L. Leath, U.K.	Superconducting breakdown in disordered arrays of josephson junctions.
03/12/93	Dr. D.K. Gautam, Sony Corporation, Japan.	Semiconductor optical switches & its applications.
20/12/93	Prof. (Ms) Ceremuga, James Cook University, Australia.	Superconducting microwave planer Circuits :- Achievements & problems.
23/12/93	Prof. T. Venkatesan, Centre for Superconducting Research Uniersity of Maryland, USA	Normal device approaches in high temperature superconductors.
07/01/94	Dr. R. Ramesh, Belcore, USA.	Ferroelectric thin films metal oxide hetero structures.
10/01/94	Prof. C. Boulesteix, Marseille, France.	Preparation by substrate coating characterization and conductivity modelisation of thick superconductive wires and layers.
11/01/94	Prof. T. Venkatesan, University of Maryland, USA	Physics & applications of high-Tc hetero structures.
14/01/94	Dr. James E. Butler, NPL, Washington, D.C. USA.	Diamond Thin film research Insitu and exsitu characterisation.
17/01/94	Prof. R. Van, President IMEC Belgium.	Evolution of photovoltaics.
20/01/94	Sh. Chunghi rhee, Korea Research Institute.	National standard system in Korea.
21/01/94	Prof. Gautam Vemuri, university of Purdue, USA.	Detecting light with light..
25/01/94	Dr. P. W. Munga, Director KBS Laboratory, Kenya.	Standardisation in Kenya.
25/01/94	Dr. Ashok Kumar, Scientist, NPL, New Delhi.	ISO-9000- Its speical relevance to ultrasonics.

28/01/94	Prof. G.F. Kuznetsov, MOSCOW, IREE RAS.	Some problems on quantitative X-ray diffractometric analysis of multilayer heteroepitaxial complex superlattice structures.
31/01/94	Prof. R.W. Cahn, University of Cambridge, U.K.	The charm of disorder.
02/02/94	Prof. Daniel F.V. James University of Rochester, NY USA.	Correlation induced spectral changes and their applications.
02/02/94	Dr. J. Sievert, PTB, Germany.	Magnetic measurements at PTB.
03/02/94	Dr. Hwhans Schmid, University of Geneva.	Magnetiç ferroelectrics.
14/02/94	Dr. Heng Li-di, Tsinghua University, President Materials Research Society, P.R., China.	Diamond like carbon (DLC) Research-Recent Trends.
22/02/94	Prof. C.R. Hill, Royal Marsden Hospital, UK.	Development in Focussed Ultrasonics Surgery & related metrology.
24/02/94	Prof. R. Suryanarayanan, CNRS Laboratory at Meudon, France.	Effect of Chemical modifications on Superconducting properties of Y(1-2-3) Cuprates.
25/02/94	Prof. G.C. Weatherly, University of Hamilton Ontario, Canada.	Interfaces in Metallic Systems.
30/03/94	Dr. P. Chaddah, Centre for Advance Technology, Indore.	Granularity Effects in Ceramic High-Tc Superconductors.

Ph. Ds. AWARDED

S.No.	Name	Title	University	Guides
1.	Ved Singh	Role of additives on the dielectric and Piezoelectric behaviour of lead zirconate Titanate ceramics	Meerut	Dr. R.P. Tandon NPL Dr. M.C. Bansal Meerut University
2.	S.K. Chauhan	An Investigation on computer modelling and Instrumentation for characterisation of Biological Tissues	Meerut	Dr. V.R. Singh NPL Dr. A.S. Yadav Meerut University
3.	Jasvir Singh	Computer modelling and Acousto-Electronic properties of gall-Bladder system	Amritsar	Dr. V.R. Singh NPL Dr. S.S. Bhatti Amritsar
4.	Ramesh Chandra	Deposition, characterization and Josephson effect studies in high -Tc super-conducting thin films	I.I.T. Delhi	Dr. Ashok Kumar Gupta NPL Prof. B.B. Tripathi I.I.T., Delhi
5.	Sunil Kumar Arora	Studies on SQUIDs of Y-Ba-Cu-O High-Tc Superconductor.	I.I.T., Delhi	Dr. Ashok Kumar Gupta NPL Prof. H.C. Gupta I.I.T., Delhi

