वार्षिक प्रतिवेदन
ANNUAL REPORT
1996 - 97

राष्ट्रीय भौतिक प्रयोगशाला
National Physical Laboratory
New Delhi

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Director's Report

It gives me a great pleasure to present the Annual Report for the year 1996-97, which describes briefly the achievements and contributions of the National Physical Laboratory. The R & D work was carried out in various national programmes, thrust areas and sponsored projects.

In the area of Standards, the developments were continued for further improvements in the accuracy of measurements and their maintenance. At- site calibration facilities have been designed and generated to meet the customers demand by Dimensional Metrology Section of NPL. The UNDP assisted project "Establishment of Surface Analytical facilities at NPL" was successfully completed. A new Radar Equation for Acoustic sounding has been developed. A challenging problem of detection and location of small defects in the coaxial carbon fibre composite materials was undertaken. An improved transducer probe for ultrasonic non-destructive testing of concrete and like material was designed, fabricated and evaluated.

The STFS broadcast has been operational throughout the year. NPL has developed a low cost STFS decoder in collaboration with ERDC, Thiruvananthapuram and STFS receiving facility has been installed at a number of stations in India. A laboratory model of precision variable wave guide blow cut off (WBCO) Attenuator has been designed and fabricated.

Research and development work in the field of materials development was continued which included the work on silicon devices, interface microstructure devices, luminescent materials, display devices, liquid crystals, conducting polymers, carbon products, thin film systems and metals and alloys. Some new facilities have been added. A special response measuring set up for 10x10cm solar cells has been established.

An automatic self locking NMR Gaussmeter was fabricated under DST funded project. "2 D. Diffuse"- a programme for two dimensional simulation of dopant impurities, diffusion in silicon for microelectronics devices has been developed. Thick a-Si:H p-i-n layers were developed to suit the requirements of x-ray detector development work. In the field of Display Devices an additional liquid crystal display processing and characterizing facility has been set up to study liquid crystals for imaging and holography application. The facilities include processing, textural studies and electro-optical studies etc. of liquid crystals.

The work on characterization of different kinds of materials was continued. Characterization of materials plays an important role in evaluating their usefulness in scientific and technological applications. A powder x-ray diffractometer has been designed, developed and fabricated under a project sponsored by Department of Science and Technology, New Delhi. NPL has supported industry in low cost Cd-Te Solar cell manufacture. High density high strength isotropic graphite is a recent addition to the existing family of carbon products. NPL has also been working on sponsored contract R&D project on the development of green coke based high density graphite. Two new certified reference materials of multi-elements in water have been prepared at NPL.

Radio & Atmospheric Science is also another major field in which the laboratory continued the work with some reoriented priorities. A major project activity during the

year has been in the ALGAS Project. The ALGAS-India National work plan is being carried out by the NPL in association with Dr. A.P. Mitra, FRS. NPL is operating the regional warning centre (RWC, New Delhi) as a part of an international network and is responsible for rapid exchange of solar and geophysical data within India and also with other centres located around the globe. An important development has been the availability of latest data from satellites at RWC, New Delhi.

NPL workshop is now equipped with a high precision CNC milling machine. This facility is further backed up by computerized 3D modeling. NPL has developed an ion beam micromilling equipment that is an important facility for preparation of specimens for microstructure analysis by transmission electron microscopy (TEM). A 10 MHz ophthalmic probe to be used for ophthalmic examinations has been developed and tested in the laboratory.

NPL has continued active collaboration with various research organisations and educational institutions, industries, public sectors and other Governmental organisations in India and foreign countries. Several projects were undertaken during the year under sponsorship from DST, NRDC, DRDO, Indo-French, PTB Germany, NIST, USA, Australia, General Electric (USA), DOE, DBT, Indo-US, Indo-German and Indo-Israel etc.

In the academic field, seven candidates were awarded Ph.D. for their work done in NPL,. About 3 dozens candidates from different organisations were given training in different fields of science. NPL scientists published about two hundred papers in leading national and international journals.

We were favoured by the visit of Prof. P.G.De Geness, N.L., Director at College de France, Paris who delivered the Krishnan Memorial Lecture on "From Rice to Snow" in February 1997.

A number of scientists have been awarded and honoured. Dr. Krishan Lal delivered Daulat Singh Kothari Memorial Lecture. Dr. A.V. Narlikar received the Homi Jehangir Bhabha Medal (1996) of the Indian National Science Academy. Mr. R.M. Khanna was awarded 1994 J. Das Gupta award. 1997 MRSI honour lecture medal was awarded to Dr. A.C. Rastogi. Dr. V.R. Singh has been elected as a Fellow of IEEE (USA). I congratulate them for their outstanding contributions.

This year as a whole was successful with major achievements in the field of science and technology, clearance of back log of assessment promotions of scientists and technical staff and their redeployment for better utilisation. The financial position is also showing a continuous improvement.

We hope for a bright future by reinforcing our strength and by moving in the right direction.

E Raj Gopal

(E.S. Raj Gopal)

निदेशकीय प्रतिवेदन

1996-1997 का वार्षिक प्रतिवेदन प्रस्तुत करते हुए मैं अपार हर्ष का अनुभव कर रहा हूँ जिसमें राष्ट्रीय भौतिक प्रयोगशाला की उपलब्धियों और योगदान का संक्षिप्त विवरण प्रस्तुत है। अनेक राष्ट्रीय कार्यक्रमों, मुरव्य क्षेत्रों और प्रायोजित परियोजनाओं में अनुसंधान एंव विकास कार्य किया गया।

मानकां के क्षेत्र में मापों की यथार्थता में सुधारों तथा ररव–ररवाव में विकास कार्य जारी रहा। प्रयोगशाला के विमीय मापिकी अनुभाग द्वारा ग्राहको की माँग पर स्थान पर जाकर उपलब्ध कराने की सुविधाओं का डिजाइन और उनकी स्थापना की गई। यू एन डी पी द्वारा सहायता प्राप्त परियोजना "एस्टेब्लिशमेंट ऑफ सफैस एनालिटीकल फेसिलिटीज एट एन पी एल" का सफलतापूर्वक समापन किया गया। ध्वानिक ध्वनि के लिए एक नई रेडार समीकरण का विकास किया है। समाक्ष कार्बन रेशों वाले संयुक्त पदार्थो में छोटे– छोटे दोषों का पता लगाने और उनकी स्थिति ज्ञात करने की चुनौतीपूर्ण समस्या को सुलझाने का कार्य किया गया। कंक्रीट और उसके समान अन्य पदार्थो के पराश्रव्य अनाशक संपरीक्षण के लिए एक परिष्कृत ट्रांस्ड्यूसर प्रोब का डिजाइन निर्माण तथा मूल्यांकन किया गया।

पूरे वर्ष एस टी एफ एस प्रसारण का कार्य जारी रहा। ई आर डी सी तिरुअनंतपुरम के सहयोग से प्रयोगशाला ने एक कम मूल्य वाले एस टी एफ एस डिकोडर का विकास किया तथा भारत में अनेक केन्द्रों पर एस टी एफ एस संकेतों को ग्रहण करने की सुविधाएं स्थापित की गई। एक परिशुद्ध परिवर्तनशील "वेवगाइड ब्लो कर ऑफ WBCO" अटैनुएटर के प्रयोगशाला मॉडल का डिजाइन तथा निर्माण किया गया।

पदार्थो के विकास के क्षेत्र में अनुसंधान एवं विकास का कार्य जारी ररवा गया। इन पदार्थो में सिलिकन साधन, इंटरफेस माइक्रोस्ट्रक्चर डिवाइस, संदीप्तिशील पदार्थ, प्रदर्श पदार्थ, द्रव क्रिस्टल, चालक पौलिमर, कार्बन उत्पाद, पतली फिल्मों वाले सिस्टम, धातु तथा मिश्र धातुएं सम्मिलित हैं। कुछ नई सुविधाएं भी इनमें जोड़ी गई हैं।

10x10 cm वाले सौर सैलो की रेस्पांस मापक व्यवस्था की स्थापना की गई। डी एस टी द्वारा निधि प्रदत्त परियोजना के अन्तर्गत एक स्वचालित सैल्फ लॉकिंग एन एम आर गौस मापी का निर्माण किया गया। डोपन अपद्रव्यों, सिलिकन माइक्रोस्ट्रक्चर डिवाइसों में विसरण के द्विविमीय सिमुलेशन के लिए 2 डी डिक्यूज नाम प्रोग्राम का विकास किया गया। एक्सरे डिटेक्टर के विकास कार्य के लिए आवश्यक मोटी a-Si:H p-i-n परतों का विकास किया गया। प्रतिबिम्बन तथा होलोग्राफी में इस्तेमाल के लिए प्रदर्श साधनों के क्षेत्र में एक अतिरिक्त द्रव क्रिस्टल प्रदर्श प्रोसेसिंग तथा अभिलक्षणन सुविधा की स्थापना की गई जिससे द्रव क्रिस्टलों का अध्ययन किया जा सके। इन सुविधाओं में द्रव क्रिस्टलों की प्रोसेसिंग, टेक्सचर का अध्ययन तथा प्रकाश विद्युतीय अध्ययन सम्मिलित हैं।

विभिन्न प्रकार के पदार्थो के अभिलक्षणन का कार्य जारी रहा। वैज्ञानिक और प्रौद्योगिक अनुप्रयोगो में पदार्थो की उपयोगिता ज्ञात करने में अभिलक्षणन महत्वपूर्ण भूमिका निभाता है। विज्ञान और प्रौद्योगिकी विभाग द्वारा प्रायोजित एक परियोजना के अन्तर्गत एक पाउडर एक्सरे डिफ्रैक्टोमीटर का डिजाइन, विकास और निर्माण किया गया। कम मूल्य वाले Cd-Te सौर–सैलों के निर्माण में एन पी एल ने उद्योग की सहायता की। कार्बन उत्पादों के परिवार में उच्च धनत्व वाले समदैशिक ग्रेफाइट ने भी प्रवेश पा लिया है। एन पी एल हरे कोक पर आधारित उच्च धनत्व वाले ग्रेफाइट एक प्रायोजित संसविदा अनुसंधान एवं विकास पर भी कार्य कर रही है।

रेडियो तथा पर्यावरण विज्ञान एक और महत्वपूर्ण क्षेत्र है जिसमें प्रयोगशाला कार्य कर रही है। परियोजना की इस वर्ष की एक प्रमुरव गतिविधि एक नए महत्वपूर्ण ढंग से जारी रही। ALGAS भारत राष्ट्रीय कार्य योजना राष्ट्रीय भौतिक प्रयोगशाला द्वारा डा. ए. पी. मित्रा, एफ आर एस के सहयोग से कार्यान्वित की जा रही है। अन्तर्राष्ट्रीय नेटवर्क के एक हिस्से के रुप में एन पी एल एक क्षेत्रीय चेतावनी केन्द्र (RWC नई दिल्ली) को चला रही है तथा भारत के अन्दर तथा भूमण्डल पर स्थित अनेक दूसरे केन्द्रों को सौर तथा भूभौतिक आंकड़े द्रुत गति से उपलब्ध कराने के लिए एन पी एल उत्तरदायी है। RWC, नई दिल्ली में उपग्रहों से आँकड़े उपलब्ध होना एक प्रमुरव घटना है।

एन पी एल कार्यशाला में अब एक उच्च परिशुद्धता वाली CNC मिलिंग मशीन स्थापित हो चुकी है। इस सुविधा को एक कम्प्यूटर चालित मॉडलिंग से भी जोड़ा गया है। एन पी एल ने एक आयन बीम माइक्रोमिलिंग उपकरण का विकास भी किया है जो ट्रांसमिशन इलैक्ट्रान माइक्रोस्कोप द्वारा माइक्रोस्ट्रक्चर के विश्लेषण के

लिए एक महत्वपूर्ण सुविधा है। नेत्र परीक्षा के लिए एक 10 MHZ की आफ्थैल्मिक प्रोब के विकास और प्रयोगशाला परीक्षण का भी कार्य कर लिया गया है।

राष्ट्रीय भौतिक प्रयोगशाला ने अनेक अनुसंधान संगठनों, शैक्षिक संस्थाओं, उद्योगों, सार्वजनिक तथा अन्य सरकारी संगठनों से सक्रिय सहयोग जारी ररवा। डी एस टी, एन आर डी. आर. ई. ओ, इन्डो फ्रेंच, पी टी बी जर्मनी, एन आई एस टी, यू एस ए आस्ट्रेलिया, जनरल इलैक्ट्रिक (यू एस ए), डी ओ ई, डी बी टी, इण्डो–यू एस, इन्डो जर्मन तथा इन्डो–इजराइल आदि द्वारा प्रायोजित अनेक परियोजनाएं वर्ष के दौरान हाथ में ली गई।

शैक्षिक क्षेत्र में सात अभ्यर्थियों को एन पी एल में किए गए कार्य के लिए पी एच डी की उपाधि प्रदान की गई। विभिन्न संगठनों के लगभग तीन दर्जन अभ्यर्थियों को विज्ञान को विभिन्न क्षेत्रो में प्रशिक्षण दिया गया। एन पी एल के वैज्ञानिकों ने लब्ध प्रतिष्ठ राष्ट्रीय तथा अंतर्राष्ट्रीय जर्नलों में लगभग दो सौ पत्र प्रकाशित किए।

फरवरी, 1997 में नोबल पुरस्कार विजेता प्रोफेसर, पी जी डी जीनेस डायरेक्टर, कॉलेज डी. फ्रांस, पेरिस ने "फ्राम राइस टू स्नो" नामक कृष्णन स्मारक व्यारव्यान दिया।

प्रयोगशाला के अनेक वैज्ञानिकों ने पुरस्कार तथा सम्मान प्राप्त किए। डा. कृष्ण लाल ने दौलत सिंह कोठारी व्यारव्यान दिया। डा. ए. वी. नारलीकर को इंडियन नेशनल साइंस एकेडेमी द्वारा होमी जहांगीर भाभा (1996)

पुरस्कार द्वारा सम्मानित किया गया। श्री आर एम रवन्ना को 1994 का जे दास गुप्ता पुरस्कार दिया गया, डा. ए सी रस्तोगी को 1997 का एम आर एस आई व्यारव्यान पुरस्कार दिया गया। डा.वी आर सिंह को आइ ई ई ई (यू एस ए) का फैलो चुना गया। मैं इन सभी को इनके महत्वपूर्ण सहयोग के लिए बधाई देता हूँ।

कुल मिला कर वर्ष सफल रहा जिसमें हमने विज्ञान तथा प्रौद्योगिकी के क्षेत्र में प्रमुरव उपलब्धियां प्राप्त की वैज्ञानिकों और तकनीकी कर्मचारियों की मूल्यांकन पदोन्नति में पहले से चले आ रहे कार्य को सम्पन्न किया तथा उनकी सेवाओं को अधिक उपयोगी बनाने के लिए स्थानांतरण किया। आर्थिक स्थिति में भी लगातार सुघार हुआ।

हम अपनी शक्ति में नवजीवन का संचार करके सुनहरे भविष्य की आशा करते है।

ई एस आर गोपाल

(ई एस आर गोपाल)

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

1. Length Standards

A. Maintenance of Primary Standard

The primary standard of length has been maintained in the form of an Iodine stabilized He-Ne Laser at 633 nm. A portable sturdy and compact laser cavity has been fabricated which will form part of a traveling standard.

B. Computerization of calibration facility

Frequency calibration facility of 633 nm He-Ne Laser against Iodine stabilized He-Ne Laser has been modernized and computerized by interfacing with PC. Automatic beat frequency data acquisition and analysis have become possible with the help of a compact software developed for this purpose. The following computerized facilities are available with the current setup:

1. Intercomparison of two Iodine stabilized He-Ne Lasers by matrix measurement technique.
2. Frequency calibration of secondary standard He-Ne Lasers
3. Variation of beat frequency (graphic) in a time scale.
4. Short term and long term stability estimation by Allan variance method (graphic).

The frequency measurement is being linked to NPL Cs-clock frequency to ensure accuracy. The setup is comparable to that of any international standards laboratory. Several secondary standard lasers were calibrated using the computerized frequency calibration facility.

C. Sponsored Project

DST project on Development/fabrication of Zeeman split frequency stabilized 633 nm He-Ne Laser source for precision laser based instrument, has been successfully completed. Commercially viable four units of this laser have been fabricated and the frequency stability was measured to be 1 part in 10^8

D. Optical workshop

Large number of precision optical components such as polished glass sphere for density standard, plane parallel flat surfaces, lenses etc. were fabricated. Germanium and Silicon wafers were polished to flatness. Optical component testing services were offered to the industries and test reports issued.

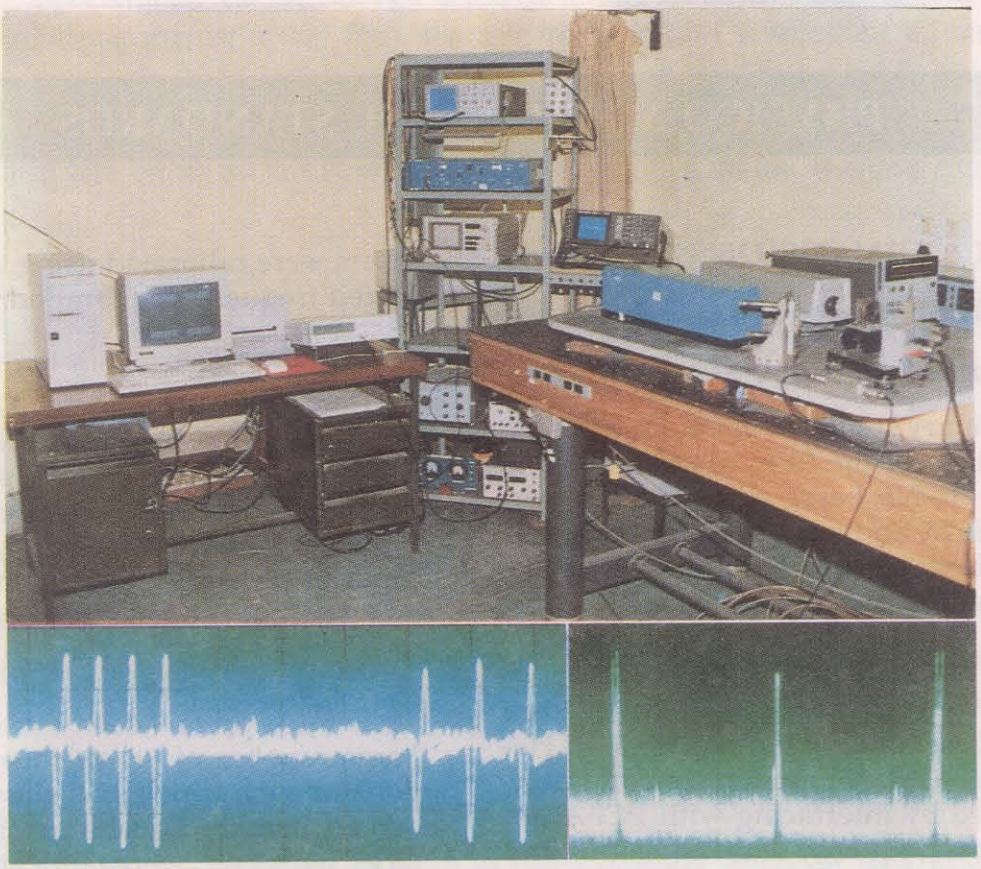
E. Bi-lateral collaboration

Under the ongoing collaboration programme with PTB, Germany, Several instruments related to calibration facilities were received and installed. Bilateral collaboration programme with D.I. Mendeleyev leyer Instt. for Metrology, Russia has been approved under ILTP.

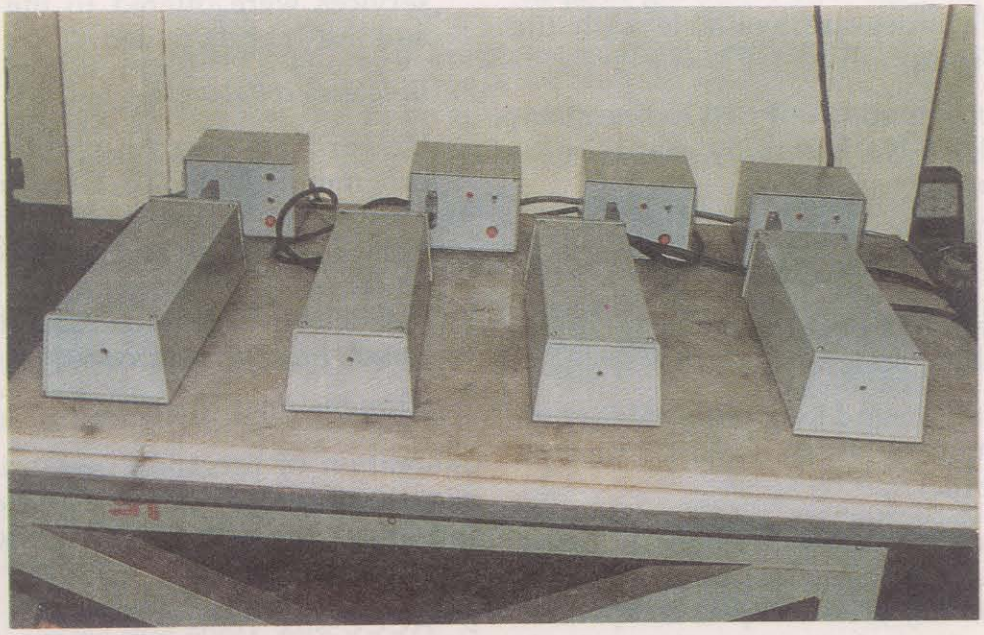
2. Dimensional Metrology

Calibration of precision measuring instruments was carried out for several companies and about 729 calibration certificates were issued.

1. ACCU-size Tools and Gauges, Pune
2. Hindustan Cables Ltd., Allahabad



Computerized frequency calibration setup. Inset show the seven iodine absorption features and the beat signal



Zeeman split frequency stabilized 633 nm He-Ne Lasers fabricated at NPL

3. Bharat Heavy Electricals Ltd. Hardwar
4. Eicher Research Centre, Faridabad
5. Eicher Tractor Engg. Centre, Ballabgarh
6. Zawar Gauges & Tools (P) Ltd., Pune
7. Size Control Gauges & Tools (P) Ltd., Pune
8. Whirpool of India Ltd., Faridabad
9. Eicher Tractors Ltd., Parwanoo
10. Cyclo Instruments Pvt. Ltd., Satara
11. Tata Iron & Steel Co. Ltd., Jamshedpur
12. Kelvinator of India Ltd., Faridabad

The following facilities have been upgraded/ added

i. Added one computerised slip gauge comparator Model TESA, Switzerland
ii. Installed and commissioned form and roundness testing facility
iii. Augmented angle measurement facility by adding photo electric auto-collimator resolution, 0.05 sec of arc
iv. Renovation of laboratory rooms with better temperature control and longer temperature stability to improve uncertainty of measurement.

PRESSURE & VACUUM

1. Pressure Standards

i. In house routine calibration of the pneumatic pressure standard upto 12 MPa has been carried out as a part of the annual exercise. With a renewed interest to determine the effective area (Ao) and pressure distortion coefficient (λ) of the industrial gauges, a computer program has been developed which can provide the uncertainty statement (both random as well as systematic) of the industrial gauges.

ii. Ultra high pressure studies of materials have been carried out on selenium and tellurium. These pressure induced phase transitions have been carried out with a view to use them for the development of the international pressure scale IPS. An attempt has also been made theoretically to obtain the band structure (BS), density of states (DOS), and phase stability of different high pressure phases of selenium, and tellurium by using self-consistent linear muffintin orbital (LMTO) method and the total energy calculation using tight binding LMTO scheme.

iii. The two newly developed piston manometers by NPL of 100 MPa and 60 MPa are characterized. The 100 MPa piston gauge was characterized for its stable and reproducible behaviour to use it as piston gauge pressure standard with special reference to the piston fall and deceleration rate for the measurement of hydraulic pressure upto 100 MPa. The effective area of the gauge as obtained by its direct calibration against NPL transfer standard has an overall estimated uncertainty of $\pm$ 0.02% at 3σ level and sensitivity of better then 3 ppm. The 60 MPa piston manometer was characterized for Regional Testing Center, New Delhi. The accuracy of 60 MPa piston manometer achieved was $\pm$0.015% of the reading and $\pm$0.01% of full scale.

2. Vacuum Standards

i. *Vacuum Gauge Calibration using Orifice Flow Method*

The work has been continued on extending the range of vacuum measurement by the NPL orifice flow system. The method being employed for this purpose is the flow division technique in which the flow from the flowmeter is directed into the lower chamber of the vacuum system and is adjusted so that the equilibrium upper chamber pressure is

matched to the upper chamber pressure measured when the flowmeter was valved into the upper chamber. The ratio of the two flowrates gives the system flow ratio which is the factor by which the extension of pressure measurement can be expected to be possible. Yet to be concluded measurements for He and nitrogen have yielded the nominal values of flow ratio as 22 and 34 respectively.

ii. A computer software is developed using QBASIC in executive mode which can be operated on any PC having DOS environment with a provision for the computation of effective area of the piston cylinder assembly experimentally as well theoretically through dimensional measurements. This software is successfully being used in our laboratory and can also be of better use in any accredited laboratory, R & D institution and industry where Dead Weight Testers are being used for pressure measurement and calibration of other gauges.

3. Surface Physics

i. *The UNDP assisted project "Establishment of surface analytical facilities at NPL"* was successfully completed on 31st December, 1996. The major achievements of the project have been the establishment of the Secondary Ion Mass Spectrometer (SIMS), MIQ256 CAMECA-RIBER at the Surface Physics Group and It's utilization for industrial application as well as R & D activities.

ii. Comparative study has been carried out between analytical instrumentation facility, North Carolina State University, USA and Surface Physics Group, NPL, New Delhi, on the doping profiles of some standard semiconductor materials like P, As, B and N doped in Silicon, using magnetic sector and quadrupole base SIMS.

iii. Standard metallic alloy sample Fe, Cr(0.25), Ni(0.20) has been analyzed by SIMS for the ratios of useful yields with respect to useful yield of Fe^+ for various primary ions (Ga^+, Cs^+, O_2^+). The sensitivity of Fe^+ in terms of the number of detected ions per nA of the incident beam has also been measured. These alloys are important in vacuum and steel industry. Similar work has also been done with GaAs which consist of two elements of different electronic structure. Comparison of yields of single atoms and diatomic molecules is interesting both for applications and for understanding of SIMS physical process.

iv. Study of the formation of epitaxial Mn and Manganese silicide surface phases on Si (111) (7 x 7) surface was extensively undertaken using Auger Electron Spectroscopy and Low Energy Electron Diffraction. The formation of the (1 x 1) Mn epitaxial phase was found for the first time to be deposition rate limited. The ($\sqrt{3}$ x $\sqrt{3}$) silicide formation was observed to occur at 350°C which is about half the temperature needed in the bulk phase. The pre-formation of a (1 x 1) template was observed to produce high quality epitaxy for the silicide overlayers of several monolayers. Epitaxial Mn with its magnetic properties and $MnSi_{1.7}$ with its semiconducting properties are foreseen to have many applications.

v. The characterization of Diamond Like Carbon (DLC) films by CVD and Plasma assisted processes were evaluated for their density and the sp^3/sp^2 hybridization ratio by using Electron Energy Loss Spectroscopy. The films prepared at National Physical Laboratory, Thin Film Division and Thin Film Laboratory of IIT, New Delhi were studied both by Auger Electron Spectroscopy and by Electron Energy Loss Spectroscopy.

vi. A Computer Simulation of the Nucleation

and Growth of sub-monolayer (2-D) thin films by the Metropolis scheme using the Monte Carlo method is preformed. Adsorption, re-evaporation and surface diffusion of the adatoms are studied on a square lattice using periodic boundary conditions. Observable factors like the cluster density, size and position distributions are derived to find the effects of deposition parameters on the morphology of ultra-thin film formation.

OPTICAL RADIATION

1. NPL Participated in the international intercomparison of luminous intensity scale under Asia Pacific Metrology Programme involving the following participants - CSIRO (Australia), NIM (China), SIRIM (Malaysia), IRL (New Zealand), PCSIR (Pakistan), PSB Singapore, CSIR (South Africa), TISTR (Thialand) and CMS (Taiwan).
2. Reference Standards of luminous intensity and luminous flux were updated. New working standards needed for day to day calibration work were prepared.
3. Quality manuals dealing with photometric and radiometric calibration procedure followed at NPL were prepared for (1) Luminous intensity and Luminous flux measurement and (2) Spectral irradiance measurements.
4. Under DST sponsored project on coherence induced spectral changes in optical measurements NPL has set up (1) Water cooled, 5 W, tunable Argon-Ion laser and (2) Febry-Perot spectrum analyzer.

INFRARED RADIATION

1. Optical grade well polished plates of ZnSe, ZnS, CaF_2, K Br, Silicon, germanium were studied and the radiometric scale of transmittance in the range of 0.4 to 1 (transmittance values) was established for the spectral region of 2.5 μm to 25 μm spectral region.
2. A collaborative project with NIST, USA, under INDO - US AID Programme on Total Spectral Reflectance, Total Spectral Transmittance, and Spectral Emittance Study of various materials in thin and thick films and bulk samples in the infrared region has been initiated since August 1996. This will enable us to measure the spectral emittance of materials at ambient temperature.
3. The reference standard for calibration of wavenumber scale of spectrophotometer in 2.5 μm to 25 μm spectral region was established.
4. Ten Calibration Reports for the calibration of IR Line Scanners, Thermovision Systems and Wavenumber Standard were issued.

ULTRAVIOLET RADIATION

Hazardous effects of ultraviolet radiation has created global interest for quantitative measurement of air UV radiation (200-400 nm) emitted from natural (Sun) and/or high intensity artificial sources, calibration of uv measuring instruments, broad band solar uv meters, uv detectors and uv blocking filters etc. Such information is required in industrial, agricultural, medical and academic fields etc.

UV Spectroradiometer developed has been used for quantitative measurement of spectral energy distribution of UV radiation sources, transmission measurement of sunglasses etc. received from industries and user institutions.

New calibration facility for broad band Solar UV meters has been created and used for the calibration of two UV-A meters received from user institutions.

Double beam photoacoustic spectrophotometer developed earlier has been maintained and used for investigations of solid sample

in powder and solid solution (glass) from in Air UV (200-400 nm) spectral region. Some interesting results have been obtained.

ACOUSTICS

I. R & D Activities

1. *Acoustics of Multipurpose Halls*

   Based on the analysis of the design details of some 27 multipurpose halls acoustically designed by NPL over lase decade (1985-1995) certain conclusions were drawn in respect of the major design criteria, viz. volume per seat, floor area in relation to seating capacity, reverberation time, aspect ratio and elevation, for small capacity halls in the country.

2. *Acoustic Evaluation* of 1) Room No. 155 in P.M.'s Office, South Block after renovation which was based on the remedial measures suggested by NPL. 2) DG, CSIR's Chamber at CSIR HQ, New Delhi.

3. *Structural Vibration Measurements at Rashtrapati Bhawan* aimed at finding out the possibility of structural damage if any due to ceremonial gun salute. The results showed that the maximum floor vibration level due to gun salute (≈ 0.007 g) was well below he recommended limit of 0.1 g for onset of structural damage.

4. *Intercomparison of Standard Accelerometer* Under the auspices of Asia Pacific Metrology Programme NPL participated in a round-robin calibration of standard accelerometer involving other standard laboratories of the region. This was aimed at verifying the traceability of NPL standards.

5. *Evaluation of Phased Array Antenna* consisting of 76 piezo-electric tweeters was undertaken towards the development of an indigenous acoustic wind profiler.

6. *A new Radar Equation* for acoustic sounding was developed for use in the design of acoustic sounding systems and study of the temperature structure of the atmosphere.

7. *Antartic Boundary Layer Studies* in collaboration with CNR, Italy. Results being accepted for publication in Antartic Science.

8. *Sodar Studies of Boundary Layer* at different topographical locations in India with special reference to Air Pollution.

9. *Monsoon Boundary Layer Studies* in collaboration with CAZRI, Jodhpur and Jawahar Lal Nehru Centre for Advanced Scientific Research, Bangalore.

II. Standardisation, Calibration & Testing

1. Accuracy of primary standards of sound pressure (± 0.2 dB) and vibration amplitude (± 0.5%) was maintained through periodic calibration exercises and participation in International Round Robin Calibration exercises (Eg. APMP Intercomparison Programme).

2. Calibration of secondary/working standards from regional laboratories and industrial labs was undertaken.

3. Evaluation and testing of electro-acoustic equipments and acoustic products developed indigeneously were undertaken.

4. Noise & Vibration Measurement & Analysis were undertaken, viz. Vibration of historic building (Rashtrapati Bhavan) and Furnance Noise in factory premises.

ULTRASONICS

A challenging problem of detection and location of small defects in the coaxial carbon fibre composite (CFC) material of varying thickness (3 to 18 mm) to test the wings of Light Combat Aircraft (LCA) was undertaken and solved under contract research with Aeronautical Development Agency

(ADA). Specially designed transducers were made for this purpose to give a -6dB beam diameter of 2.5 mm throughout the sheet thickness with high transmitting and receiving sensitivities. Further systematic studies led to the development of "BWE Gating Technique" which gave very high and almost equal near surface resolution for both front and rear surfaces. It has been proved on site with the new transducer and technique developed that all the various kinds of simulated defects appeared clearly on the C-scan image. Another interesting feature of the technique is that the equal-size defects occurring at different depths appeared to be of same size in the C-scan image without invoking DAC, TGC or any other correction.

An improved transducer probe for ultrasonic nondestructive testing of concrete and like materials having its frequency in the vicinity of 50 kHz and based on sandwich configuration was designed, fabricated and evaluated for performance on concrete samples.

A complete tunable acoustic receiver was fabricated for 40 to 120 kHz with audio output using surface mount components and PCB. The device was tested on the indigenous 75 kHz pinger tag, developed earlier, from a range of 20 m. The acoustic receiver with the pinger tag was successfully demonstrated in operation at Research Centre of Central Marine Fisheries Research Institute, Tuticorin (T.N.)

Design considerations of barrel stave flextensional transducers for applications as compact high power low frequency source of 1 to 2 kHz for barrel stave materials of Aluminium, Titanium and Fiber glass reinforced composite material was studied and computed. Work on fabrication and development of these transducers was initiated.

Further experiments have been conducted on the Air to water Transmission of ultrasound at 20 kHz, keeping the air borne transmitting transducer 2 cm above water surface. The acoustic pressure received underwater with a hydrophone has been theoritically estimated using acoustic pressure of the transmitting source in air. The theoretical results have been compared with the experimentally obtained sound pressure in water and agreement is found to be within + 3dB. A possible application of this technique for hydrophone calibration has been explored.

Further studies on the development of parametric source for estimation of nonlinearity parameter of interacting liquid media have been carried out using nonlinear interaction of high power ultrasonic waves generated by carrier suppressed double side band excitation to a primary transducer capable of generating SPL of 198dB re 1μ $Pa.m^{-1}$. Using the primary signal of frequency 500 kHz and modulating signal of frequency of 25 kHz, a difference frequency signal of 50 kHz is obtained using a piezoelectric sandwich sensor which was specially designed and fabricated. Propagation and directional characteristics have been experimentally measured to ensure the parametric nature of the difference frequency. The 3dB beam width of difference frequency signal is measured to be 7° at 2m.

The standardisation of ceramic composition of piezoelectric material based on Lead Metaniobate ($PbNb_2O_6$) and optimisation of ceramic processing parameters for the fabrication of modified lead metaniobate piezoelectric ceramic material resulted in a material designated as NPLMN-1 equivalent to Vernitron - PMN-1, EDO - EC-82 and Kezite - K-81 possessing the following dielectric, electrical and electromechanical parameters.

The high stability of dielectric constant and piezoelectric parameters with variation of temperature and pressure make it suitable for deep water and high temperature transducer applications. Being a low mechanical Q_m transducer material, it is well suited for

Table: Typical Properties of NPLMN-1: Modified Lead Meta Niobate

	Parameter	Value
i	Dielectric Constant (KT_3)	285
ii	Loss factor (tan δ)	0.009
iii	Charge Constant (d_{33}) x 10^{-12} C/N	85
iv	Voltage Constant (g_{33}) x 10^{-3} V-m/N	33.7
v	Mechanical Quality Factor (Q_m)	~15
vi	Curie Temperature (Θ_C)°C	~495
vii	Density (ρ_m) x 10^{-3} kg/m^3	6.0

use in flaw detectors, thickness gauges and in applications where a broad band width is desirable.

Systematic studies of piezoelectric ceramics, Pb ($Zr_{0.53}$, $Ti_{0.47}$)O_3 added with MnO have been carried out. Vector impedance measurements of radial mode and its three over-tones with different levels of MnO addition ie x=0.1 to 9.2 mole% were made using a computer-controlled impedance analyzer at room temperature. An effective value of Poisson's ratio (σ^E) has been determined from fundamental to overtone frequencies ratio, which comes out to be 0.34 ± 0.01. The planar coupling coefficient k_p is found to be independent of overtones and peaks at around x = 1.0 mole% whereas the dielectric constant K^T_3 peaks at x = 0.46 mole%. The coupling coefficient k_{31}, elastic compliance S_{11}^E, strain constant d_{31} and voltage constant g_{31} have been determined which are difficult to obtain otherwise and these are found to be independent of overtones. Large variations in piezoelectric and dielectric parameters are due to structural changes.

Piezoelectric ceramic transducer elements in various shapes and sizes for certain specific applications have also been batch produced and supplied to user industries.

CRYOGENICS & HUMIDITY STANDARDS

Liquid nitrogen based cryo-surgical probe system alongwith its transfer system have been tested during this period. Preliminary results of the testing are quite encouraging.

Under DST funded project on cryosurgical system for ENT, three units have been assembled under this period. One of the units has been handed over to an ENT surgeon at Safdarjang Hospital for its detailed performance evaluation in the destruction of malignant tumours. Results on six patients on which this cryo-machine has been used are found to be very encouraging.

We have a DST project in collaboration with BHU on the development of module hydride air-conditioner. We have designed and fabricated four heat reactors (heat exchangers) during this period.

The water cooler of 10 litre capacity based on Lithium Bromide-Water vapour absorption cycle has been assembled and put to testing during this period.

Humidity Standards is a new activity of the laboratory. The objective is to establish National Humidity Standard at NPL and to provide calibration services to various industries. In a short span of time the following work has been done.

1. Development of an aspirated psychrometer using two matched quartz thermometers
2. Fabrication of an insulated humidity chamber
3. Testing of humidity oven
4. Work on humidity generation using saturated salt solutions

Besides, the group has offered calibration services to industries for the calibration of hygrometers in the range of 10 - 90% RH.

FLUID FLOW MEASUREMENT

Installation of the water flow measurement system (Two test rigs 200 DN & 50 DN)

including the infrastructure development work required for this purpose, have been completed

Both the test rigs have been tested using the overhead tank in the estimated flow range 3m^3/h to 600 m^3/h (for DN 200) and 100 l/s to 60 m^3/h (for DN 50).

The 1-ton and 10-tonne weighing systems have been calibrated using the dead-weights which were calibrated at NPL mass standard section.

Study on environmental parameters (temperature, humidity etc) prevailed in the fluid flow laboratory and their effect on flow measurement has also been done in the winter season. It is observed that environmental conditions required for a fluid flow laboratory as mentioned in the national and international standard has been achieved in the flow measurement room. It has been planned to carry out such studies in the summer and rainy seasons.

ELECTRICAL STANDARDS

TIME AND FREQUENCY

NPL continues to contribute to the generation of UTC of BIPM through monitoring of GPS time signals.

The study of the reliability and availability of GPS signals in India has been completed. Different parameters related to GPS signals have been monitored at eight well scattered places (Delhi, Calcutta, Vishakhapatnam, Hyderabad, Thiruvananthapuram Mumbai and Ahmedabad) of India for one year. These data have been thoroughly analysed. A consolidated report has been prepared and printed in the form of a book for wide circulation.

Selective Availability (SA) has been intentionally introduced on GPS signals to deteriorate the position and timing accuracy. The impact of SA on accuracy has been studied in detail. A model to counter partially the SA effect on Timing has been successfully developed.

The STFS broadcast has been operational throughout the year. The highlights of this year's activity have been firstly the development of a low cost STFS decoder in collaboration with ERDC, Thiruavnanthapuram and secondly installation of the STFS receiving facility at a number of stations in India. These include Power Grid Corporation (Andheri, Bhallbhgarh, Kanpur); MSEB, Thane; Tata Electric, Mumbai; Secure Meter Ltd., Udaipur; Delhi Doordarshan Kendra and All India Radio FM Transmitter Pitampura, Delhi.

JOSEPHSON VOLTAGE STANDARD & DEVICES

I. Josephson Voltage Standards

(i) Under NPL-PTB collaboration programme, several Josephson series arrays containing 1600 to 3216 $Nb/Al_2o_3/Nb$ tunnel junctions were fabricated and tested at PTB, Braunschweig, Germany. These chips will be used in NPL's Josephson series array voltage standard. NPL's secondary standard (Zener Diode) was Calibrated at 1, 1.018 and 10 volts respectively with PTB's standard.

(ii) In collaboration with ETL, Japan, the effect of operating frequencies on $Nb/Al_2o_3/Nb$ Josephson series array was studied. It was observed that the arrays have wide band behaviour and can be used at frequencies other than the designed operating frequency.

II. High-T_c rf-SQUID measurement system

(i) RF-SQUID sensors with microbridge of reduced dimensions ($\approx$ 25μm) have been fabricated on Bi (Pb)-Sr-Ca-Cu-O films. These sensors showed improved performance than earlier sensors having larger microbridge dimensions ($\approx$100μm). The amplitude of Voltage-flux oscillations is considerably increased in these sensors.

(ii) High-T_c material reacts with moisture present in the atmosphere and hence its superconducting properties degrades with time and thermal cycling between room temperature and liquid nitrogen temperature. We have developed a method to stop the degradation in properties of high-T_c SQUIDs by suitable passivation and encapsulation of the device. The passivated and encapsuled sensor has been characterized for its V-Φ characteristics and flux noise density

for a period of about a year, the sensor has been thermally recycled several times. No significant degradation in the characteristics of the sensor have been observed.

(iii) A rf-SQUID basic measurement system has been designed and fabricated. The system consists of a high-T_c rf-SQUID probe, liquid nitrogen cryostat, rf and magnetic shields. It is capable of measuring magnetic fields of samples either kept at LN_2 temperature or at room temperature. Detailed characterization of this system is in progress.

III. High-T_c BSCCO thick films

(i) The process parameters for growth of high-T_c phase in screen printed BSCCO thick film have been optimised. The XRD studies show that the film has predominantly high-T_c 2223 phase. The T_c (R=0) ≈112 K has been obtained in these films. These films are being used to fabricate rf-SQUIDs

IV. Harmonic generation effects in high-T_c films

A detailed study has been carried out on harmonic generation effects in Bi(Pb)-Sr-Ca-Cu-O(BPSCCO) thick films and Y-Ba-Ca-Cu-O (YBCO) thin films. The application of an ac field ($H_{ac}>H_{cl}$) of frequency f causes generation of odd harmonics at frequency (2n+1) f. If an additional dc field, H_{dc} is applied, then even harmonics at frequency 2f also appears in case of BPSCCO thick film. However, the appearance of even harmonics is not observed in YBCO thin films except in case when the film has very low J_c ($\leq 1x10^3 A/cm^2$).

The amplitude of even harmonics in thick films has been found to vary linearly with the magnitude of dc field for low field region. A magnetometer based on the measurement of the amplitude of second harmonic in BPSCCO thick film has been developed. It has a field sensitivity of $\approx 10^{-8}$T.

V. Conduction noise studies in YBCO thin films

A systematic study of conduction noise has been carried out in YBCO thin films prepared by dc magnetron sputtering. The noise has been measured as a function of temperature and frequency both in the normal and the superconducting state. 1/f noise was observed upto 20 Hz while above it the white noise dominated. The magnitude of the noise was found to be dependent on the temperature with a pronounced peak appearing at the superconducting transition temperature. The amplitude of the peak decreases as the frequency is increased and it almost disappear in the white noise region.

VI. Studies on Microwave Superconductivity

A high-TC superconducting microwave cavity was designed and fabricated using dense material of $YBa_2Cu_3O_{7-x}$ composition. The cavity was operated in TE_{011} mode at 16.564 GHz. The quality factor Q=31,000 was obtained at 65K which is more than that of the best copper cavity and is comparable to the best value reported by other workers.

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

(i) The measurement set up to assign the ac-dc transfer error to thermal voltage convertors (TVCs) of rating 1 volt to 1000 volts has been automated.