6.	Devinder Kaur Walia	Preparation and Characterization of high-Tc superconducting films and study of grain boundary Josephson effects.	Delhi	Dr. Ashok Kumar Gupta NPL Prof. S.C. Pancholi Delhi University
7.	Sanjay Yadav	Research Contributions to the development and analysis of ultrasonic instrumentation in forensic, medicine, engineering and allied sciences	Meerut	Dr. V.R. Singh NPL Dr. A.S. Yadav Meerut University
8.	Mansha Ram	Development & Studies of new thermocouple combinations to establish temperature standard.	Jamia Millia Islamia	Prof. Z.H. Zaidi J.M.I. Sh. V.P. Wasan NPL
9.	B. Sarkar	Synthesis technique and Ac susceptibility studies on BPSSCO super-conductor.	Delhi	Dr. R.G. Sharma NPL Dr. G.K. Chaddha Delhi University
10.	S.R. Shukla	Critical current studies in Bulk and metal-CLAD high T_c superconductors.	I.I.T. Delhi	Dr. R.G., Sharma NPL Prof. D.K. Pandya I.I.T. Delhi

HONOURS AWARDS

Prof. E.S.R. Gopal was selected by Indian National Science Acadamy (INSA) for its 1993 Academy Award and he will receive the Homi Jahangir Medal for his contributions to fluid mixture system and glassy semi-conducting alloys.

He was elected as the president of the Instrument society of India from July, 1993.

He was also elected as a member of the council of BIPM, Paris in May, 1993.

Dr Ajay Dhar was awarded URSI Young Scientist Award at Japan in Aug., 1993.

Dr. A.V. Narlikar was awarded Doctorate of Science (Sc D) degree by Cambridge University, UK for contribution in the area of superconductivity.

He was elected on the Editorial Board of the British Journal "Super conductor science and Technology".

Dr. R.S. Yadav & Dr. M.K. Raina were elected, Life Member of Instrument Society of India. Bangalore.

Dr. B.C. Chakravarty was elected Sr member of IEEE Inc. (N.Y.) USA.

Dr. S.K. Sharma was invited by the organisers of the International Congress on Electron Microscopy to become a member of the International Scientific Advisory Committee.

Dr. S.P. Singhal was elected as President, Acoustical Society of India.

Dr. V. Mohanan was elected chairman, Acoustical Society of India, Delhi Chapter.

Dr. D. Gupta was made member of council for optical Radiation measurements in optical radiometry

He represented the country as official invitee to participate at CORM-93, "An International Conference on optical Radiation Measurements.

Dr. D.R. Lakshmi was invited to be fellow of the institution of Electronics and Telecommunications Engineers.

Dr. Tuhi Ram Tyagi was elected member of URSI commission G (WG:G2) for the period 1993-96.

Dr. K.K. Mahajan was offered the membership of the reconstituted ISRO Advisory Committee on Space Research (ADCOS).

He was invited to be member of Working Group of International Reference Ionosphere (IRI).

He was invited to be a member of the International Scientific programme Committee for the Annual IRI Workship to be held at NPL, in January 9-13, 1995.

Dr. H.N. Dutta was elected as the Fellow of the Academy of Environmental Biology.

He was. elected as the fellow of the Institution of Electronics and Telecommunication Engineers.

Dr. V.R. Singh was invited by the Katholieke University, Leuven, Belgium in the capacity of a member of International Jury for Doctoral Research in Lithoripsy.

He was nominated as a member of MHD-11, MHD-12, CHD-11, MHD-19 committees of BiS on Electro-Medical Equipment.

He was elected as the convener of BIS panel MHD-19-Pl on Electro-Medical Standards.

KRISHNAN MEMORIAL LECTURE

XXIV Krishnan Memorial Lecture was delivered by Prof. Norman F. Ramsay, NL, Higgins Professor at Lyman Physics Laboratory, Harvard University, Cambridge, USA, on 22nd March 1994. The title of the lecture was "Time and the Physical Universe".

A memento sandalwood saraswati was presented to the speaker by Prof. E.S.R. Gopal, Director, N.P.L.