(ii) Using the above measurement set up, international inter-comparison of LF voltage standards (TVCs) has been carried out during Dec. 96 - Jan. 97 with thermal transfer standard of NML

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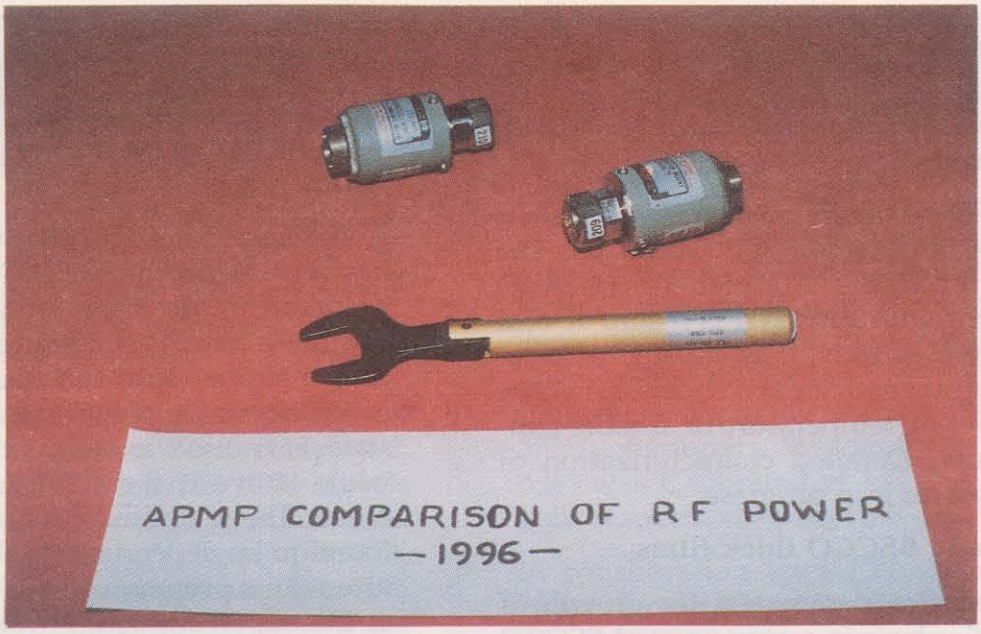
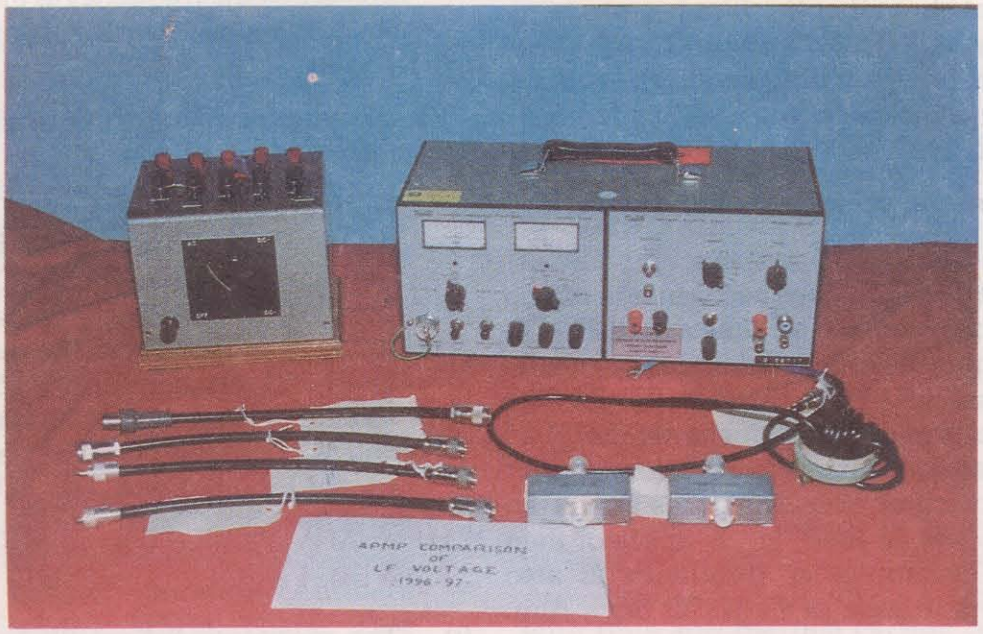


APMP Comparison of RF Power -1996



APMP Comparison of LF Voltage (1996-97)

Australia under Asia Pacific Metrology Programme. The intercomparison has been carried out at voltage levels of 10 volt, 100 volt and 1000 volt in the frequency range 10 Hz to 1 MHz. At 10 volt level, the comparison has been carried out at 10 Hz, 40 Hz, 1 kHz, 20 kHz, 50 kHz, 100 kHz and 1 MHz while it has been carried out at 10 Hz, 40 kHz, 1 kHz, 20 kHz, 50 kHz and 100 kHz at 100 V level and at 40 Hz, 1 kHz, 20 kHz and 50 kHz at 1000 volt level. The relative ac-dc transfer error of travelling standard with respect to NPL TVC is

within ±0.003% at 10 V and 100 V levels while it is within ±0.01% at 1000 volt in the entire frequency range. The results of intercomparison have been communicated to the Pilot Laboratory NML Australia for compilation of the final report. The other participating countries are South Korea, Hongkong, Philipines, Taiwan, Malaysia and Japan. The comparison set up is shown in the photograph attached.

(iii) The pilot laboratory (PTB Germany) has circulated the results of CCE comparison of AC-DC voltage transfer standards at lowest level of uncertainty carried out during January, 96. The results of ac-dc transfer difference assigned to the travelling standard multijunction thermal convertor are shown in the following graph.

In the graphs NPl (India) is shown at No. 17 while PTB Germany, NPL (UK), NIST (USA), NML (Australia); LCIE (France) have been shown at 1 and 10, 2, 14, 15 respectively. The graphs also shows a very close agreement in values of ac-dc transfer difference assigned by PTB, NPL (UK), NIST and NPL (India). This establishes the compatibility of NPL (India) Standards with international standards.

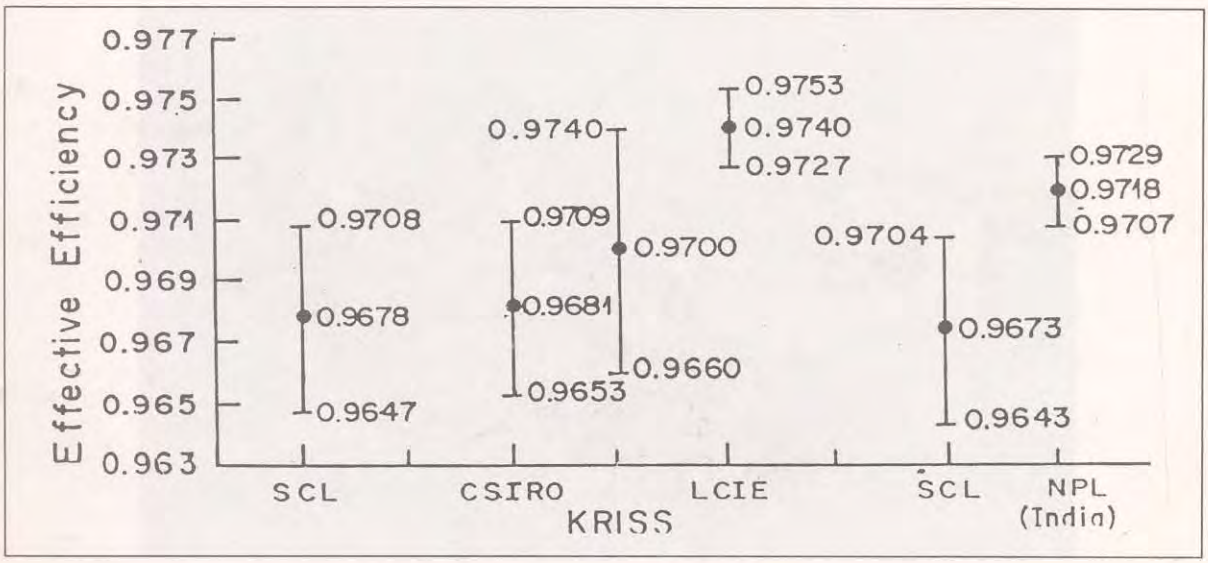
(iv) International Comparison of RF Power under Asia Pacific Metrology Programme

NPL India has participated in the international comparison of RF Power at the frequencies of 100 MHz, 1 GHz, 12 GHz and 17 GHz.

Two thermistor mounts received from the Pilot Laboratory, 'Standards and Calibration Laboratory, Hong Kong' in December, 1996 have been measured for their effective efficiency at the aforesaid frequencies using the recently established "Coaxial microcalorimetric system". The results have been communicated to the Pilot Laboratory.

This intercomparison programme started in Jan. 96 and is due to end in

Effective Efficiency at 112GHz (Mean ± 1 Sigma)
UUT : HP8478B S/N : 3314A24673 (GCLRFO183-04)



APMP Intercomparison of RF Power

Dec. 1997. In 1st Phase SCL, Hong Kong; SIRIM Malaysia; NML Australia; KRISS, Korea; LCIE, France; VMI, Vietnam; and NPL, India have completed the assignment; in the IInd Phase, ETL, Japan; CMS/ITRI Taiwan; VSL, Netherlands; and PSB, Singapore; are taking part. In all 11 countries of Asia, Europe, etc. are participating in this programme.

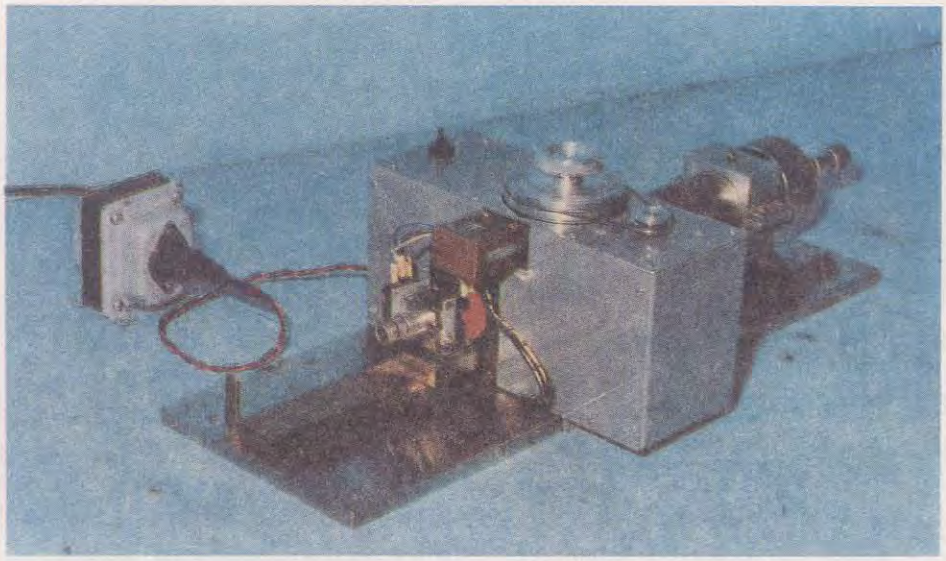
A view of the coaxial microcalorimeter system with two thermistor mounts received for inter comparison is shown in the photograph.

Preliminary results, received from Pilot Laboratory (SCL, Hongkong) show a very good agreement among the participating countries shown in the figure. Agreement is extremely good with KRISS Korea as the Korean system of measurement is identical to NPL India because both system got assistance from PTB Germany.

HF & MICROWAVE ATTENUATION AND IMPEDANCE STANDARDS

A laboratory model of precision variable waveguide below cut-off (WBCO) attenuator operating at 30MHz in TE_{11} model has been designed and fabricated in 50 ohm coaxial system using precision cylindrical copper waveguide for attenuation range of 0-100 dB. Resonant inductive antennas matched at 30MHz have been fabricated and incorporated in the cylindrical waveguide in such a way that one serves as fixed transmitter and the other as moveable receiver for changing the attenuation. A Faraday screen type mode filter has also been fabricated to suppress the unwanted TM_{01} mode generated in the waveguide from the transmitting antenna to an attenuation level of 60 dB reducing the non-linearity error to a negligible level. The WBCO attenuator has approximately 20 dB insertion loss and has been calibrated against a 10dB fixed standard coaxial attenuator in steps of 10 dB over the 0-60 dB range. The results were found to lie within 0.01 dB/10dB.

Calibration of coaxial and waveguide attenuators and coaxial unismatches of different Govt. departments was carried out. Testing of various X-band microwave components and instruments such as VSWR meter, Gunn oscillator and Klystron oscillator power supplies has also been carried out.



WBCO Attenuator

MAGNETIC STANDARDS

We are in the process of setting up of Magnetic Standards Laboratory with PTB, Germany, collaboration. The major facilities which are being established are apex level calibration of H-sensors, Fluxmeters etc. and measurement on soft magnetic materials. Some of the precision equipments are being fabricated at PTB.

AC measurements on soft magnetic materials were carried out at PTB with the help of Epstein frame as per IEC standards. Measurements were conducted on grain oriented and non-grain oriented electrical steel sheets. The different parameters determined for these samples are: total core loss, magnetic induction, field strength, specific power etc. It has been observed that in case of non-oriented samples upto polarization values of 1.4T, and for grain oriented samples with magnetic induction values upto 1.7T, the power loss results obtained from PTB and NPL AC measuring setups are in agreement to within ±0.5%.

A big electromagnet, with 25 cm pole diameter and variable air gap, capable of giving homogeneous field was tested for its performance at Brucker Co., Germany. The maximum field at 3 cm and 25 cm pole piece gap was of the order of 18 kilogauss and 8.6 kilogauss, respectively. This magnet is being installed at NPL and shall be used for calibration of H-sensors, search coils etc.

Work on fabrication of precision Hall sensors of different materials is in progress in collaboration with JVS & Squid Group.

Help has been rendered to the following groups of NPL in conducting magnetic measurements.:

JVS & Squid Group
Cryogenics Division
Length Standard

Consultancy services are being rendered to some of the Indian industries/organisations in addition to the calibration work carried out.

MATERIALS DEVELOPMENT

SILICON AND SILICON DEVICES

The work in this area was aimed at developing high performance silicon solar cells on low cost and low minority carrier lifetime ($\tau < 10\mu s$) substrates of area 94-100 cm^2 using minimum number of steps which are described in brief below:

As cut wafers were textured by creating straight pyramids chemically and then diffused in a microprocessor controlled furnace in an ambient of $POCl_3$, N_2 and O_2. The junction depth and dopant profile were measured and optimized by using a new method of dopant profile analysis that does not require prior knowledge of mobility for which there is considerable divergence in the literature. This method uses Lange's method of Hall coefficient and sheet conductivity measurement after successive sectioning by anodic oxidation. A representative dopant profile along with its validation by spreading resistance probe (SRP) is shown in Fig. 1.1 Difusion was followed by growth of a thin (4-5 nm) passivating SiO_2 layer and its thickness was measured by an ellipsometer. Thereafter metallization was carried out by screen printing. Reflection loss was reduced to ~15% due to texturing and then ~10% by SiN_4 coating using a plasma enhanced chemical vapour deposition (PECVD) system. A spectral response (SR) measuring set up for 10cm x 10cm solar cells was established by mounting fifteen narrow band optical filters on a rotating wheel as shown in Fig. 1.2 in the wavelength range of 400-1100 nm. The SR is poor in the lower wavelength range because screen printed contacts require junction depth in the range of 0.4-0.5 μm whereas evaporated contacts require ~0.15 μm. Therefore some of the minority carriers are lost in the emitter. The resulting solar cells of area 94 cm^2 yielded :- shortcircuit current density : 27-30 mA cm^{-2}, curve factor : 0.75-0.76 and open circuit voltage : 600-605 mV as measured under an Astro Power solar simulator of 1 Sun intensity and AM1.5 spectrum. The efficiency turned out to be 11.5-12% (total area) and 13-14% (active area). The active area efficiency become important under textured cover glass in panels.

"2D DIFFUSE", a program for two dimensional simulation of dopant impurities diffusion in silicon for microelectronic devices has been developed. The results of the simulation

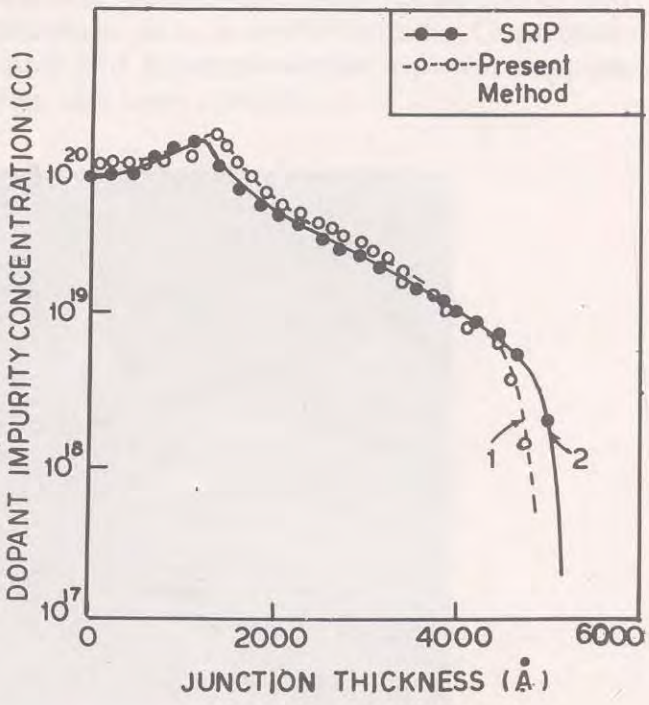


Fig. 1.1 Dopant profiles of P in Si

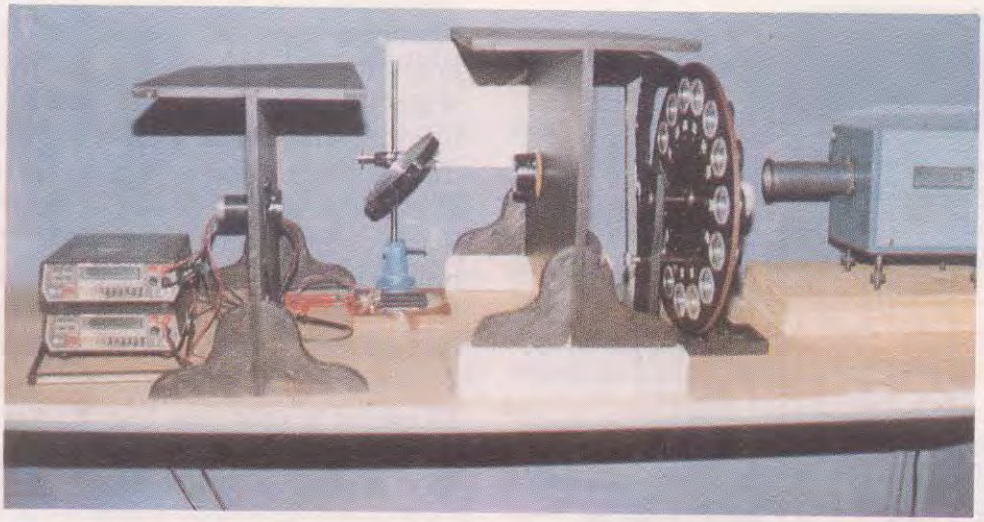


Fig. 1.2 Fifteen narrow band optical filters on a rotating wheel in the wavelength range 400-1100 nm.

are in the form of impurity profiles both in vertical and lateral directions. "2D-DIFFUSE" is based on modular structure i.e., numerical solver, process models, various special effects, input, output and data management files have been developed as separate subroutines and has following features:

* A partial differential equation solver for gradient driven diffusion equation and the built in electric field driven flux term solved numerically using finite difference method.
* Two dimensional oxidation based on analytical model and simulation of shape of the oxide (i.e. "bird's beak") grown under non-planner surfaces such as trench structures, mask edges etc.
* Diffusion of dopants viz., boron, phosphorus, arsenic and antimony in silicon under neutral and oxidizing ambient.
* Advanced diffusion models for boron, phosphorous, arsenic and antimony based either on phenomenological data or physical theory.
* Intrinsic and extrinsic diffusion in silicon.
* Annealing (Drive-in) under different ambient.
* Effects like emitter push effect, heavy doping effect, band gap narrowing, oxidation enhanced and retarded diffusion.
* Non-linear mesh generation.
* Graphics for visual display of 2D impurity profiles and oxide shape.

It enables the user to have finer grids in the region where doping concentration varies sharply with distance and to have coarse grids in the region where the change is not so pronounced without sacrificing the accuracy. It is in an interactive program and needs inputs for mesh generation, substrate and processes etc. The output of the program is in the form of concentration profile both in lateral and vertical directions. A typical example of phosphorous diffusion with oxide is shown in Fig. 1.3.

1. High Temperature Superconducting Wires/Tapes

During the year, the work on silver clad high temperature superconducting BPSCCO tapes was done in two main directions : (i) The fabrication of long length silver clad BPSCCO mono-filamentary, (ii) Fabrication of multi-filamentary silver clad BPSCCO tapes. Multi-filamentary (6-7 filaments) tapes upto 2

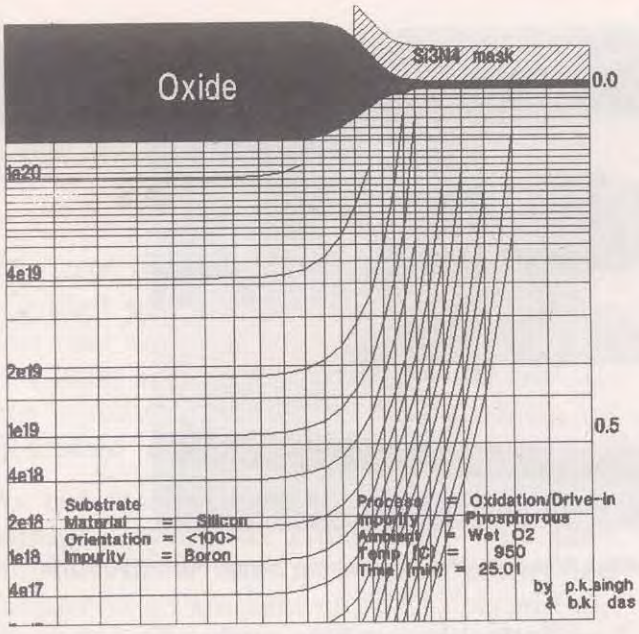


Fig. 1.3 Phosphorus diffusion with oxide

meters length were successfully fabricated.

Silver clad mono-filamentary or multi-filamentary tapes were made by the PIT (power-in-tube) method. First the calcined powder of desired phase content were put inside a silver tube the groove rolled upto approximately 1.2mm diameter. For multi-filamentary tapes, this wire was cut into six or seven pieces and put inside a fresh silver tube again and groove rolled to suitable diameter. At every stage the thickness and separation between adjascent filaments were monitored. Below 1.2 mm diameter, both mono-and multi-filamentary wires were flat rolled upto suitable thickness. In mono-filamentary tape, the area reduction during flat rolling was always 10% per pass at every step followed by annealing. The tape was finally sintered at 810-840°C for 250-300 hours. Process parameters were optimised for long length tapes. Several coils made of 5-10 meters long tape were fabricated. These coils showed end to end superconductivity upto 10 meter length (see Fig. 2.1) with a critical current density (J_C) of approximately 4000-5000 A/cm^2 at 77K in self field.

Similarily the multi-filamentary tape with 6-7 filaments were made upto a length of 2 meters. These tapes were sintered at 830-845°C for 250 hours with intermittent rolling. A J_C of 6000 A/cm^2 upto 35 cm gage length at 77K and self field was recorded. End to end superconductivity was observed upto 1.25 meter length.

2. Special Ceramics

Two projects - (i) Development of beta alumina tubes for sodium metal production and (ii) Development of porous ceramic particulate filters for IC engine exhaust were initiated during the year. The first project is a collaborative project with the Indira Gandhi

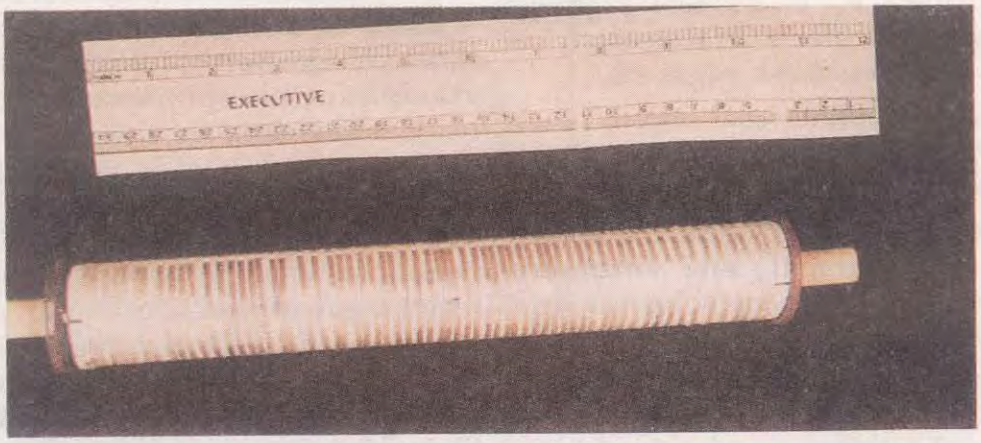


Fig. 2.1 The HTS silverclad BPSCCO (2223) end to-end sup. conducting 10M tape with T_C~110/C and J_C~5000A/cm^2 at 77K. Zero field

Centre for Atomic Research (IGCAR) with funding from Board of Nuclear Studies. Under the project large size beta alumina tubes are to fabricated and supplied to IGCAR for use in the electrolytic cell being developed by IGCAR for production of high purity sodium metal. During the year fourteen tubes of 50 mm nominal diameter were supplied for use at IGCAR. In the second project, particulate filter based on porous sponge ceramics for IC engine exhaust is under development in collaboration with the Indian Institute of Petroleum (IIP) with funding from the Department of Science & Technology. Detailed sintering studies were carried out for material synthesis and design parameters for the filter was arrived at in consultation with IPP.

3. Magnetic Materials

A DST funded project to fabricate *an Automatic Self Locking NMR Gaussmeter* was completed during the year. Several sub-systems like controller, auto range selector, digital amplitude detector and NMR resonance-to-frequency converter were fabricated.

MICROSTRUCTURE MATERIALS AND DEVICES

The project sponsored by the Ministry of Non-Conventional Energy Sources, for the development of electrodeposition technology for CdTe solar cells has made significant progress. The process know how involving the Br/methanol etch and electrodeposition control has resulted in the successful fabrication of solar cells with over efficiencies. Up gradation of the process to larger area cells and lowering of contact resistivities is in progress. Commercial level technology development for contacts and encapsulate of CdTe modules has been carried out for Ecosolar Pune, the industry which has sponsored a project with our group. It has been provided with cell characterization and evaluation know how to optimize their production line.

A new high capacity thermal deposition system for the fabrication of CIS absorber layers by elemental co-evaporation process developed earlier for solar cell hetrojunction has been setup. The Se vapour selenization process has been further optimized. Process steps have been developed for the fabrication of N doped and Zn compensated ZnSe films with significant lowering of resistivity. The mechanism responsible for this lowering has been identified. Modeling of the selenization reactor has been extended for use of multiple chalcogen atoms. Work on the preparation of $ZnTe_xSe_{1-x}$ films has shown band gap and resisting modification of window layer can be achieved by operating the reactor at higher Te/Se ratio in the gas phase.

Ferroelectric PZT thin film by electron beam evaporation has been investigated as storage element for high density DRAMS.

The design fabrication and testing of the ion beam microetching system, including the micro manipulator, multiple ion guns and accessories, developed as part of the DST sponsored project has been completed. This system is meant to achieve micromilling of a varieties of materials for planner and cross-sectional specimen preparation for microstructure analysis by transmission electron microscopy. Demonstration of the system has been completed and approved by DST following which a technology document has been delivered to DST for prospective industries for commercial production.

LUMINESCENT MATERIALS & DEVICES

1. R&D of Long Decay Phosphor (DRDO)

NPL concentrated its efforts on time targeted DRDO sponsored project "Development of long decay phosphors and phosphor coated plastic tapes". In this activity, a zinc sulfide preparation facility was duly installed. A mechanical stirrer was incorporated in zinc sulfide reactors for better control of reaction

and trouble free performance. To take care of gaseous effluents a closed cycle scrubber unit was designed, fabricated and installed. A reactor was put up to neutralize liquid cum solid sludge of hydrogen sulfide gas generator which led to its safe and environment friendly disposal. The facility was fully commissioned and sulfides were produced in batches. Phosphor development required re-orientation of existing testing cum evaluation facility and expertise. Earlier expertise was for short decay times for display devices whereas the present one is for storage and slow decay of energy. This required a completely different experimental set up for testing which was developed for the purpose. The required long decay phosphor has been developed after preparation and evaluation of a large number of samples.

2. Thin Film Electroluminescent Display (DST)

Sponsored project on "Thin Film Electroluminescent Displays" has progressed with installation and commissioning of 18" vacuum evaporation unit with varied facilities such as multiple source E.B. gun, multi filament heating and planetary substrate mounting. A number of ZnS based thin film EL cells have been fabricated and their characteristics tested.

DISPLAY DEVICES

1. Polymer Dispersed Liquid Crystal (PDLC) Composites

A new liquid crystal laboratory has been setup to study liquid crystals. A large number of equipments were imported from Germany and USA under the Volkswagen Foundation sponsored project entitled "Electro-optical and structural studies of oriented nematic dispersion" in technical collaboration with Technical University Berlin, Berlin. The facilities include processing, textural studies, and electro-optical studies etc. of liquid crystals. Majority of the equipments have been interfaced via a personal computer which has resulted in complete automation of the measurements.

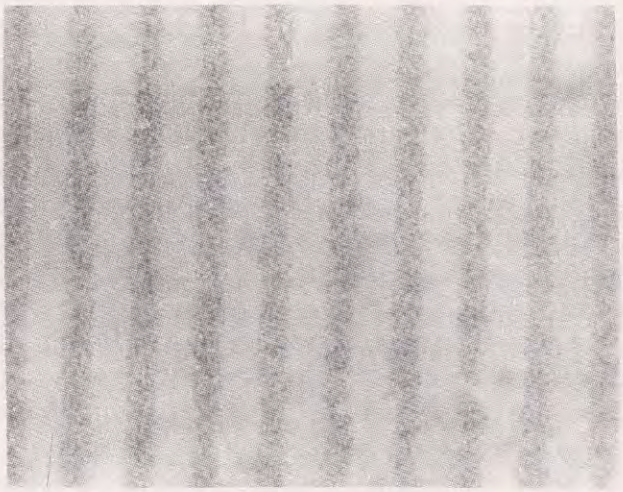


Fig. 1 : Micrograph of a line pattern (line width = 10 μm) recorded on a PDLC film by UV-curing through a photomask.

PDLCs for optical recording

It has been demonstrated that PDLCs can be used for optical recording and data storage. Spatially varying photo initiated polymerization induced phase separation structures could be formed by modulating the intensity of light across the film during curing. A mask has been used to expose different portions of the PDLC film to different cure intensities. This results in the variation in the scattering from different areas of the PDLC film cured differently. Figure 1 shows the recording of a line pattern with a resolution of 10 microns. We could also record diffraction grating formed by the interference of the laser light that results in sinusoidal variation in intensity of the recording light. In a way one could realize an electrically controllable diffraction grating.

Oriented nematic dispersions for scattering polarizer

A new technique has been developed to produce oriented nematic dispersion in PDLC composites produced either by thermal-

induced or UV-polymerization induced phase separation process. The technique is primarily based on shearing the PDLC film during phase separation. Such a PDLC film exhibits strong polarization dependent light scattering. The linearly polarized light with its electric vector of polarization lying parallel to the shearing direction is strongly scattered while the perpendicular component is transmitted. This arises due to large birefringence of the liquid crystal and matching of the refractive index of the polymer and the ordinary refractive index of the liquid crystal. The polarization efficiency of such a scattering polarizer depends on a host of material and fabrication parameters. They include the choice of liquid crystal and polymer; shape, size and density of liquid crystal droplets and the degree of orientational order in liquid crystal droplets. Role of the various parameters on the polarizing efficiency has been determined and some of the fabrication parameters have been optimized. Figure 2 shows the transmission characteristics of one such cell which exhibits a polarization efficiency of ≥ 15. Efforts are on to increase the polarizing efficiency and study their electro-optical response behaviour.

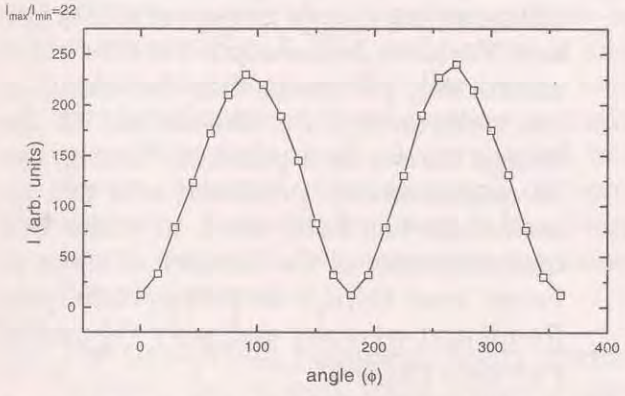


Fig. 2: Transmission of a linerly polarized light through an oriented PDLC cell containing polymer NOA-91 and LC mixture 403 (wt. ratio 2:1) as the cell is rotated on a microscope stage. The minimum transmission corresponds to when the polarizing axis is parallel to the orientation direction and the maximum transmission corresponds to when the polarizing axis is perpendicular to the orientation direction.

2. Dielectric studies in Ferroelectric liquid crystal

It has been predicted that the dielectric permittivity measurement technique is an effective approach like the electro-optical method for characterizing the surface stabalized phenomenon in ferroelectric liquid crystal (FLC) materials. Dielectric studies of first order phase transition FLCs, having a phase sequence of chiral nematic to smectic phase have been carried out in a thin (3.5 μm) planarly aligned monostable cells in the frequency range of 10Hz to 10 MHz. The behaviour of Goldstone mode which comes due to phase fluctuations of the tilt of the molecules has been done for positive and negative polarity of the bias field. The dielectric permitivity due to Goldstone mode gets suppressed with positive polarity of the bias field (Fig. A) whereas, with negative polarity of the bias field (Fig. B), first it increases and then decreases with the increase in the bias field. The dielectric results obtaind in the investigations fully agree with the electro-optical phenomenon in the monostable surface stabalized FLC cells.

3. Development of Solid State Electrochromic Devices (ECDs) for Display Applications

Development work on ECDs using POLYVINYL BUTYRAL (PVB) based Solid Polymeric Electrolytes (SPEs) was continued. Feasibility of "All Solid State ECDs" has been established. A novel method of "Self Sealing" ECDs, using the incorporated SPE as the sealant has been developed. Extensive efforts have been made to suitably modify the SPEs resulting in ECDs with improved performance characteristics such as low operational voltage, higher contrast, fast response times and enhanced lifetime and open circuit memory.

Sol-gel technique was adopted to deposit WO_3 films. Our preliminary spectral, structural

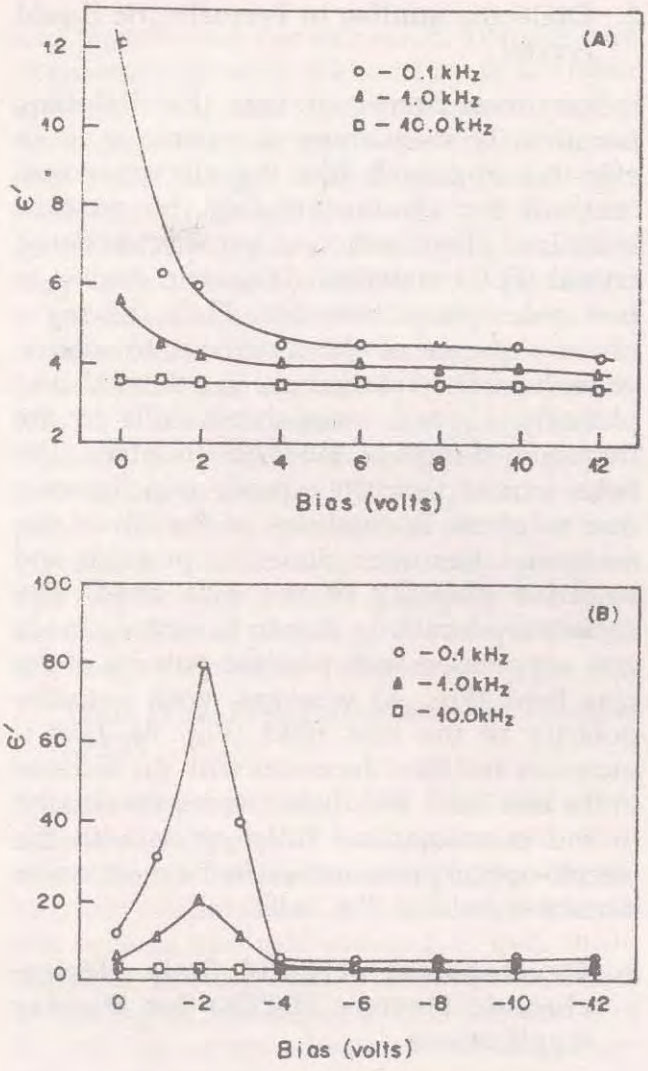
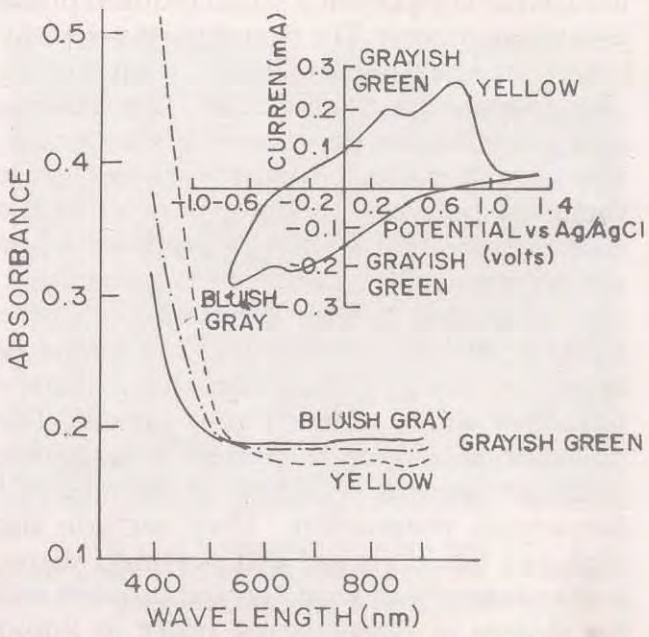


Fig. A, B. Effect of biasing voltages on the dielectric permittivity e' due to the Goldstone mode at different frequencies when positive (A) and negative (B) polarity field is applied to the rubbed surfaces of the cell.

investigations on such films have shown their suitability for ECDs. Using sol-gel technique V_2O_5 films were also deposited on ITO coated glass substrates and were used as optically passive counter electrodes (CE) in ECDs. The observed reproducible optical modulation in such ECDs was attributed to the good ion storing capacity of the CE controlling the charge transfer at the primary EC electrode. Detailed optical, structural and electrochromic properties of the sol-gel deposited V_2O_5 films have been carried out (see figure).



Optical spectra & voltammogram of sol-gel deposited V_2O_5 film.

4. Conducting Polymer Membrane Filters

(i) One of the most important features of conducting polymeric materials, which are being used for making conducting membranes, is to have full knowledge about the different parameters, which influence the charge transport in this system. We have demonstrated in the field of conducting polymers that the radius of the polaron (r_p) i.e. the radius of the charge carrier in a polarized lattice, can be quantitatively predicted and this information has been used to make true quantification of the density of states at Fermi level ($N(E_F)$) in polypyrrole, poly (N-methyl pyrrole) and poly (N-methyl pyrrole - pyrrole).

ii. By using the dielectric strength and spin density obtained from dielectric and electron spin resonance data respectively, in the field of conducting polymers we have evaluated the average site spacing (r) i.e. the distance between two charged sites involved in the conduction process in

polypyrrole, poly (N-methyl pyrrole) and poly (N-methyl pyrrole - pyrrole).

These two important findings would help the scientific community towards the better understanding of the molecular designing of conducting polymers suitable for various device applications.

iii. In the present investigation we have used a model of multiple dielectric relaxation to explain our experimental results. The experimental results suggest the application of two relaxation mechanisms to explain the temperature and frequency dependences of ac conductivity which form the basis of our proposed model for charge transport in this systems. In this model it is asumed that the measured ac conductivity $\sigma(\omega) = \sigma_1(\omega) + \sigma_2(\omega)$; in which the two mechanisms of charge transport may be associated with (i) hopping of the charge carriers excited to the localized band tails giving rise to dielectric loss peaks, and (ii) hopping of the charge carriers near the Fermi level giving a linear frequency dependent conductivity. As a representative result the model calculations for one sample of poly (N-methyl pyrrole - pyrrole) copolymer film is shown in Fig. 1. The estimation of site spacing (r) suggests that the charge carrier localization in these systems is about per 4-8 pyrrole rings. A correlation between dielectric relaxation and dc conductivity is established and it has been found that both originate from the same hopping process.

(iv) The conducting polymeric filters (membranes) developed from polypyrrole family of polymers were tested for virus retention on it by using Plaque Assay and Polymerase Chain Reaction (PCR) techniques by Department of Microbiology, AIIMS, New Delhi. It has been found that some of the membranes arrest almost 100% viruses on it. The optimization process for the preparation of membranes are in progress.

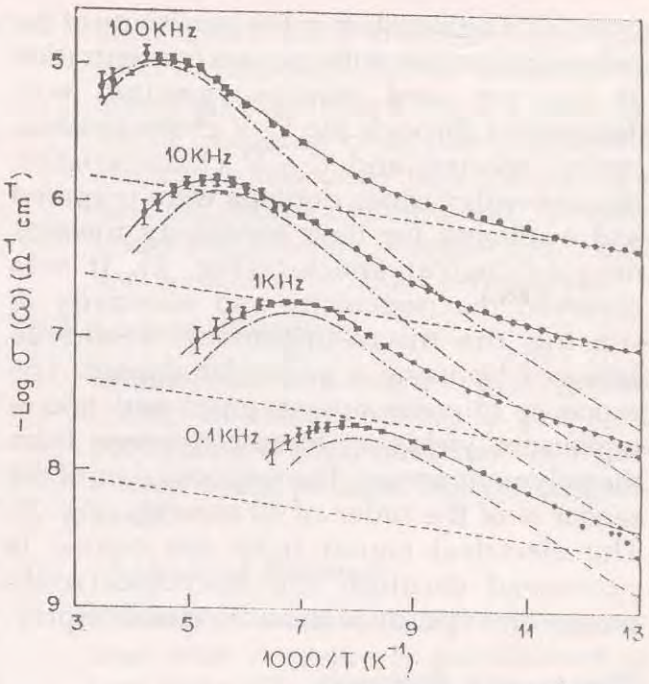


Fig. 1. The dash-dot curve shows the contribution of $\sigma_2(\omega)$ calculated by Cole-Cole equation. The dashed line gives the contribution of $\sigma_1(\omega)$ calculated by Mott's relation. The solid line gives the sum of the two contributions $\sigma_1(\omega) + \sigma_2(\omega)$. The experimental values of ac conductivity $\sigma(\omega)$ is marked by solid circles. Error bars indicate the uncertainty in the experimental points.

5. Polymeric Sensors

Polymeric thin film based sensors have been developed for monitoring gases in environment and detection of microbiological species. Their sensitivity towards pathogenic and non-pathogenic biological species and bacteria have been studied. Sensors prepared from polymer pellets and vacuum evaporated thin films doped with Al, Fe and Cu & Ni were tested at NPL New Delhi, DRDE Gwalior and Defence Laboratory, Jodhpur. The process parameters for batch production of polymeric thin films sensors have been standardized. Evaluation of polymer thin film sensors for CO was carried out at CMRI Dhanbad (Fig. 1). The sensitivity threshold of these sensors was observed to be in the range 2 - 5

ppm CO. The variation in the sensitivity of the polymeric sensors with various concentration of the gas and micro-organism was determined through the I - V characteristics, optical spectra, and C - V characteristics. Sensors with various dopings were prepared and evaluated for their sensitivity towards microbiological species (Fig. 2). It was observed that specificity and selectivity in sensing the micro-organisms could be achieved by using a particular dopant. The exposure to environment, gases and micro-organisms, yields an instant response from the polymeric sensor. The response time of the sensor is of the order of 10 seconds (Fig. 3). The electrical signal from the sensor is processed through the microelectronic processors to produce an audio visual display.