A summary of the Prof. Ramsey's talk on "Time and the Physical Universe" is given below:-

Human's perception of time developed from their observations of periodicities in the universe to which they were expressed, such as changes from day to night and from summer to winter. Measurements of time depend on the observation of periodicities such as the oscillations of a pendulum or the vibrations of an electrically excited quartz crystal. The greatest accuracy and stability are achieved by atomic clocks which depend on internal interactions within an atom-usually cesium or hydrogen. Stabilities better than 10^{-15} or one part in a thousand, million, million can now be achieved and new developments may increase the stability of atomic clocks even more. Highly stable clocks are needed for many fundamental measurements in astronomy, physics, navigation and communication. Such clocks provide important tests for the validity of both the special and general theories of relativity. Inversely, these theories affect the measurements and even the meaning of time, especially for extreme conditions of the universe, such as neutron stars, near black holes and at the earliest stages of the universe.

RESEARCH COUNCIL

Prof. B. V. Sreekantan, Chairman
National Institute of Advance Studies.
C/O Indian Institute of Science.
Bangalore-560012

Prof. D. Chakraborty Member
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Lt. Gen A.S. Bhullar (Retd.), Member
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Gas Turbine Research
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New Delhi-110 003.

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Research Instt.,
Pilani-333 031.

Prof. E.S.R. Gopal, Member
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National Physical Laboratory,
New Delhi-110 012

Prof. C.K. Majumdar, Member
S.N. Bose National Centre for
Basic Sciences,
DB-17, Sector 1,
Salt Lake,
Calcutta-700 060.
DG's Nominee

Sri G.K. Arora, Non-Member Secty
Scientist "F" NPL

MANAGEMENT COUNCIL

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New Delhi

Dr. Ravi Mehrotra Member
Scientist, NPL,
New Delhi

Sri O.P. Kakkar, Member
FAO, NPL,

New Delhi
Sri M.M. Sharma Member Secty.
Sr. COA, NPL,
New Delhi.

TRAINING

1. Training was provided to Mr. Siddhartha Jeevan, Department of Ceramic Engineering, Varanasi on fabrication and testing of piezoelectric lead zirconate titanate ceramics.
2. Two IRDE scientists on large area DLC coatings process were trained for 3 weeks.
3. Training was provided to Mr. Yogesh Kumar Verma of Guru Nanak Dev University, Amritsar on solar cell fabrication and their characterization.
4. Miss Ulrike Thesing from Technical University, Berlin worked in Acoustics Section for two months as a research trainee undergoing practical training in various acoustical measurements/ investigations.
5. The training in the calibration of dimensional measuring instruments and length standards were imparted to the participants of Indian industries and legal metrology department of several countries.
6. Mr. B.V.N. Raju, M.Sc. Tech student from J.N.T.U. college of Engineering, Anantpur (A.P) was trained for two months in the use of Faraday rotation technique to study the total electron content of the Ionosphere.
7. Dr. H.N.Dutta guided M. Tech Dissertation alongwith Prof. Jagdish Rai on design and development of a transmitter system for sodar by Deepak Johri, Roorkee University.
8. Three Engineering students from various colleges were imparted training in electronics instrumentation as a part of their academic programme.
9. Training was provided to Dr. Bhatt, Scientist from CSMRI, Bhavnagar on "Methane campaign studies"
10. Training was provided to various participants those who took part in the workshop-cum-training course on methane emission studies for five days.
11. M.Sc. students from various Universities were given training on the working of FTIR and its applications in the field of materials characterisation by spectroscopy techniques, Under CSIR-UGC Collaboration programme.
12. Two SC/ST students of Secondary level attended the one weak training programme.
13. 5 students of M.Sc. (Prev.) Physics attended the familiarization programme.
14. 19 students from different Engg. Institutes carried out their project work towards the fulfilment of their course.