Electro-optic Polymers

Semiconductor polymer thin film devices have been prepared for Integrated Optics. Polyaniline thin films have been found promising for integrated optics. The fabrication and optical characterization of vacuum deposited

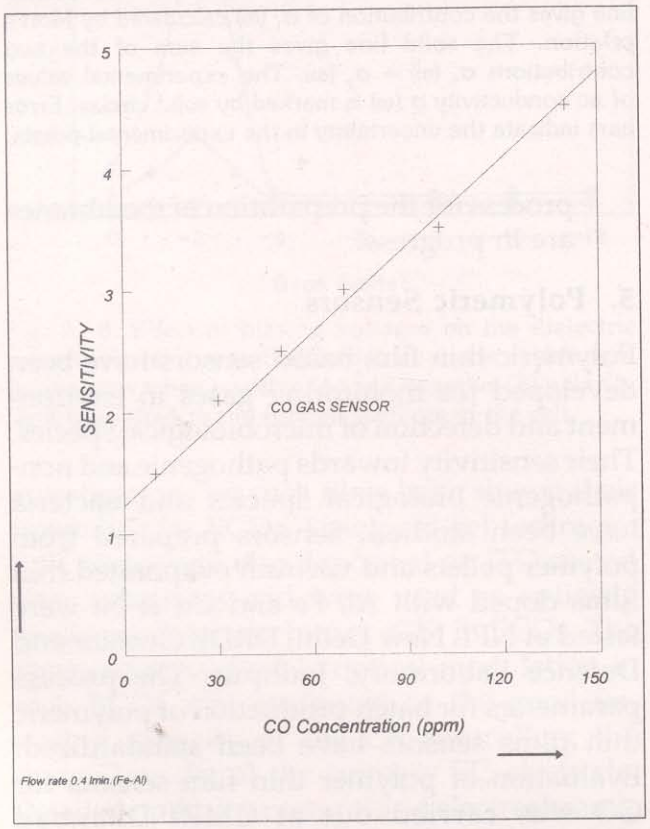


Fig. 1. Sensitivity of thin film polyaniline sensors for CO

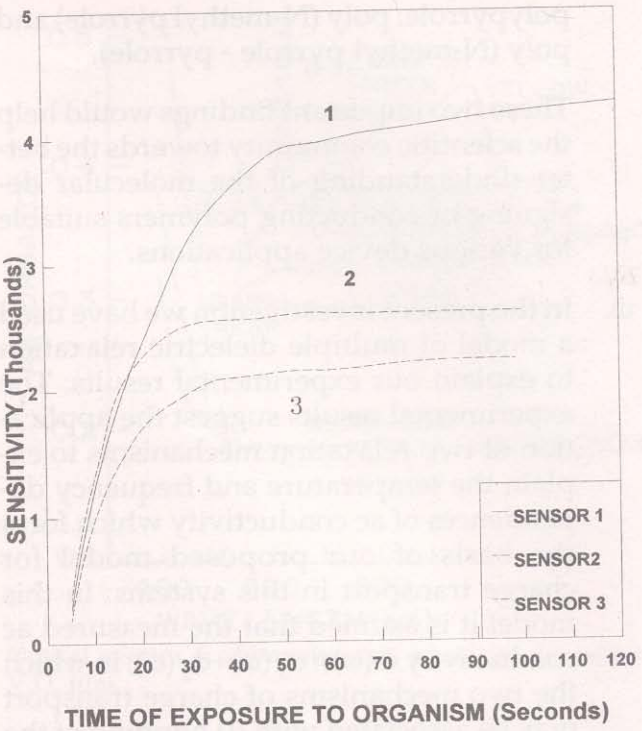


Fig. 2. Sensitivity of polyaniline thin film sensors for microorganism

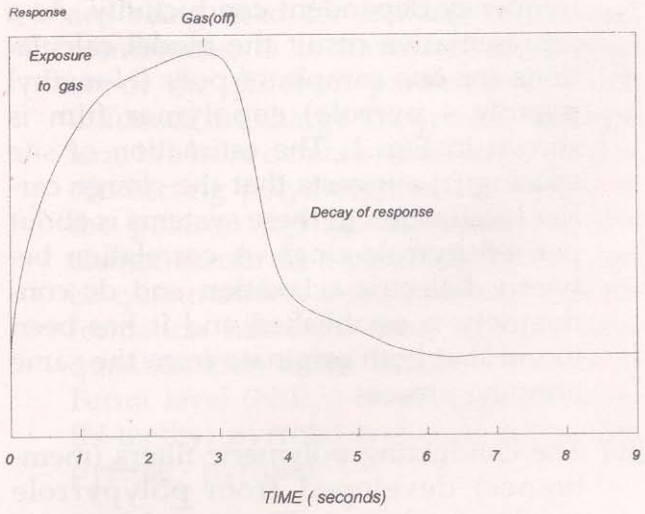


Fig. 3. Response of polyaniline thin film sensors

polyaniline thin film optical waveguides and their coupling with semiconductor devices for use in integrated optics has been carried out. The waveguide parameters of polyaniline films were determined to assess the non-linear optical properties of the thin films.

A method has been developed to determine the energy band gap and energy states in non transparent polymer thin films, using optical reflection spectroscopy.

Alloy Thin Films

The electrical switching and structural analysis of semiconducting alloy thin films of selenium - arsenic - tellurium and binary alloys of zinc - cadmium, in collaboration with Department of Physics, Meerut University, were carried out by Auger electron spectroscopy and X-ray diffraction.

6. Biosensors

(i) Glucose Biosensor

The thermal stability of glucose oxidase (GOX) in polypyrrole (PPY) was experimentally investigated by differential scanning calorimeteric (DSC) technique. A broad distribution in the temperature range, 35-40°C and a well defined peak at 60°C were found in the DSC curve recorded for native GOX. The GOX immobilized on PPY showed an endothermic peak at 54°C attributed to the denaturation of GOX. The endothermic ethalpy determined from the area under the curve was found to be 65.345kj mol^{-1}. It has been tentatively shown that GOX molecules physically adsorbed on PPY exhibit co-operativity between the various structural domains.

Glucose biosensor developed at NPL has been marketed by Gamma Instrumentation Pvt. Ltd., Faridabad.

(ii) Urea Biosensor

Immobilization of urea in polyaniline electrochemically prepared films has been carried out. It has been found that upto a maximum of two units can be immobilized in these films. The potentiometric response of urease-polyaniline electrodes has been determined as a function of urea concentration. The electrodes are presently sensitive upto 9 mM and are stable for about seven days.

(iii) Lactate Biosensor

Immobilization of lactate dehydrogenase (LDH) in electrochemically prepared polyaniline (PANI) films has been conducted using physical adsorption technique.

(iv) Cholesterol Biosensor

Cholesterol oxidase (COD) and peroxidase were respectively immobilized in tetra-ortho-silicate (TEOS) (sol gel film) by micro encapsulation technique.

Conducting Polymers

Metal-insulator-semiconductor (MIS) structures were fabricated by vacuum deposition of various metals like indium, aluminium and tin on Langmuir Blodgett films of cadmium stearate (Cd St_2) obtained on polypyrrole (PPY) films electochemically deposited on indium-tin-oxide glass. Junction parameters such as rectification ratio, barrier height and work function of such devices were experimentally determined Passivation of semiconducting polypyrrole films is seen to result in a lower value of the ideality factor.

A semi solid electrochomic display has been fabricated using polypyrrole film. It has been shown that the kinetics of the process is controlled by ionic diffusion for polyethylene oxide (PEO) containing electrolytes whereas the current decay has been demonstrated by proton environment movement or counter ion motion for the film containing p-toluene sulphonate + lithium perchlorate + urea.

It has been shown that electrochromic displays based on polycarbazole can be fabricated. Such an electrochromic display

exhibits excellent contrast between green (oxidised) also pale yellow (reduced) states.

Tetraethyleortho silicate (TEOS) derived sol-gel films have been utilized for the electrochemical polymerization of aniline. The presence of electroactive polyaniline (PANI) within the porous skelton of the TEOS sol gel film has been confirmed using cyclic voltammetry (Fig. 1), UV-visible, infra red

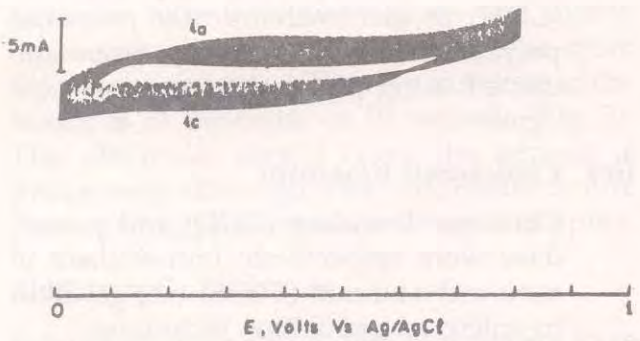


Fig. 1 : Potentiodynamic growth of PANI in TEOS-derived sol-gel/ITO surface (area = 3.25 cm^2) in the potential region 0.0-0.8 V versus Ag wire at a scan rate = 10 mVS^{-1} for 22 cycles.

spectroscopy and scanning electron microscopic measurement.

Langmuir Blodgett Films

It has been shown that transferrable Langmuir Blodgett monolayers can be formed at the air-water interface by dissolving polyemraldine base in a solution of N-methyl-2-pyrrolidinone (NMP) and $CHCl_3$. The Langmuir Blodgett (LB) films of polyemraldine base have been deposited on quartz substrates. These LB film have been characterized using UV-visible and FTIR techniques. With a view to investigate the thermal stability of Langmuir monolayers of emraldine base, pressure-area isotherms (Fig. 2) have been obtained covering a wide range of temperatures from 9.2 to 40°C, when the emraldine base is dissolved in a solvent comprising at 40% NMP and 60% $CHCl_3$. It has been found that the L-G phase transition occurs when the area per molecule of emraldine base changes from 27 to 35A^{02}. The solid condensation area is however, observed to change from 15.91 to 17.0 A^{02} as the temperature varies from 9.2 to 40°C. Interestingly, the nature of the various pressure area isotherms remains the same indicating the thermal stability of polyemeraldine base on the

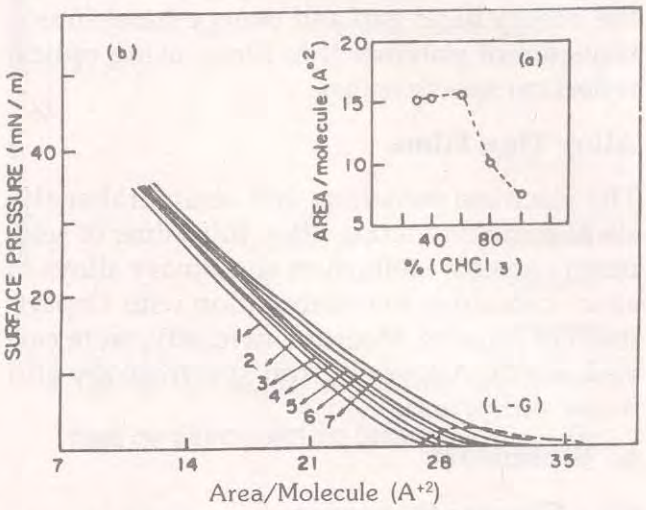


Fig. 2: (a) Variation of area per molecule of polyemeraldine base as a function of NMP containing varying percentages of $CHCl_3$ at a pressure of 25 mN m^{-1}. (b) Variation of the pressure-area isotherm as a function of temperature at 9.2°C (curve 1), 15°C (curve 2), 22°C (curve 3) 26°C (curve 4), 29°C (curve 5), 34°C (curve 6) and 40°C (curve 7)

surface of water.

7. On-line Determination and Systematic Recording of Sugar Contents in Sugarcane Jiices and Sugarcane Solids

A number of synthetic samples of different sugar concentrations have been prepared in the laboratory and their infrared spectra have been recorded in Attenuated Total Reflectance (ATR) mode. A suitable range has been selected for quantitative determination of sugar contents in sugarcane juices and sugarcane solids. Later, in the month of January, 1997 the instrument has been shifted to Mawana Sugar Works, Mawana for doing the calibration on real samples. The calibration for Mixed juice, Primary juice and Clear juice

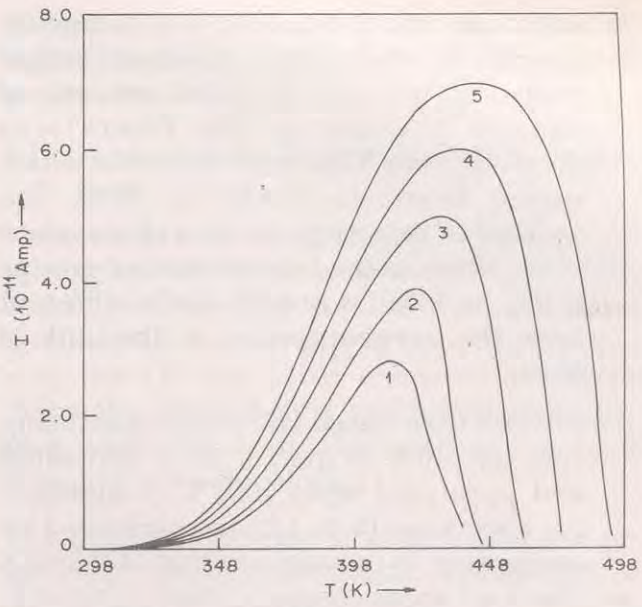
have been done on 125 samples each cases.

8. Optical and Electrical Properties of Langmuir Blodgett Films

During the year a number of Langmuir Blodgett films of organic and polymeric materials have been fabricated on various substrates. Optical characterisation is done using UV-visible spectroscopy and Fourier Transform Infrared Spectroscopy of all the samples. The UV-visible data of poly (o-toluidine) films show the shifting of bands in the doped from which probably could be due to the π-π^* transition after doping. Surface morphology at elevated temperature is studied using optical microscopy of arachidic acid and cadmium arachidate. The microscopic results show small defects in the films. The defects increase in size as the temperature is raised. The degradation of films is confirmed by Fourier Transform Infrared Spectroscopy. Electrochemical properties of conducting Poly (o-toluidine) LB films are studied using cyclic voltammetric techniques.

Xero radiography

To develop new and better X-ray imaging materials for xeroradiography photoreceptors fundamental investigations were carried out in organic polymers such as PVDF, PVF, VCl_2 : VC copolymer with regard to the study of charge storage mechanisms, etc especially in their vacuum deposited film forms to use them as interfacial barrier layers for enhancing the X-ray sensitivity of xeroradiography photoreceptors. The enclosed Fig. 1 shows the first time investigations in vacuum deposited PVF films with regard to the polarisation process in this potentially useful polymeric material. The Fig. 1 shows the TSD curves of PVF films about 1 µm thick polarised at a fixed field of about 8 Kv/cm and polarisation time of about 1.25 hour but at different polarisation temperature. Curves 1 to 5 correspond to polarisation temperatures of about 313, 353, 393, 433 and 453 K, respectively. These curves show a strong dependence of the relation



TSD spectra of PVF films (~1 µm) at fixed polarisation field about 8 KV/cm and fixed polarisation time 1.25 hour bût for different polarisation temperatures. Curves 1 to 5 correspond to polarisation temperatures of 313, 333, 353, 393 and 433 K, respectively.

peak, in terms of its position, magnitude of charge, and activation energy, on the polarisation temperature. The important finding of these investigations is the distributed space charge being suuggested as the dominant mechanism responsible for the polarisation in PVF and this space charge formation has been attributed to migration of charge carriers at macroscopic distances and their subsequent trapping at trapping levels which are distributed in the range of energies between 0.55 and 0.69, eV, respectively.

CARBON

I. Carbon Composites

A. Pyrolysis behaviour of panex fiber based polymer composites

Under the Indo-French sponsored project which has initiated in March 1996, oxidised PAN fibers were prepared possessing different surface energetics. PANEX fibers were characterised for their physical and mechanical properties,

enthalphy change ΔH, surface energetics by ESCA and Direct Contact angle measurement and the total amount of oxygen present in the fibers was determined by Elemental Analyser which varied from 4% (PAN) to 21%. The amount of oxygen present on the surface of the fibers in the form of surface groups (7.8% to 14%) is substantially different from the oxygen present in the bulk of fiber.

PANEX fiber based UD composites using coal tar pitch as matrix were fabricated and pyrolysed upto 1000°C. Longitudinal shrinkage (8 to 10%) experienced by composites is the same as that of PANEX fibers whereas cross-sectional shrinkage in composites is influenced by fiber/matrix interactions which further depend on the surface energetics of the reinforcement. The fiber/matrix interactions in composites also influence the char yield of composites which is around 55 to 60% compared to 45 to 50% in case of coal tar pitch and PANEX fibers.

B. *Development of carbon fiber composites illizarov ring fixator for orthopeadic applications*

The main objectives of the project were development of CFRP half ring fixator as replacement of currently used stainless steel ring. The main advantages of CFRP rings are savings in weight and proper monitoring of the fracture site due to transparency of the carbon composite rings to X-rays. Under the above mentioned DST sponsored project. S.S. Illizarov fixators were characterised for their mechanical properties under compression loading. The compression load at yield point was 120 Kg and the K wire used for giving tension to the ring showed a tensile load of 100 Kg at yield point.

Carbon fiber based half rings (ID = 160 mm, OD = 175 mm and thickness = 5 mm) were fabricated using different resin systems such as Epoxy, Phenolic and Polyester. Characterisation of some of rings was carried out for density, thickness uniformity and compression loading with holes and without holes. Compression loading for rings without holes was around 190-200 Kg whereas it decreased to 120-130 Kg for the samples with holes of 7 mm.

C. *Oxidation Resistant Carbon/Carbon Composites*

Investigations were carried out to enhance the oxidation resistance of Carbon/Carbon Composites which are widely employed in aerospace applications. The following methods were adopted to increase the oxidation resistance and also to develop oxidation resistant composites.

1. Carbon/Carbon Composites were coated with sol-gel derived silica (SiO_2) and silicon carbide (SiC) precursors which were later heat treated under suitable atmosphere to get silica and silicon carbide coated composites.
2. Carbon/Carbon composites were also coated with zirconia - silica (ZrO_2 - SiO_2) by sol-gel technique.
3. Carbon/Carbon composites incorporated with silicon carbide were developed by employing sol-gel method. The advantage of the method was that silicon carbide precursors could be homogeniously mixed with the matrix material which was impregnated on carbon fibre/cloth. Different silicon alkoxides and their mixtures were tried to arrive at the suitable material which can yield oxidation resistant SiC/C-C composites with required mechanical properties.

Of the above methods the C/C

compsoites coated with SiO_2, SiC and ZrO_2 - SiO_2 enhanced the oxidation resistance but had certain limitations.

The method in which SiC could be incorporated in the processing stage has many advantages. The distribution of SiC is more uniform and it makes part of the matrix and this enhances the oxidation resistance and mechanical properties.

Work was also carried out to prepare silica monolithis which also have many engineering applications. Silica monoliths were synthesised by sol-gel technique employing DCCA. The products obtained by this method were found to have carbon residue and porous. Hence a new technique was developed in which silica monoliths were prepared by using azeotropic solvent mixture. The monoliths obtained using this newly developed technique were crack free and did not have carbon residue.

Sol-gel method was exploited for developing Pt/silica catalyst. The applicability of the catalyst was tested by hydrogerating cyclohexene to get cyclohexane at different temperatures.

II. Specialty Carbons

Extensive work was done on the development of high density graphite from self-sintering carbonaceous powder (green coke) obtained from coal tar pitch by suitable treatment under a project sponsored by Graphite India Limited, Bangalore/Calcutta. It was observed that the sinterability of a carbonaceous powder is highly sensitive to its coking value and solvent analysis. A good carbonaceous powder leads to plates which on heat-treatment to 2500°C are found to possess an apparent density of 1.94 gm/cm3, bending strength of 61 MPa, Shore hardness of 72 and an electrical resistivity of 1.7 m Ohm cm. Besides this, the plates to develop products of size 30 mm x 30 mm x 20 mm and 25 mm dia required in the sponsored project.

III. Fiber Grade Pitch and Fibers Therefrom

Varieties of coal tar pitches were studied by mixing suitable organic solvents with varing concentrations. The soluble fractions were distilled till the solvents evoporated. In this way the QI free pitch compositions were thermally treated in a controlled temperature profile and suitable pitches for fibre drawing were developed.

The pitch fibres were drawn, under the required pressure, from the derived pitches in the spinneret assembly developed at NPL having multi filament nozzles. The pitch fibres were oxidised and further carbonised to get pitch based carbon fibre.

IV. Brushes

1. Supplied 250 nos of each grade of Brushes to HAL, Nasik for field trials.

   250 Nos. of MGS-8; catagory PR-72005

   250 Nos. of MGS-7; catagory PR-72002

V. Development of the rocking chair carbon fibre battery

As a part of the collaborative programme with CECRI, Karaikudi, NPL have prepared four nos. of carbon samples based on HM-45, T-300, Natural Graphite - 150 mesh and RK-3000 and processed them to CECRI for their evaluation to charge/discharge experiments. One of the typical report of the testing of the samples as indicated by CECRI is that the lithium cells thus fabricated were put for trials in 1M $LiClO_4$ in 70:30 EC/DMC and 1M $LiAsF_6$ in 70:30 EC/DMC and 25 cycles have been so far obtained.

Encouraged by the progress of the above cited works, our laboratory carried out basic studies on PAN based carbon fibres using aqueous lithium chloride and lithium

perchlorate. Corrosion rate, exchange current density and other electro chemical parameters have been obtained using Impedance technique. Surface morphology of the carbon electrodes have as well been performed employing SEM. This work was presented in the National Conference on Carbon at Kanpur during December 19-20, 1996.

THIN FILM SYSTEMS

Amorphous Thin Films, Devices and Systems

i Diamond like carbon (DLC) films find many applications due to their extreem hardness (30 GPA), low coefficient of friction (0.1) high transmission in the infrared and to their immunity from chemical attack. However, they can not be made sufficiently thick due to high value of compressive stresses of about 4-6 GPA or more when grown by the conventional Rf self bias technique. This way we succeeded in growing DLC films with thickness more than 2.0 μm on glass substrates without delamination of the film on storage.

ii A novel technique to seperate the ionic and neutral radicals from the beam coming out of a saddle field fast atom beam source has been made using a positively baised deflector arrangement. DLC films have been grown simultaneously by these ionic and neutral radicals of CH_4 gas, onto the substrates placed at two different positions. Faraday up measurements carried out on the two beams confirm the separation of ionic and neutral radicals. A measurement of neutralisation coefficient reveals that under certain conditions of operation saddle field sources indeed produce vastly different amount of charged precursors. Films formed with entirely neutral, entirely charged and partly charged and partly ionised beams reveal that the optical absorption as measured by a PDS setup in DLC films grown using entirely ionised precursors in the lowest whereas a partly charged and partly neutral beam deposition leads to the deposition of hardest DLC films.

iii Thick a-Si:H p-i-n layers were developed to suit the requirement of X-ray detector development work of IIT, Kanpur undertaken jointly with BARC (BRNS funding). The devices supplied by NPL on testing were found to give noise figures comparable to the best reported `and using these' p-i-n a-Si:H devices X-ray detection was performed.

iv DLC films which contain high percentage of tetrahadralily bound carbon atoms i.e. high Sp^3/Sp^2 ratio (>75%) are known as amorphous diamond or ta-C. Such films show improved electronic properties and have aroused a lot of interest for the fabrication of Field Emission type flat panel displays. A system to deposit these films by a technique known as Filtered Vaccum Arc Discharge has been set up. This technique once mastered and scaled up will be suitable for production of TiN films for many industrial applications.

Optical Coatings

i *Mixed Composition Infrared Optical Thin Films :* Films of Zinc Sulphide - Thorium Fluride and other compositions, in different proportions by weight were deposited and characterised for their optical and mechanical properties. It is found that for certain composition built up stress in these films reach a minimum value. This information is of significant importance in designing multilayers for professioal optical coatings for the infrared.

ii *Infrared Optical Filters :* Narrow-band interference filters with central wavelengths from 0.85 to 3.2μm have been fabricated during this period and designs

for filters for higher wave-length were obtained and materials required for coating etc. identified.

With the increasing importance of pollution monitoring, several agencies are approaching NPL for calibration as well as fabrication of Neutral Density Filters. We have fabricated N.D. Filters for M/s ARAI and calibrated N.D. Filters for M/s ARAI and AVL.

HIGH PRESSURE TECHNOLOGY

The work on the synthesis of cubic boron nitride (cBN) crystals using amorphous boron nitride/turbostratic boron nitride (aBN/tBN) under high P-T conditions in the presence of a catalyst-solvent was extended to include some non-conventional catalysts. It may be mentioned that cBN is usually synthesized under high P-T conditions in the presence of a conventional catalyst namely the alkali metals, alkaline earth metals and their nitrides. Our earlier investigations carried out on cBN synthesis using conventional catalyst-solvents namely magnesium and magnesium boron nitride had shown some interesting and new results with respect to the minimum pressure required for cBN formation (25 kb at 1800°C). In order to study the behaviour of less ordered boron nitride under high P-T conditions in the presence of non-conventional catalyst, iron metal was selected with a view to study (i) the effectiveness of non-conventional catalyst solvents in cBN synthesis (ii) to confirm our earlier findings regarding the role of three dimensional ordering in the starting boron nitride in cBN conversion under high pressures and temperatures using conventional catalysts.

Our detailed investigation on tBN and Fe system under high P-T condition shows that Fe is not as efficient catalyst as the conventional catalysts (magnesium, magnesium boron nitride etc.) in the cBN conversion with respect to the yield and quality of the crystals synthesized. However, the results suggested that even in the case of a non-conventional catalyst-solvent, the use of low ordered boron nitride as the starting material brings down the minimum pressure for cBN conversion significantly.

Some exploratory investigations on the behaviour of glassy/turbostratic carbon under high P-T conditions in the presence of Fe was also undertaken.

We have rendered assistance to Display Devices and Instrumentation Groups of NPL in the preparation of large number of pallets of various samples of different sizes used in their R & D work. Microhardness measurement of different thin films samples of Thin Films and Amorphous Group have also been carried out.

METALS & ALLOYS

Work was extended on the development of high strength-low weight Hi-tech materials for different aerospace applications. Collaboration was sought at both international and national level with different R & D institutes/agencies on the development of these materials.

I. International Collaborative Projects

a *Development of Advanced AlLi-MMC Material with Low Density and High Stiffness for Aerospace Industries" - Germany*

The development of advanced AlLi-MMCs with Li content upto 5 wt% and SiC particulates as reinforcement upto 20 wt% has been employed, using Rapid Solidification technique with additional well established hot deformation techniques. AlLi alloys produced by conventional metallurgical methods are limited to Li levels of about 2.5 wt%. Above this level difficulties are experienced in casting of ingots, especially due to the formation of course second phase particles, deterimental to the mechanical properties. Institute of Material Research

(IFAM), Dresden, Germany, and NPL, New Delhi, are jointly collaborating to carry out the developmental work on this promising technology. A M.O.U. was also signed between IFAM, Dresden, Germany and NPL, New Delhi in April '96 on a joint collaborative project, for a period of two years.

Exploratory deformation work was carried out on the sintered, Powder Metallurgically processed, billets of this material, using a 500-ton vertical hydraulic press. The products were characterized at NPL, IFAM, Dresden and by Air-Bus Industries. Initial exploratory work has yielded very encouraging results. The density obtained in these MMCs was 2.44-2.46 gm/cc and maximum modulus achieved was 102.7 GPa with 17.5 wt% SiCp. A second batch of hot deformed products were produced at NPL in February '97 and have been sent to IFAM, Germany for further characterization.

b. *"Development of Precision Forging to Manufacture Near Net Shaped Automobile Parts"- Japan*

Another important activity being pursued in NPL is on the development of cold and warm forging technology for the manufacture of automobile components. A collaboration with the Japanese R & D institutions, engaged in the development of the technology, was sought to develop this technology considering its potential for the Indian Industry.

Magnesium alloy (ZK 30) Square Tube for Space Applications

Oval Shaped Tube for Advanced Light Helicopter

The main objective of this collaborative project is to cary out tool design, selection of sequence of operation and finally to develop near net shaped forgings.

II. National Collaborative Projects

a *"Development of Square Tube of Mg-alloy (ZK 30)" for Space Programme of Vikram Sarabhai Space Centre, Trivandrum*

The developmental work was taken up jointly by NPL, New Delhi and VSSC, Trivandrum, pertaining to the development of Payload Adaptor Structure of PSLV/GSLV in ZK30 Mg alloy. The proposed use of Mg alloy for the payload adaptor will lead to significant weight savings over the presently used Al-alloy version. Initial exploratory work to hot extrude ZK 30 Mg-alloy in form of a square tube (as shown in figure) have been quite successful. These square tubes developed at NPL have been characterized and have met the desired specification.

b. *"Development of Oval Shaped Tube for Advanced Light Helicopter as Skid Landing Gear"*

Helicopter Design Bureau of HAL, Bangalore, have been in contact with NPL for the development of oval shaped tubes to be used in their Advanced Light Helicopter as Skid Landing Gear. The initial feasibility studies for the development of the oval tubes (reduced size) have been completed at NPL and a prototype (reduced scale) oval tube one meter in length has been successfully produced (as shown in the figure). Consequently a project proposal has been submitted to HAL for funding the technology development of 150 x 100 mm oval tubes in length of about 4 meters.

III. Inhouse/Sponsored Research Projects

a *AR & DB sponsored project - "Spray Deposition and Property Evaluation of Aluminium Matrix Composites"*

A 40 kW induction furnace was installed in the Spray Atomization and Deposition (SAAD) Unit. All ancillary units of this induction furnace like cooling tower, water tank, copper induction coil, etc. have been erected and water pipes laid down. A hydraulically operated substrate movement assembly with fine rotary and vertical movement has been designed and is expected to be installed in the SAAD unit shortly. A purging unit assembly, for nitrogen/argon gas supply employed during melting and atomization/deposition, has been designed. A one-ton wall mounted Jib crane has also been installed on the SAAD unit for facilitating the experimentation and maintenance of the SAAD unit.

All these sub-assemblies would then be coupled with the vacuum chamber and total SAAD unit would be commissioned by December 1997.

b. *DST sponsored project - "Deformation Behaviour of Composite Materials"*

This project has been successfully completed in September 1996. Under this project the 2124 Al-alloy+SiCp Metal Matrix Composites (MMC) rods and tubes were successfully developed with the desired mechanical target properties. An economical alternative post-processing technique for the MMC billets, made using powder metallurgy technique, was developed which yielded exruded products with better mechanical properties. Using this new technique, thin walled MMC tubes of Al-alloy+SiCp were made and exhibited better metallurgical and enhanced mechanical properties.

MATERIALS CHARACTERIZATION

CHEMICAL METHODS

During the year, the work on testing and calibration of instruments received from different organisations were carried out and 155 test reports were issued to e.g. various industries, election commission of India and various development projects of the lab. e.g. Indian reference Materials and Electrochromic Display Devices etc.

Research & Development

The development work on preparation and characterization of material, atmospheric chemistry and Aerosoles measurement were carried out during the year

Preparation & characterization of gallium nitride powder was undertaken as GaN is the most promising material for electronic devices, LED and detector in the uv region. GaN was synthesized by heating Ga_2, O_3 in a stream of dry ammonia & nitrogen gas. The final products were characterized by using XRD. The XRD pattern of the powder sample synthesized at 900°C shows GaN (Hexagonal) phase formed along with trace amount of gallium nitrate.

— Hydride generation kit was assembled and method of determination of arsenic in low concentrations of the order Sppb was optimised by generation of arsenic hydride and its detection by flame AAS. Four standards of arsenic in the range 1--100 ppb were prepared & supplied to four National Laboratories for use as reference solutions for testing water for drinking purposes.

— *A highly sensitive method was developed for the determination of trace quantities of Germanium in waste water of semiconductor industries*. The method works on the principle of formation of an orange coloured complex of Ge with phenyl fluorone as complexing agent. A no of surfactants of quarternary ammonium salt type were tried to improve the stability of the complex. The method has been successfully applied for determination of Germanium in high purity silicon and quartz used in semiconductor devices. A number of measurements for ppm nitrate solution were done for IRM project using Ion chromatograph. Measurements were done for multi element standards consisting of Cu, Fe and Zn by flame AAS to be used as reference materials for IRM project.

Atmospheric Chemistry

Chemistry Division has been carrying out research in the IGAC project of IGBP since last few years in collaboration with various institutes in India for greenhouse gas (GHG) emissions from agricultural sources and with international Meteorological Institute (IMI), Stockholm for precipitation and aerosol studies.

Indian Ocean Experiment (INDOEX)

An International Programme called Ocean Experiment (INDOEX) has been initiated which is being coordinated by NPL. Ist and 2nd precampaigns of this programme have been successfully carried out on board Sagar Kanya on cruise 109 between Jan. 2 and Feb. 8, 1996 and cruise 120 between Dec. 27, 1996 and Jan. 31, 1997. The main programme will be carried out in 1999. Our group is planning to participate in the same by carrying out shipborne measurements and in particular for measurements of greenhouse gases, aerosoles, precipitation SO, and NO. using different techniques.

INDIAN REFERENCE MATERIALS

Work on preparation of Bharatiya Nirdeshak Dravya (BNDs) i.e. Certified Reference Materials has been continued. Ten litre stock solution of two new Certified Reference Materials (i) nitrate in high purity water and (ii) Multi-element standard containing copper, iron and zinc in high purity water have been prepared at NPL. Analytical data received from different participating laboratories have been compiled and it is under statistical analysis to assign certified values alongwith standard deviation and random uncertainty values to these solutions. These materials will be released shortly.

In a meeting of scientists organised at Central Salt and Marine Chemical research Institute, Bhavnagar on December 4, 1996. It was decided to initiate work on preparation of next batch of lead, cadmium, arsenic and chromium standards in high purity water and new single element standards of copper, iron and zinc in high purity water. It was also decided to prepare a plan for preparation of Pesticide Standards.

Market survey has also been conducted to assess the need of Certified Reference Materials in the country. A questionnaire had been prepared and it was despatched to 400 different R & D organisations belong to private and public sectors. The survey shows that 55% organisation are aware about the importance of the use of reference materials in calibration of analytical instruments and validation of analytical methods to get precise and accurate measurements, but they are finding difficulties in their procurement. The majority of CRMs required in the country are elements (50%) and pesticides (20%). The rest 30% demand is in the area of other miscellaneous type of CRMs. The predicted growth in annual consumption of reference materials is about 50%. 10% organisations offered to provide assistance in decimination of BNDs prepared by us.

SURFACE AREA & POROSITY

Twenty five samples were prepared at NPL using precursor pretreated at HEG. These sample were characterised for BET surface area. Some of the samples were tested for tensile strength. Trial runs carried out on experimental set up. Attempts were made to tackle the problem of air leakage in the system. Proper arrangement at the entry and exit were made, exhaust system was improved considerably. Inspite to these changes still significant leakage of air was observed. Finally a new reactor was designed which is now under fabrication. Several sample, prepared at HEG, were tested in NPL.

Thirty nine samples of Activated carbon cloth were prepared. Sixteen samples were characterised for pore structure parameters.

The studies made during this period indicate the following results

1. Heat treatment temperature for the preparation of activated carbon cloth possessing super high surface area was optimized for minimum energy inputs.
2. The minimum temperature range in which the reaction of carbon dioxide with carbonised material is initiated was identified and found to be 600-700°C.

FTIR EMISSION SPECTROSCOPY

Under the DST sponsored programme, TGS Pyroelectric Infrared Detectors have been developed. They have high sensitivity, good frequency response and operate at ambient temperature. They have uniform response over a wide wavelength range of black body source. Windows and optical filters limit the wavelength response. Pyroelectric detectors belong to a special category of thermal detectors in which response depends upon the rate of change of surface temperature of the sensing element rather than the change of temperature of the material as is the case of thermal detectors. TGS and doped TGS have

very high figure of merit as the ratio (P/ε) of the Pyroelectric Coefficient (P) to the Dielectric Constant (ε) is highest, in these materials. Practically all the modern infrared spectrophotometers such as FTIR and laser power meters employ pyroelectric detectors. These are used in different industries, R & D Organisations, Universities and in defence projects. No Indian firm is manufacturing them and these are imported from certain manufacturing houses in USA and Great Britain.

FTIR spectroscopy was used to characterise the bondings of hydrogen and nitrogen atoms in silicon nitride films. Low temperature studies have shown SiH_2 bending and wagging modes as well as the SiH strectching modes. Phonon spectroscopy was used to reveal molecular species in hydrogenated silicon nitride films. Broad IR absorption band in 700 to 1100 cm^{-1} as observed by other workers was shown to comprise of three bands at 742, 826 and 890 cm^{-1} in low temperature measurements.

EPR SPECTROSCOPY

Characterization of different materials for paramagnetic centres by EPR spectroscopy was provided to various projects of NPL and outside organisations. EPR investigations of vanadyl ions in $xCoO.(1-x)(ZnO.2B_2O_3)$ glasses show that on increasing the CoO:ZnO ratio, the octahedral symmetry at V^{4+} site improves and 3 dxy orbit of V^{4+} contracts. Such change in site symmetry was observed only when diamagnetic modifier of the glass composition was replaced by paramagnetic modifier. Values of theoretical optical basicity were found to increase with increasing CoO content suggesting thereby that bond length of V^{4+} -vanadyl oxygen should increase and this prediction was found to be in agreement with the experimental findings. In phosphate glasses broadening of EPR lines with increasing CuO content was assigned to dipole-dipole interaction between different transition metal ions. Further work on such glasses is in progress.

X-RAY DIFFRACTION & FLUORESCENCE

X-ray diffraction and fluorescence studies were carried out for about 385 samples of materials including high Tc superconductors and their films, gall bladder stones, C/C composites & fibres, fi' as of PLZT, WO_3, gadolinium oxysulphide on glass plates, SiC, cBN, ZnSe, CdTe, GaN, activated carbon cloth, cordierite, hydroxylapatite, orientation studies of Si single crystal, corrosion product and bundles of cotton fibres etc. Assistance was provided to Sardar Patel University, Vallabh Vidyanagar; RAW, New Delhi; M/s G. Surgiwear Ltd., Shahjahanpur; NTPC, Noida and IARI, New Delhi regarding the X-ray analysis of their materials.

X-ray diffraction studies were carried out on Pb-free and Pb-doped Bi high Tc superconductors synthesized by rapid and slow furnace cooling for different sintering duration. All the samples were found to belong to Bi-2212 phase and furnace cooling has led to a sharpening of the peaks alongwith increased intensity of the (001) reflections as compared to rapid cooling, suggesting an increase in the size and improvement in the preferred orientation of the grains. Also, Pb-doped samples showed a contraction of the b axis and expansion of both the a and c axis indicating that some of the Pb ions have been incorporated into the Bi-2212 grains. Studies have also been carried out on the effect of Y and Pr doping in Bi-2223 samples. Effect of Zn dopant in the $LaBaCaCu_3O_{7-\delta}$ system has also been carried out by X-ray diffraction analysis.

In the Ga-Te system, the semiconducting compounds like Ga_2Te_5, GaTe and Ga_3Te_4 synthesized earlier were poorly crystalline and were annealed at 300°C for about 8 months to obtain a better crystallinity and

single phase material. It was found that these compounds segregated into Te and Ga_2Te_3. DTA studies on Ga_2Te_3 in the temperature range 100 to 800°C revealed the presence of single endothermic peak at temperature 454.4°C confirming the X-ray investigations of stable hexagonal phase of the compound studied earlier. The X-ray powder data on CuInSeTe has been finalised and the ratio c/a and the parameter u, which locates the Se and Te atomic positions in the unit cell were calculated.

XRD analysis of bundles of cotton fibres of different variety was carried out. XRD pattern showed three broad diffraction peaks in the scanned range of 2θ and these were the 101, 101 and 002 reflections of cotton fibres. The complete data for all the three peaks was analysed for 2θ, d value, full width at half maximum (FWHM) and area (normalized) and the XRD results were correlated with the other properties of cotton fibres. This work was carried out for the Nuclear Research Laboratory, IARI, New Delhi. XRD studies were also carried out on thin films of V_2O_5 prepared by sol-gel method on ITO coated glass substrates. The as deposited films were non crystalline and the post deposition heat treatment at 673 K yielded orthorhombic structure of the film.

Ferrofluid polymer composite films of water, ionic and diaster base were prepared under the influence of magnetic field and without field. Orientation behaviour of domains lead to certain structural and physical changes in the system and the work is under progress for their characterization using XRD and electron microscopy techniques. An increased amount of pollutant in the environment is menace to health. The dust laden air collected from the highly congested area and green sites of Delhi were analyzed and found that the dust constitutes mostly crystalline silicon oxide (α-quartz) along with the minor amount of silicate hydroxide. Similar studies have been carried out on various gall bladder stones and found that they contain cholestrol as the main phase along with a weak phase of calcium monoxalate.

A DST sponsored project on the Development of Powder X-ray Diffractometer has been continued further. The complete goniometer system has been realigned for maximum X-ray intensity and precise θ-2θ rotation of the goniometer has been checked thoroughly at various scanning speeds. The diffractometer has been tested by recording the X-ray diffraction patterns of a number of powder materials and comparing them with the standard JCPDS data. It was found that the measured `d' values and relative intensity matched very well with the standard data. Some of the XRD patterns were compared with the existing commercial powder X-ray diffractometer. The reproducibility of the diffractograms has also been checked. A scintillation counter has been fabricated for which a PCB card for pre-amplifier circuit has been developed. In the area of Indian Reference Material program, about 100 gm of Si powder with mean dimension of about 8 μm has been prepared for X-ray diffraction standard.

ELECTRON MICROSCOPY

Gallium arsenide, silicon and metallic glass samples were ion milled to observe their microstructure. Discs of 3mm dia were cut from the samples and subjected to argon ion milling. The microstructure and electron diffraction patterns of these specimen were recorded.

In order to study SiO_2/Si interface and Si/Si (Ga-diffused) interface using cross sectional TEM, the samples were cut into strips, stakes were prepared and ground to bring down their thickness to 150 μm. These stakes were then thinned down using argon ion milling to pierce a fine hole in the centre of the stakes. These specimen were then studied for their microstructure and electron diffraction pattern.

Indium antimonide thin films were deposited at various temperatures using thermal evaporation under high vacuum. A systematic study was made to find out the changes in microstructure and electron diffraction pattern of these films grown and annealed under different experimental conditions. The study would be very useful in deciding the application of these films as sensors. Preliminary results were presented in Asian Science Seminar held at Japan in March 1997.

More than twenty five samples of gold coated copper wire, tantalum, carbon cloth, microchannels on silicon, metallic glass were characterized in respect of surface structure/ morphology and deformation with SEM.

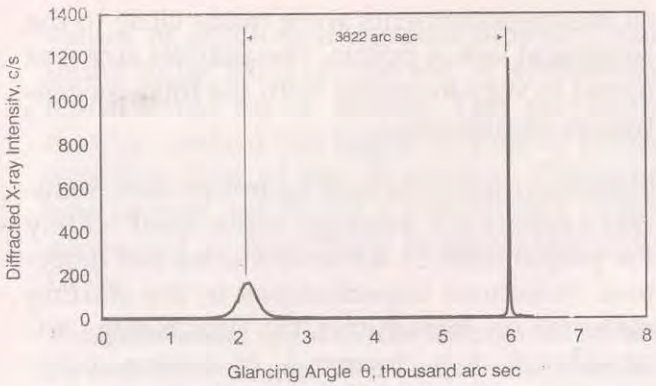
More than thirty five samples of ployanelene, polypyrol, methyl pyrol, iron oxide, $CaCO_3$, ZnS films, InSb films, Metallic glass thin sheets, thin GaAs wafers, CoCu-Co films, CdS films were characterized for their microstructure and electron diffraction pattern using transmission electron microscopy.

CRYSTAL GROWTH & CHARACTERIZATION

Structural characterization of bulk single crystals, epitaxial films, interfaces and devices

The five crystal X-ray diffractometer, designed and developed at NPL has been extensively used for structural characterization of a variety of semiconductor single crystals, epitaxial films, interfaces and membranes. Membrane sensors are among the most advanced series of new sensors which can be integrated with microelectronically produced circuitry. Structural characterization techniques have been employed for evaluation of long term stability and high quality performance of these devices. A 2.5 μm thick coiled membrane had been fabricated on a (100) n-GaAs (carrier concentration 3.5×10^{17} cm^{-3} at R.T.) substrate. Optical lithography, implantation by 2 MeV N^{++} ions followed by selective etching have been employed to achieve the free hanging sensor. The membrane is 5.3 mm long and has five linear segments (~70μm wide separated by a gap of ~30 μm). For structural characterization, diffraction was studied from (511) planes in asymmetric Bragg geometry and (400) planes in symmetrical Laue geometry. For recording diffraction curves, the width of the exploring beam was reduced to ~ 10 μm in the plane of diffraction. In asymmetric geometry for 511 reflection, the illuminated area of the specimen was ~ 180 μm. By translating the specimen across the exploring beam in a stepwise manner, the entire membrane sensor was covered. In all, 13 diffraction curves were recorded after linear translations of ~ 10 μm each. Fig. 1 shows one typical diffraction curve showing three peaks from three different linear segments of the coiled sensor. By analysis of all the diffraction curves, diffraction peaks due to all the five vertical linear segments of the coil could be identified. From these diffraction curves, angular misorientations between different segments were determined and found to be in the range : 15 arc sec to 325 arc sec. Also, from the half widths of the diffraction curves of different segments, quality of crystalline perfection of each segment could be estimated. The half widths were in the range : ~ 58 arc sec to ~ 166 arc sec. The diffraction curve of the substrate had a half width of ~ 16 arc sec. The broadening of the diffraction curves of membrane segments reflects the degree of their crystalline perfection. Interesting results were obtained by X-ray diffraction topographic evaluation of the sensor. In one series of experiments, the membrane appeared as a shadow on the recorded topograph, the main diffracted beam being from the bulk substrate at the back of the hanging membrane. For recording topographs of different segments, experiments were performed with (400) reflection and a narrow exploring beam. The structural perfection could be directly imaged in this case.

Considerable efforts are being made for developing new high temperature stable



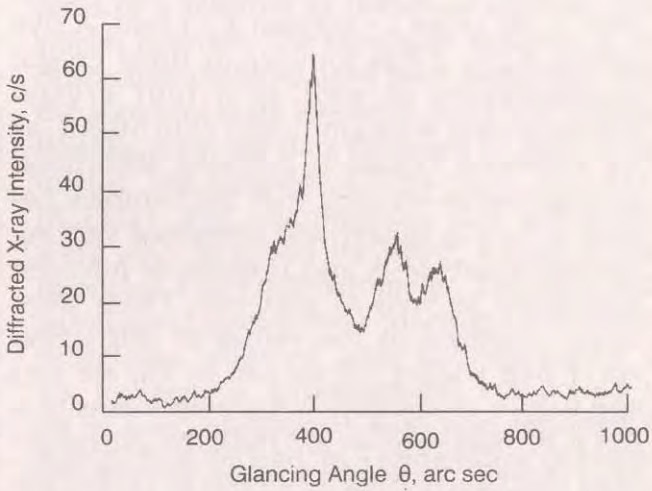
High resolution X-ray diffraction curve

Determination of Crystalline Perfection and Lattice Mis-match between Epitaxial Film of Gallium Antimonide and (100) Gallium Arsenide Substrate by using a Five Crystal X-ray Diffractometer

Speccimen : # 3/M96115; film thickness 2μm; 400 relp; Mokα1 radiation; (+, -, +) configuration of the diffractometer.