SYMPOSIA/WORKSHOP/SEMINAR

1. The first National Seminar on "Heat pipe for Rural and Industrial applications" was organised by NPL on Sep 6-7, 1993. The Seminar was inaugurated by Prof. S.K. Joshi, D.G., SIR and Secretary, DSIR.
2. Two International workshops were organized under the guidance of Dr. A.P. Mitra, F.R.S. Bhatnager Fellow
   (i) Asian Workshop cum Training Course on Methane emission studies, September 20-24, 1993 at NPL.
   (ii) FASAS Seminar on Global environment chemistry, Sept. 27 to Oct. 1, 1993 at NPL.
3. CSIR Foundation Day celebration function was held on 26.9.93.
4. Saha Centenary International Symposium on Spectroscopy and Astrophysics, was held at Physics Department, Allahabad University, Allahabad during Oct. 4-6, 1993.

5. ZOPP workshop was conducted at NPL from Oct. 4-7, 1993.

6. The Seventeenth National symposium on vacuum science and Technology (IVSNS-93) was held at NPL during 6-8th Oct. 1993, The Symposium was organised Jointly by NPL and the Indian vacuum society of which Dr. J.K.N. Sharma is president. The symposium was inaugurated by Prof. Yas Pal.

7. A one day workshop on Awareness of SIMS (Secondary Ion Mass Spectroscopy) was organised at NPL on 9th of October 1993.

8. "Industry-User-Researcher Seminar on Distrometer" was held on 13th October 1993 at NPL, New Delhi. The seminar was inaugurated by Hon'ble Minister of state for science & Technology, Shri P.R. Kumar-amangalam in the presence of 700 invited dignitaries from Industries, user organisations and academic Institutions.

9. Seventh International Workshop on Physics of Semiconductor Devices (IWPSD-93) held at National Physical Laboratory, New Delhi, during Dec. 14-18, 1993. Under the chairman ship of Dr. Krishan Lal.

ABBREVIATIONS

AIIMS	:	All India Institute of Medical Sciences.
ARDB	:	Aeronautical Research Development Board
ASCA	:	Asian Crystallographic Association
BARC	:	Bbabha Atomic Research Centre.
BHEL	:	Bharat Heavy Electricals Ltd.
BIS	:	Bureau of Indian Standards.
BITS	:	Birla Institute of Science & Technology.
CCIR	:	International Radio Consultative Committee.
CEERI	:	Central Electronics Engineering Research Institute.
CEL	:	Central Electronics Ltd.
CFC	:	Chloro Fluoro Carbon.
CSIRO	:	Commonwealth Scientific and Industrial Research Organisation.
CSIR	:	Council of Scientific and Industrial Research.
CSIO	:	Central Scientific Instruments Organisation
DAAD	:	German Academic Exchange Service.
DMRL	:	Defence Metallurgical Research Laboratory.
DNES	:	Department of Non-Conventional Energy Sources.
DOD	:	Department of Ocean Development.
DOE	:	Department of Electronics.
DRDO	:	Defence Research and Development Organisation.
DST	:	Department of Science & Technology.
DXS	:	Diffuse X-ray Scattering.
EPR	:	Electron Paramagnetic Resonance.
FTIR	:	Fourier Transform Infrared.
IARI	:	Indian Agricultural Research Institute.
IIT	:	Indian Institute of Technology.
IISC	:	Indian Institute of Science.
IMD	:	Indian Meteorological Department.
INMARSAT	:	International Maritime Satellite.
INSA	:	Indian National Science Academy.
IPCL	:	Indian Petrochemicals Corporation Ltd.
IRDE	:	Instrument Research Development Establishment.
ISRO	:	Indian Space Research Organisation.
JNU	:	Jawaharlal Nehru University.
KDMIPE	:	K D Malviya Institute of Petroleum Exploration.
MCF	:	Master Control Facilities.
MST	:	Mesospheric Stratospheric & Tropospheric.
LOS	:	Line Of Site.
NBRI	:	National Botanical Research Institute.
NEERI	:	National Environmental Engineering Research Institute.
NCTCF	:	National Coordination of Testing and Calibration Facilities.
NGRI	:	National Geophysical Research Institute
NIAES	:	National Institute of Agro-Environmental Studies.
NIST	:	National Institute of Standards & Technology.
ONGC	:	Oil and Natural Gas Commission.
PTB	:	Physikalisch Technische Bundesanstalt Braunschweig.
SEM	:	Scanning Electron Microscope.
SHAR	:	Shriharikota Rocket Launching Station.
STFS	:	Standard Time & Frequency Signal.
UCMS	:	University College of Medical Sciences.