Azimuthal Orientation : 0

microelectronic devices based on GaAs electronics. In this connection, we have started investigating epitaxial films of gallium antimonide on GaAs used for making heterostructures. In high resolution X-ray diffractometric experiments, it was observed that there are two types of mismatches between the films and the substrates. The main mismatch is due to the difference in the lattice parameters of the two materials. However, an additional mismatch is there due to orientational difference between corresponding lattice planes of the film and the substrate. Experiments had to be devised to determine the value of the two mismatches separately and accurately. In addition, crystallographic perfection of the films and the interfaces was determined from the half widths of diffraction curves as well as from stationary topographs recorded at the peak positions of diffraction curves. A typical diffraction curve is shown in Fig. 2 for a ~ 2 μm thick film. It is seen that the film is a single crystal though its diffraction curve is considerably broader than that of the substrate. The work reported above is part of the joint R & D work carried out with Technical University, Darmstadt, Federal Republic of Germany under an Indo-German Project. During the visit of one of NPL scientists to Technical University, Darmstadt, high resolution X-ray reflectometry experiments were performed on the following systems: InGaAs films on GaAs substrates; AlGaAs films on GaAs substrates prepared by molecular beam epitaxy and N^+ implanted interfaces. These experiments helped in determining the composition of the films and composition profile across the thickness. Another NPL scientist during his visit to Institute of Semiconductor Physics, Frankfurt Oder, studied heterostructures of Si_{1-x} Ge_x layers of silicon substrate by diffuse X-ray scattering and Raman spectroscopy.



A typical high resolution X-ray diffraction curve of a free hanging coiled membrane sensor fabricated on a (100) GaAs substrate. The sensor has five linear segments (~2.5μm thick). The three peaks are diffraction maxima of thee adjoining segments of the sensor. (+, -, +) configuration of the five crystal X-ray diffractometer, 511 reflection, and MoKα1 radiation were employed.

Diamonds are a fascinating subject of scientific research. It has been realized that though general perfection of diamond crystals has been investigated by several authors by using

a variety of techniques, a systematic indepth study of defects, particularly point defects and their clusters in diamonds has not been made. We have undertaken a detailed study of general perfection of natural diamond platelets as well as point defect clusters in the same by using high resolution X-ray diffraction techniques. In particular, we have employed high resolution X-ray diffractometry, absolute integrated intensity measurements, topography and diffuse X-ray scattering measurements. The specimens were selected to have varying degrees of perfection as shown by the diffraction curve half widths. Experiments were performed with a number of diffracting planes in reflection as well as transmission geometry. Fully symmetric reflections like 220 and some asymmetric reflections like 111 were used. The samples are <111> natural diamond platelets of ~ 2 mm X ~ 2 mm dimensions with thickness in the range : ~ 0.5 mm X ~1 mm. A five crystal X-ray diffractometer in three crystal configuration as well as a four crystal diffractometer were employed with $MoK\alpha_1$ as the exploring radiation. Infrared absorption measurements showed that the samples belong to type Ia variety and contained varying concentrations of A and B forms of nitrogen aggregates as well as platelets. There were large variations in the values of diffraction curve half widths (18 arc sec to 550 arc sec) and values of absolute integrated intensity ρ (2.4×10^{-5} rad - $76 \times 4 \times 10^{-5}$ rad), for 111 reflection, showing a wide variation in crystalline perfection. Projection and composite stationary X-ray topographs recorded with different diffraction vectors showed the presence of defects like low angle boundaries. From the analysis of the observed distribution of diffuse X-ray scattering (DXS), point defect clusters were characterized. The clusters were of interstitial as well as vacancy type. The sizes of defect clusters (R_{cl}) were determined to be in the range : 40 nm to 190 nm and the volume of defect clusters (A_{cl}) were in the range : $\sim 1 \times 10^{-19}$ to $\sim 28 \times 10^{-19}$ cm^3. The defect clusters with sizes reported here could be investigated as the measurements were made close to the reciprocal lattice points. The platelet size was found to very inversely with the total concentration of nitrogen.

Cadmium telluride and cadmium zinc telluride crystals are amongst those used widely for preparation of advanced infra-red detectors. Structural imperfections in the starting material or introduced by processing, adversely affect performance of devices fabricated on these. High resolution X-ray diffractometry and topography methods have been employed to evaluate crystallographic perfection of a number of these crystals. Very fine angle boundaries could be observed in cadmium telluride crystals. Indeed, there is hardly any report in literature on angular tilts of less than 50 arc sec as observed in this study. High resolution of the double crystal X-ray diffractometer employed in this investigation enabled us to detect these boundaries. Topographic observations also confirm these results. In some crystals, there were regions free of low angle boundaries. However, the diffraction curve width of such regions were quite large (~75 arc sec). Indeed, there were large variations in half widths as well as intensities of diffraction maxima. A comparative study of X-ray diffraction from both the surfaces of a CdZnTe crystal was carried out. Diffraction curves were recorded from different regions of the A and B surfaces of the specimen. Diffraction curves from A surface showed a single peak having half widths in the range : 34-40 arc sec. These values of half width are smaller than those observed from 'B' surface. For recording topo-graphs, two traverse scans were necessary. There was an angular misorientation of ~40 arc sec between the two regions. These results showed that 'A' surface has higher degree of perfection in comparison to the 'B' surface. The absolute value of integrated intensities of (111) reflections were also determined experimentally. A very fine exploring beam was used for recording diffraction curves of (111) reflection. The

values of absolute integrated intensity were found to be: 8.04×10^{-5} rad for 'A' surface and 8.57×10^{-5} rad for 'B' surface. This also shows that 'A' surface has higher degree of perfection than that of the 'B' surface. This work was carried out under a consultancy project sponsored by Solid State Physics Laboratory, Delhi.

Establishment of facilities for crystal growth by low thermal gradient Czchoralski method and growth of bismuth germanate crystals

Under a joint project with Institute of Inorganic Chemistry, Novosibirsk, Russia, a crystal growth equipment had been received which allows growth of single crystals by low gradient Czchoralski method. It has automatic diameter control facility through control of weight of the crystal in a closed loop system. This equipment has been fully commissioned with the help of scientists from Novosibirsk and tested by growth of single crystals of bismuth germanate. Fairly large size crystals, ~45 mm in diameter and ~85 mm in length have been grown successfully. The perfection of these crystals has been evaluated by using double crystal X-ray diffractometry and topography. for this purpose, thin wafers were cut, lapped and chemically etched. It was observed that large volumes of the crystals had a high degree of crystalline perfection as shown by small half width of diffraction peaks. Typical half widths of diffraction curves recorded from nearly perfect regions were ~10 arc sec. Diffraction curves from imperfect regions, generally lying around the edges of the sample were broad with half widths in the range : 17 arc sec to 23 arc sec. In imperfect regions, very low angle boundaries could be detected in some cases. In such situation, the diffraction curve showed two well resolved peaks with an angular separation of 30 arc sec from each other. Traverse topographs were recorded by orienting the specimen at the two peak positions. The presence of low angle boundaries could be directly observed. Low angle boundaries with such a small angular misorientation between the regions of the specimen on two sides had not been reported earlier.

Development of a powder X-ray diffractometer

A powder X-ray diffractometer has been designed, developed and fabricated under a project sponsored by Department of Science and Technology, New Delhi. It has been thoroughly tested by recording diffraction patterns of a number of materials starting with silicon powder. The results of analysis of the diffraction patterns have been compared with the standard data available from the internationally accepted data supplied by Joint Committee for Powder Diffraction Standard (JCPDS). For comparison, diffractograms were also recorded by using a commercial imported X-ray diffractometer. The data, such as values of inter-planar spacings for different reflections obtained from diffractograms of the indigenous diffractometer was found to be in good agreement with that reported in JCPDS files. Indeed, in a wide range of angles, the data obtained from indigenously developed diffractometer was closer to the standard values as compared to that obtained by the commercial diffractometer. An indigenously developed X-ray detector (Scintillation counter) is now under testing and will also be incorporated into this system.

LOW TEMPERATURE PHYSICS

HIGH TEMPERATURE SUPERCONDUCTIVITY

(i) Superconductivity in Zn-doped tetragonal $LaBaCaCu_3O_7$ systems

Resistivity and ac susceptibility of Sn-doped samples of the $LaBaCaCu_3O7$-(LBCCO) system have been measured for Zn content of 0.5%, 1.0%, 1.5%, 2.0%, 2.5%, and 3.0% at wt. X-ray diffraction has been used to find the lattice parameters of the samples. The samples remain tetragonal for all the considered concentrations of Zn. Idometry and thermogravimetric analyses have been done to estimate the oxygen content of different samples. Analyzing the resistivity and ac susceptibility data the following conclusions are drawn about the role of Zn in LBCCO samples. (1) The conduction mechanism of electrons appears to follow a crossover from the purely metallic regime to the localization regime due to either weak localization or electron-electron interaction effects after about 1.5% Zn. (2) The superconducting transition as revealed by the resistivity vs temperature curves or susceptibility vs temperature curves becomes sharper with Zn increasing content of Zn up to 1.0%. After 1.4% the resistive and ac susceptibility transitions become broader with increasing Zn. (3) T_c depression up to Zn content of 1.0% seems due to direct suppression of the effective pairing interaction, while at and above 2.5% Zn T_c depression is expected to be due to disorder effects such as reduction of density of states at the Fermi energy.

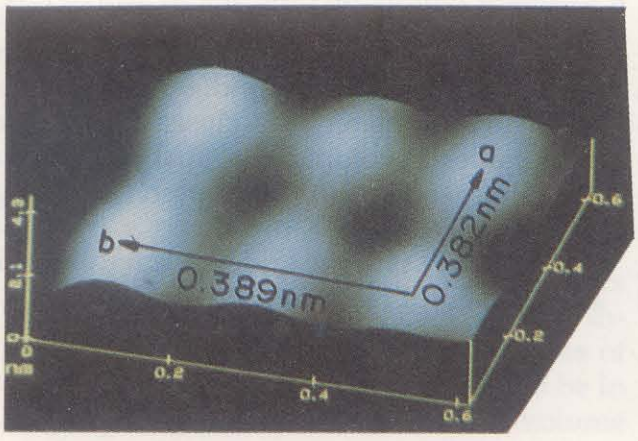


Fig. 1 : 3D STM photograph at 30° pitch of the ideal chain structure of the basal plane of YBCO Single Crystal.

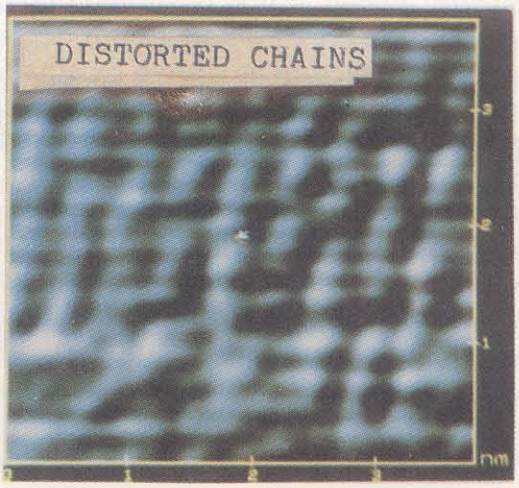


Fig. 2 : Distortion of chains of YBCO Single Crystal due to additive

(ii) Low temperature specific heat and related studies on pure and substituted phases of high T_c cuprates

Specific heat measurements on various high T_c cuprate superconductors have been carried out. In the present review, we discuss briefly a few of the important results obtained in our studies. The results on the single phase samples of Bi- and Tl- based cuprates have been discussed first. Subsequently, from the specific heat and other measurements, we discuss the possible effect of lead substitution in Bi- based cuprate system where both low-T_c and high-T_c phases are present. Finally, we summarize our work on the excess specific heat and the fluctuation induced effects in conjunction with substitution in RE-1-2-3 systems. A brief description of the instrumentation has also been given.

(iii) Order parameter dimensionality, resistivity and transition temperature in pure and zinc doped $YBa_2Cu_3O_{7-y}$ thin films

In pure and 0.33% Zn doped (at Cu-site) c-axis oriented laser ablated epitaxial thin films of $YBa_2Cu_3O_{7-y}$ superconductors the excess conductivity, order parameter dimensionality (δ) and the effects of their variation on dimensionality cross-over have been studied. Relative to the dimensionality crossover in pure film the Zn doped film shows fast suppression of superconductivity fluctuations. Comparison with other studies indicates : (1) high mean field critical temperature (T_c^{mf}) does not necessarily imply that $\rho(T)$ will be less; (2) for pure films, cross-over correlates more with $\rho(T)$ than T_c^{mf}; (3) in Zn doped sample order parameter dimensionality has an uncertain correlation with $\rho(T)$, but the pure fiolms have an inverse variation; (4) in pure and Zn doped samples is directly proportional to T_c^{mf}. These suggest inverse correlation between T_c^{mf} and resistivity in the pristine system, which is absent in the case of Zn doped sample.

(iv) Excess conductivity, critical region and anisotropy in $YBa_2Cu_4O_8$

Conductivity fluctuation effects in two $YBa_2Cu_4O_8$ samples from different batches are studied in the light of system anisotropy. The Lawrence-Doniach model is not suitable, hence the Aslamazov-Larkin model with Anderson-Zou's formulation $\rho n(T)=A+B/T$ has been used. In the mean field region both the samples show 3D order parameter fluctuations. For the mean-field critical temperature three alternatives and their consequences are discussed. The order parameter dimensionality remains the same in all the alternatives. To account for the anisotropy of the Y-124 sample a single-crystal analog for ab-plane resistivity has been invoked. The Ginzburg point and theoretical and experimental critical region widths are calculated and discussed in the light of anisotropy. Small variations due to different batch synthesis do not affect the analysis. A theoretical formulation without anisotropy factor does not hold good. The experimental critical region widths lie between the theoretical values of GL and those of Fisher *et al.* (Phys. Rev., B42, 1991, 130). Compared to Y-123 system these widths and the fluctuations are larger. Binding energy considerations confirm this fact.

(v) A simple quasi-adiabatic calorimeter for specific heat measurement in the temperature range 77-300K

A simple and high precision quasi-adiabatic Nernst-type calorimeter (<1%) that essentially is a modification of a previous calorimetric cell, is designed

and fabricated. Fundamental problems occur when samples with low thermal conductivity, low emissivity coefficient and/or specific heat, strongly varying with temperature, are measured. For those conditions a more elaborate and better procedure for the evaluation of the post-heating curves is given.

(vi) Normal state magnetism of Zn doped and oxygen deficient $CaLaBaCu_3O_7$ superconductor (collaboration with Brazil)

Both on-site Zn substitution and oxygen deficiencies in the $CaLaBaCu_3O_7$ system decrease the superconducting transition temperature T_c of the pristine sample. We observed that the normal state magnetism, measured in a field of 5koe, shows a Curie-Weiss behaviour in terms of a localized magnetic moment presumably on Cu sites, in both cases. The pristine system, i.e., without Zn substitution or oxygen deficiencies, shows a weakly temperature dependent small magnetic susceptibility, in the normal state, i.e., above T_c. It has been argued that the normal state magnetism of HTSC systems plays a vital role in determining the T_c of these materials.

(vii) A new route to study fluorination of high T_c superconductors : crystal growth with fluorine ion as additive (collaboration with the Clarendon Laboratory, Oxford, U.K.)

The influence of fluorine ion as additive on the crystal growth from high temperature solution has been studied. A small amount of BaF_2 greatly improved the crystal growth and the superconducting transition temperature (T_c) by reducing aluminium contamination of Cu-O chains from the alumina crucible. The conductance spectra for Cu-O chains by scanning tunnelling microscopy (STM) showed that such contamination made the chain layer more insulating. No F^- was found in the crystal. A growth model with a monomolecular layer spiral dislocation mechanism is proposed which enables to understand the function of F^- high quality crystals with sharp superconducting transition at 94K have been obtained in a yttria crucible by using BaF_2 as additive.

(viii) Effect of substrate temperature and heat treatment on the microstructure of diamondlike carbon films (collaboration with IIT, Kanpur)

Nonhydrogenated diamondlike carbon films prepared at a substrate temperature (ST) of 100, 300, and 500°C by the laser ablation of graphite on a single-crystal silicon substrate have been characterized by scanning tunneling microscopy for the surface structure and Raman spectroscopy for the microstructure. Distorted pentagonal and hexagonal rings are observed on the surface of the film grown at 100°C while only hexagonal rings are observable for the one grown at 500°C. The rise in ST in found to increase the surface roughness. To assign the various coexisting carbonaceous species formed at different growth temperatures and to check their thermal stability, heat treatment was performed at up to 1300°C in a vacuum and 600°C in air. The changes occurring on heat treatment in vacuum in these films around 600°C have been correlated with the release of defects from the threefold network. Likewise, 950°C temperature has been associated with the conversion of disordered tetrahedral bonding to a distorted trigonal one. The heat treatment in air shows that the microstructure induced due to lower ST is thermally more stable.

(ix) Thermoelectric power studies on $Nd_{1.82-x}Sr_xCe_{0.18}Cu_y$: x 0.18 superconductors (in collaboration with IIT, Bombay)

Thermoelectric power (S) studies on a $Nd_{1.82-x}Sr_xCe_{0.18}Cu_y$: x 0.18 superconducting system in the temperature range 35-250 K are reported here. In the x=0.09 sample, synthesized in the reduced environment, the small magnitude of S is highly metalliclike and its sign is negative, a characteristic of electron conduction. The sign of S for the x=0.18 sample shows a crossover below 75K from negative to positive, in apparent conflict with electronic conduction. Interestingly, after oxygenation this sample exhibits a broadened but positive phonon draglike peak. This oxygenated sample shows overcompensation of the carrier (electron) concentration. Critical analysis of the data suggests that Sr dopping seemingly causes a competition between electron and holelike conduction. The slope dS/dT is, in general, negative suggesting that the main contribution is coming from the diffusive part. The observed thermo-power features seem to fall in line with the theoretical curves of Dureze-wski and Ausloos [Z.Phys. B 85.59 (1991) : Phys. Rev. B 53, 1762 (1996)] based on the inelastic scattering of quasifree electrons by phonons.

THEORETICAL STUDIES

Electron spin resonance behaviour of $KC_{60}(THF)_x$ is Studied. Its unusual features are explained by assuming that the solvation of K^+ ions by THF changes the interaction between K^+ and C_{60}^- ions. The broad spectra is found to be from C_{60}^- ions in cubic environment for x = 0 and 1, since in this case a spin-orbital vibronic quarteret Γ_8 level is in the ground. The sharp spectra near g = 2 is from C_{60}^- ions in anisotropic environment corresponding to $0 < x < 1$, where the ground level is an orbital singlet.

RADIO & ATMOSPHERIC SCIENCES

1. GLOBAL CHANGE

Global Change Research

South Asian Regional Research Centre (SAS-RC), hosted by the Centre on Global Change under an MoU signed in January 1997 between NPL and the International START Secretariat, Washington was established. START, which stands for the Global Change System for Analysis, Research and Training is an international organisation supported by ICSU and UN systems charged with the responsibility of capacity building in various regions around the globe to enable scientific communities in these regions to undertake research activities leading to an improved scientific understanding of global change processes, their regional impacts and mitigatory options. SAS-RC which coordinates the interests of India, Bangladesh, Maldives, Mauritius, Nepal, Pakistan and Sri Lanka has been functional at NPL since last two years on an adhoc basis. The arrangement has been formalised this year. The activities conducted this year include promotion of some cooperative regional programmes, workshops in the areas of Human Dimension Issues, cyclones, biomass burning/aerosols & acid-rain, hydrology of upland mountain regions, a few publications and augmentation of global change data centre and its electronic connectivity within and outside the region, etc.

Solar UV-B Radiation and Aerosol Measurement

Regular solar UV-B Radiation measurements from 280nm to 340nm at an interval of 2nm were carried out throughout the year. The minimum erythemal dose, which is directly relevant to biological application, was also measured round the year by UV-B Biometer instruments. Data collected on Erythemal doses by this instrument at different location in India as well as in Antarctica was analysed.

Measurement of Total Ozone, Water Vapour, UV-B radiation

A highly sophisticated and hand held microprocessor based sun photometer has been used to measure the solar radiation at 300, 305, 312, 940 and 1020 nm. The first three filter channels were used to derive atmospheric total ozone while later two channels were used for water vapour and aerosol optical depth. The instrument was used successfully at Goa, on board ship, Mauritius on the way to Antarctica and finally at Maitri. The hourly observations were taken on all clear cloudless days.

Ozone Studies

In order to model the low latitude tropospheric ozone, a photochemical model including processes involving large number of minor constituents and non-methane hydrocarbons and diffusion process was made. Effect of excess water vapour carried by convective thunder cloud column was considered. The model gives a low ozone value in middle thunder cloud column as seen from observations.

Infra Red Sun Photometer

An infrared sun photometer has been designed, developed and set up at NPL, New Delhi. The IR Sun photometer has been used to study the absorption spectrum of the Earth's atmosphere in the .8 μm - 15.0 μm wavelength range.

Dial

A prototype Differential Absorption Lidar system was designed and tested using some of the components from Laser Heterodyne system and measurements were made for surface water vapour and ozone. The diurnal variations of water vapour and ozone show maxima around noon hours.

2. ANTARCTIC STUDIES

UV-B and Aerosol Studies

Presently three instruments (i) Sun Photometer operating at 368, 500, 675 and 778nm for turbidity and aerosol studies. (ii) UV-B Filter Photometer operating at 290, 300 and 310 nm for UV-B studies. (iii) UV-B Biometer UV-B range for erythemal dose studies are continuously being run and data is being analysed.

PBL Activity

As part of the PBL activity over Antarctica, all the PBL monitoring systems were run continuously by the NPL wintering team member of the 15th Indian Scientific Expedition to Antarctica. During this period, we have initiated activities related to Environmental monitoring, EIA and auditing and have submitted several quotations for undertaking EIA projects.

Radio Spectrometer Studies

The data obtained from the mm-wave ozone radio spectrometer was converted from the 'Asyst' format to ASCII format and is being further analyzed to obtain the annual variation of ozone at Maitri, Antarctica.

Laser Heterodyne System

The Laser Heterodyne System using a tunable CO_2 laser as a local oscillator and sun as a source with one GHz acousto-optic spectrometer (AOS) as back end designed and developed at National Physical Laboratory, New Delhi has been set up at Maitri (70° 46' S, 11° 44' E) during 16th Indian Scientific Antarctic expedition (1996-97) to measure the vertical profiles of minor constituents in the stratosphere and troposphere. The observations for ozone line profiles were obtained on all clear blue sky/cloudless days. Some data for NO2 were also taken during the summer 1996-97.

3. RADIO COMMUNICATIONS

Media characterisation for tropospheric and ionospheric communications:

Several studies have been undertaken during this year to study the propagation characteristics over Southern India in different frequency bands.

i. Experimental campaigns were conducted to collect HF field strength data from certain critical zones in Southern India to study the fading characteristics in HF signals.

ii. A model for estimating the rainfall rate distributions has been developed.

Ionospheric variability studies for radio communications

Ionospheric variability is a major problem to ionospheric forecasters and this is particularly severe over tropical latitudes. This problem has been studied for Indian latitudes using different solar and magnetic indices including solar EUV flux and also the derived geophysical parameter Equatorial Electrojet strength (EEJ). The study has shown that EEJ is a better index for predicting variability trends in ionospheric parameter foF2 as compared to traditional solar indices like R12 or F10.7 and even EUV flux.

Mobile Radiowave Propagation

The analysis of field strength measurements conducted at VHF and UHF for different base station antenna heights in south Indian coastal zones as a function of distance showed that at UHF and VHF the path loss values decreased

respectively by 8 dB and 6.3 dB from urban to sub-urban, by 9 dB and 8 dB from sub-urban to quasi-open, by 9 dB and 13.5 dB from quasi-open to open areas. Field strength values predicted using Hata's technique showed better agreement with measurements as compared to other methods.

Microwave/mm Wave Radiometry

Design and Development of the Front End of a Dual Channel Microwave Radiometer at 19.4 and 22.235 GHz has been completed in the portable commercial mode incroporating a calibration mechanism of switching between the noise source and absolute calibration using liquid nitrogen bath. A set of attenuation values using Microwave Radiometer measurements data at 19.4 and 22.2 GHz were evolved for cloudy conditions in the atmosphere. Based on the measured antenna temperature, various types of cloud were classified according to their properties and altitude. Further the design parameters were fixed for the development of an operational front end for a Microwave radiometer at 37 GHz.

4. IN-SITU OBSERVATIONS

The daily collection of data from the Retarding Potential Analyser (RPA) experiment, onboard the Indian satellite SROSS-C2, was continued. Both the electron and ion RPA's were operated everyday in two high elevation orbits over the Indian region covering the latitudes -5° to 35°N (geographic), longitudes 65° to 90°E and altitudes between 430 and 630 km. Thus, RPA data has been recorded so far for more than 2000 orbits during the last 3 years after the launch of satellite in May, 1994.

Some amount of data was analysed to retrive the ionospheric parameters like electron and ion temperatures, total ion density and ion composition. The diurnal variation of electron temperature at 450 km and above showed very large increase in temperature values between 3000 to 4000 K after sunrise hours. This large increase is similar to that what is expected in the lower F region only i.e. below 350 km at equatorial latitudes. Further, large amount of data was examined for understanding certain unknown features observed in the data time to time. It was then established that many of these are due to the combined effect of satellite spin, magnetic field and sun light over the sensors. Efforts are being made to model these effects for removing uncertainties from the data.

Concrete plans were made by the ISRO HQ to involve universities and other institutions, already working in ionospheric research, for participation in SROSS-C2 data analysis. Under this programme, a workshop cum training course was organised by NPL in which 20 scientists from 10 Universities/ Institutions participated. The training included, apart from data handling and processing, the actual training on PC;s for data reduction. Now onwards all these groups shall participate in the satellite data jointly. The coordination of this activity is being done by NPL and ISRO HQ.

5. RADIO & SPACE PHYSICS

Satellite Radio Beacon Studies

Total Electron Content (TEC) measurements using Global Positioning System (GPS) signals have been continued. As the GPS satellites are orbiting with 12 hour period, TEC observed is a function of satellite latitude, longitude and time of Day. A software based of kalman filter technique has been developed, which converts the observed TEC from different satellites into vertical TEC at the observing station and varies with time of day. Day-to-day variability in ionospheric electron content observed over Delhi during solar cycles 21 and 22 has also been studied.

Scintillations

It is attempted to have a new way of looking at plasma bubbles through scintillation effects

and deduce some crucial ionospheric parameters from the analysis of plasma bubble induced (PBI) scintillations. PBI scintillations are treated as an auto regressive (AR) process and the scintillation spectra with a specific AR order are parametrised.

Improvements in IRI

The altitude variation of observed N / NmF2 as a function of altitude h above the F2 peak i.e. (h - hmF2) were compared with IRI. It was observed that for both the periods the IRI generally overestimates the electron density during all the seasons in the topside region. Further B0 and B1 parameters from Incoherent scatter radar measurements were compared with IRI.

It has been already shown that in IRI model foF2 saturates when R12 (12 months running mean solar sunspot number) exceeds 150. To examine this discrepancy ionospheric data from three Indian stations namely Kodaikanal, Ahmedabad and Delhi for 35 years during solar cycle 19, 20 and 21 was analysed. It was found that foF2 increases with solar activity. It is observed that foF2 saturates for R12 above 150 in a large number of cases. To study the global morphology of foF2/R12 relationship still more data needs to be analyzed from various parts of the globe. The value of R for saturation in foF2 is obtained by equating the derivative dfoF2/dR to zero in the second degree equation, foF2 = A+ B*R + C*R**2, as the basic relation between foF2 and a value of R for saturation is obtained equal to (-B/2C).

Response of Venus ions to solar wind dynamic pressure

Orbiter ion mass spectrometer measurements, as available in the UADS data files were used to study the response of dayside Venus ions at various altitudes to solar wind dynamic pressure, Psw. We find that ion densities below about 200 km are not affected by changes in Psw. At altitudes above 200 km the ions get abruptly depleted with increase in Psw, and this abrupt depletion occurs at lower altitudes when Psw is high. At lower Psw, the depletion occurs at higher altitudes. The effect is similar for all ions.

VHF Propagation Mechanism

Contour diagram over India for the percentage occurrence of Spread - F have been drawn from already existing data. This has been done for pre-midnight, midnight and post-midnight periods during summer, equinoxes and winter in high and low solar activity periods. It has been observed that the occurrence of spread-F during pre-midnight period dominates in high solar activity. While midnight and post-midnight spread-F occurrences found to be more during low solar activity. As VHF signals are enhanced with range spreading on ionograms at the midpoint, it has suggested that the range spread-F which occurs during the pre-midnight period in high solar activity, can be utilized for this purpose.

Earthquake Rescue System

A project proposal "Development of a Post-Earthquake Rescue System by EM Wave CW Doppler Technique" was submitted to DST in 1995. The proposed system functions on the following principle:

When a human subject trapped under rubble is illuminated by a low intensity UHF radio beam, the backscattered signal is modulated in phase and amplitude by the small amplitude chest movement of the subject due to breathing and heart beats. The backscattered signal emerging from the rubble carries this information which is detected by the method of coherent detection. The detected signal shows two vital life signs - heart beats and breathing. This indication provided by the instrument, to be developed, can be very effectively used for the rescue of the trapped victim.

INDO-NIGERIAN COLLABORATION ON THE F-LAYER SPLITTING FACTOR USING THEORETICAL IONOGRAMS TECHNIQUE

In this work a new paradigm in theoretical ionograms technique has been developed. Delhi ionograms used as a model were analysed and their production rates (q_o), Linear loss rates(β_o), Scale heights of atomic oxygen (H_o) and structure factor (b_o) were estimated at the heights of maximum production (h_o). Expressions for the derivation of electron density curves have been explained. The value of b_o was found to be minimum in summer and equinox months and maximum in winter months.

TECHNICAL INFRASTRUCTURE

LIBRARY

A sum of Rs 72.86 lakh was spent for updating the library collection in physics and its related areas. It acquired a total of 377 books, and subscribed 200 journals. As has been the trend in the past, this year again the major share of acquisitions budget, nearly 92 per cent, was directed towards journal subscriptions. The expenditure on journals was pegged at Rs 67.21 lakh. The average subscription rate was recorded at Rs 33605, and compared to the rate recorded last year, Rs 29190, it increased by 15%. Significantly, this year there was 10 per cent increase in the acquisitions budget compared to the budget allocated last year. Since this increase had to be used to neutralize the increase in journal prices, effectively the library could not add any new journal this year. However, it continued to subscribe most of the important and reputed journals in physics, known for their high impact factor, and published by leading publishing houses in the world.

The Library used these databases extensively for rendering information services especially to its external clients from market segments in universities, and industry. The library also used these databases for offering information services to scientists within the Laboratory: (i) Selective Dissemination of Information (SDI) service, (ii) bibliography service, (iii) literature search and (iv) current contents of journals. In terms of library outputs it compiled 19 bibliographies on demand, conducted 84 literature searches downloaded as many as 21528 references from CD databases while rendering literature search service. Its output in photocopying service was 1,24300 copies (9 per cent more than the output recorded last year).

During the year 1890 publications were issued, 2196 visitors came to consult the library, 35 new members were enrolled and 30 members sought withdrawl of their membership upon retirement or transfer.

This year the library started an in-house project on retrospective conversion for converting cataloging records of books into machine readable form. During the year nearly 7000 records in respect of books on superconductivity and computer sciences were created using CDS/ISIS software. The ultimate objective of this program is to provide computer based access to library collection in-house as well as on DELNET network. The network access is becoming essential for the purpose of resource sharing with member libraries in Delhi.

The Library continued using DELNET network linkages for resource sharing, document access, and e-mail.

GLASS WORKSHOP

This unit G.T.U. has continued its activities in the field of Scientific Glass Instrumentation to design and development, Fabrication and Repairing of Scientific Glass and Quartz Glass Apparatus & Equipments for the uses within our own Laboratory and our sister Laboratories as well as for outside Institutions, Industries, R & D Organisations. In additions to this the G.T.U.'s activities are going on well and has made very satisfactory progress by way of saving the foreign exchange.

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

1. Department of Atomic Energy, Indira Gandhi Centre for Atomic Research, Kalpakkam-Tamilnadu
2. M/s. Industrial Carbon, Calcutta
3. M/s Engineers India Ltd. Gurgaon (Hr.)
4. Division of Plant Physiology, IARI, New Delhi
5. Jamia Millia Islamia, New Delhi
6. C.E.E.R.I, Pilani (Raj.)
7. M/s Indian Oil Corporation Ltd. Faridabad (Hr.)
8. M/s Maharishi Ayurvedic Products, Noida (U.P.)
9. D.M.S.R.D.E. R & D Establishment, Kanpur (U.P.)
10. C.R.R.I. New Delhi
11. National Thermal Power Corp. Ltd. Noida
12. Kumaun University, Nainital (U.P.)
13. University of Delhi, New Delhi
14. Jawaharlal Nehru University, New Delhi
15. M/s Hicks Thermometer India Ltd. Aligarh (U.P.)

During the year 1996-97 (184) Internal Jobs were undertaken of various Divisions/ Projects of our own Laboratory.

INSTRUMENTATION

Ultrasonic Biometry System (DST Project I)

The work of ultrasonic Biometry Unit has reached a stage that a Prototype model of Ophthalmic Diagnostic Unit has been Completed. Know-how process has been developed and is ready for commercialization, after the proper clinical/field trials are over.

The electronic systems developed for the unit are : transmitter, receiver, transmit-receive switch, display, power supply (both H.V. and regulated low voltage supply).

A 10 MHz opthalmic probe to be used for ophthalmic examination has been developed and tested in the laboratory. The instrument is used in evaluation of abnormalities produced by ocular and orbital tumors, viterous haemmorhages, trauma and presence of foreign bodies. This instrument can calculate the refraction power of 10L which is useful in medical treatment.

Tumour Therapy System (DST Project II)

A high power ultrasonic system has been designed by using different types of acoustic lenses to focus the ultrasound beam to concentrate at one point. The transducer has been tested for various parameters Trajactory control (X,Y,Z,θ) system facility has been designed and established.

Standard Frequency Source

A standard frequency source was developed for use in standard quartz crystal frequency systems, having 6 Vpp, 10 MHz sine and six 3.5 Vpp level square wave frequencies of 1; 10, 100 and 500 KHz, and 1 and 5 MHz were obtained with the long term stability as 5×10^{-10}/day averaged over a period of 10 days and short term stability as 1×10^{-9}/sec. Pulse delay generation of 1 pps was achieved from standard 10 MHz source in steps of 100 msec, 10msec, 100 usec and 1 usec, for precision measurements. The unit was further invented for better stability. Know how is ready for commercialisation.

This year 217 instruments were tested, evaluated and checked for their workability and perfromance before return to Central Stores. Some of the major instruments were gas chromatograph Frequency Counters, CROs, RF Analysers, DMM Power Rectifiers, Power Amplifiers, Printers, Computers, Electronic Typewriters etc. The work involved testing of their electronic circuits and associated sub-systems.

The major repairs undertaken during the year, were different types of transducers, temperature controllers, computers, electronic multimeter, IF systems, etc., The systems were

analyzed for the faults and made functional to restore the working of a laboratory setup.

As usual, from time to time, routine technical assistance has been rendered to various scientists in their projects in the design of electronic circuits and subsystems.

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

This year also, the Group rendered technical assistance in the physical verification of electrical and electronic stores.

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APPENDICES

Sponsored/Supported Projects

Sl. No.	Title	Agency	Amount Received (Rs. in Lakhs)
NEW			
1.	Development of the Beta Alumina Tubes for Sodium Metal Production	BRANS/DAE	14.584
2.	Development of Silicon Carbide Incorporated Carbon-Carbon Composites (GD)	ARDB	20.900
3.	A Major Upgradation of the Standard Time and Frequency Signal (STFS) Broadcast via INSAT Satellites	BRNS/DAE	14.542
4.	Total Spectral Reflectance. Total Spectral Transmittance and Sepctral Emittance Study in the Infrared Region of Various Materials Thin and Thick Films and bulk Samples	INDO-US	13.200
5.	Development of Micro Base graph Units (CP)	IIG	1.500
6.	Carbon Composite Ring Based Ilizarov Fixator for Orthopaedic Application (GA)	DST	21.755
7.	A Study of Optically Addressed Spatial Light Modulars Based on Nematic and Ferroelectric Liquid Crystals (GA)	DST	10.854
8.	Transport Behaviour of Strongly Corrected Electron Systems (GA)	DST	9.841
9.	National Mapping of Science Using INSPEC Database (GA)	DST	2.190
10.	Development of Sensors & Particulate Filters for Diesel Engine Exhauxt. (GA)	DST	11.457

11.	Improved Pressure Standards in the Range 10-360 Kpa (CP)	NIST	19.850
12.	Programme of Technical Collaboration and Co-operation in Metrology with NIST (USA) (CP)	NIST	USD 2000/year
13.	Studies on Development and Sturcture of Si.C.N.O. based Multicomponent Ceramics through Organometallic Route	DP/MULTICOM	9.900
14.	Index International Workshop on Indian Ocean Experiments from Jan. 3-6, 1997	ISRO/VCAR (USA)	5.000
15.	Studies of Organic and Inorganic Thin Film : Self Assembled Mon olaver Templates for Metal Oxide Film Processing	INDO-ISRAEL	10.496
16.	Investigations aimed at Producing Stress Relieved Diomond Like Carbon Film of High IR Transmission (GP)	DST	23.303
17.	Fabrication and Characterization of Real Time Image Processing Devices	DRDO (DTSR)	17.250
18.	Recording of SROSS-C2 RAP Pavload D on CD Roass at NPS for retrieval	ISRO	1.200
19.	Development of Piston Gauge Transfer Pressure Standard upto 80 Mpa (CP)	DST (INDUSTRY)	9.830
20.	Training Course on Green House Gases from Agricultural Sources on 7-11th April 1997	IGBP	9.000
21.	Development of Tungsten Oxide Based Electrochromic (EC) Films by Sol-Gel Technique (CP)	DST	6.085
22.	Research and Development on (a) Atomic Hydrogen Masers and (b) Precision Frequency Metrology (CP)	US-INDIA	19.900
23.	Intensifying Screen : a New Dimension in X-ray Xerography (GA)	DST	9.910

24.	Development of a Post Earthqu'ake Rescue System by Wave CW Doppler Technique (GA)	DST	9.940
25.	International Programme - the conduct of Cruise-120 Indian Ocean Experiment (INDOEX) (CP)	ISRO	—

CONTINUING

1.	Development/Fabrication of Zeeman Solit Frequency Stabilized 633 nm He-Ne Laser Source for Precision Laser Based Instrument (DST)	DST	7.020
2.	Development of HTSC RF SQUID Basic System Suitable for Operation at Liquid Nitrogen Temperature. (6 Nos) (DST) (GA)	DST	10.100
3.	Laser Heterodyne System for the Study of Ozone and Other Minor Constituents in Antarctica (DOD)	DOD	50.000
4.	Electron Acceleration using Radiation Characteristics and Development of Solar Flare Model (DST)	DST	3.477
5.	National Methane Campaign for Actual Methane Measurements (M E&F)	Min. of Environment & Forest	10.000
6	Investigation of Materials Under Ultra High Pressure for Metrological Applications (DST)	DST	8.091
7.	Simple Technology Development for a Heat Pipe Room Heater from Ground Heat (DST)	DST	2.389
8.	Hydrogen Maser for VLBI Studies (NGRI)	NGRI. Hyderabad	—
9.	Development of Ultrasonic Biometry Equipment (DST)	DST	16.003
10.	Calibration Service Programme under the NABL Programme (DST) (GA)	DST	Yearly Grant
11.	Development of a Powder X-ray Diffractometer (DST)	DST	42.000

12.	Development of Solid State Electrochromic Devices (ECDS) for Display Applications (DOE)	DOE	28.400
13.	Development of Conducting Polymeric Filters for Virus Monitoring in Water (DBT)	DBT	11.450
14.	Development of Polyaniline Based Gas Sensors (DOE)	DOE	7.470
15.	Laboratory Level Technology Development of some Biosensors and Related Bio-Materials (DST) (GA)	DST	34.950
16.	Manufacture of 50 Prototypes of Glucose Biosensors and 50.000 Glucose Biosensor Strips for Full Scale Field Trials (NRDC)	NRDC	1.506
17.	Development of Module Hydride Air-Conditioner (DST)	DST	3.258
18.	Fabrication and Supply of Underwater Pinger Unit (NSTL)	NSTL	3.970
19.	Synthesis, Characterization and Application of some Conducting Polymers (Phase-II) (Indo-EEC)	Indo-EEC	ECU 73300
20.	Programme of Technical Cooperation in Metrology with the Saudi Arabia Standards Organisation. Saudi Arabia (SASO)	SASO	—
21.	Use of the Laser Heterodyne System with Acousto-Optic Spectrometer for Atmospheric Studies over Tropical Latitudes (Indo-French)	Indo-French	18.000
22.	Augmentation of National Standards of Measurement at NPL under the Programme of Technical Collaboration with PTB. Germany - Phase-II	PTB. Germany	—
23.	Interaction with Universities/Laboratories in the Area of Superconductivity (UGC)	UGC	5.000
24.	High Resolution X-ray Diffraction Imaging for Advanced Materials Characterization	Indo-US	65.000

	(Indo-US)		
25.	Charge Carrier Transport in Crystalline Materials - Metrological Applications (Indo-US)	Indo-US	21.320
26.	Electro-Optical and Structural Studies of Oriented Nematic Dispersions with Low Cross-Over Frequency in a Polymer Matrix	Tech. Univ. (Barlin)	In Kind
27.	Development of Activated Carbon Cloth on Experimental Set-up (HEG. Ltd)	M/S HEG Ltd. Bhopal	10.000
28.	Optical and Electrical Properties of Langmuir Blodgett Films (DST)	DST	8.955
29.	Nitrous Oxide Emission from Agricultural Fields and Wet Lands in Northern India (DST)-GP	DST	2.996
30.	Development of Suitable Antimine Material for Boot Antimine (DRDO)	DRDO	7.000
31.	Spectral Shift Due to Source Correlation and its implication in Optical Measurements (DST)	DST	18.858
32.	Fabrication & Characterization of Prototype Hydrophones using PZT Polymer Composite Material Developed NMRL (GA)	NMRL	3.500
33.	Development of a Unit for the Destruction of Benign and Malignant Tumors in the Region of ENT. Based on High Refrigeration apicity J.T. Cryo Probes (DST)	DST	6.300
34.	Development of Electroluminescent Display Devices (DST)-GA	DST	9.588
35.	Development of a Focussed Ultrasound System for Tumour Therapy (DST)	DST	24.580
36.	Continuous Measurement, Updating, Modelling and assessment of Greenhouse Gases	ME&F	4.773

37.	Global Atmospheric Science Programme on Centre on Global Change (DST) (GA)	DST	33.360
38.	Measurement of Thermospheric wind and Temperature with Ground-Based Fabry-Perot Interferometer (DST)	DST	28.510
39.	Development of an Automatic Self Locking NMR Gaussmeter (DST) (GA)	DST	4.380
40.	A Study of Biomass as Energy Source and Technical Option for Greenhouse Gas Emission Reduction (Asian Institute of Technology, Thailand) (C.P)	AIT, Thailand	USD 32500
41.	Development of Process and Coating System for Fabrication of Infrared Optical Filters for use in Environmental and Pollution control Instruments (DST)	DST	12.670
42.	Development of Process Technology for Electro-Deposited CdTe Solar Cells/Modules-GA	MNES	44.850
43.	Deposition and Properties of Mixed Composition Infrared Optical Thin Films (DST) (GA)	DST	15.820
44.	To Investigate a New Category of Catalyst used for the Synthesis of Diamond Under High Pressure and Temperature (DST)	DST	6.492
45.	Development of Single Chamber PECVD System for Fabrication of Thin Film Transistors (GA)	Kurushetra Univ.	2.500
46.	Amorphisation of Boron Nitride and Study of its behaviour under pressure and temperature. (GA)	DST	10.523
47.	Third SERC School on Uper Atmospheric Studies on "Chemistry of the Atmospheric Environment" (30 days School) (GA)	DST	6.680
48.	Standardization of Techniques for Immobilization of Proteins and Enzymes in Conducting Polymers (CP)	Indo-US	15.320

49.	Ozone Over India - Change in the Past & Future (GA)	ME&F	5.405
50.	Weight, Measures & Dimensional Metrology Instrumentation & Techniques (a book on Dimensional Metrology) (DST)	DST	1.803
.51.	Characterisation of Tropospheric and Ionospheric Media to Aid in Radio communication (DST)	DST	17.000
52.	Spray Deposition & Property Evaluation of Aluminium Matrix Composites	ARDB	23.950
53.	Asian Workshop and Training Course on Measurement Techniques and Inventories of Green-House Gases (Seminar from 30.10.95 to 4.11.95) (GA)	International Start Secretariat	USD 2000.710
54.	A Regional Workshop cum Training Course-(Asian Dev. Bank) (GA)	Asian Dev Bank	USD 8000 2.84
55.	Study of Least Cost Green-House Gas Abatoment Stratgy for Asia (GA)	ADB	USD 80000
56.	Development of a Long Decay Phosphor and Phosphor Coated Plastic Tapes for the Army (SP)	DRDO	3.250
57.	Influence of the Surface Energetics of Micro-Structure of Metrix and Fibre/Metrix Interaction in Composites	Indo-French	22.860
58.	On Line Determination and systematic Recording of Sugar Content in Sugarcane Sugarlane Juice and Sugarcane Solids (DST) (CP)	DST	23.700
59.	Electron Paramagnetic Resonance Optical Absorption and Electrical Conductivity Investigations in Glasses (DST)	DST	7.527
60.	Development of Operational Front End of the Radiometer at 37 GHz (CP)	Allahabad. Univ.	3.500

COMPLETED

1.	Development of a Superconducting Magnet System with a Long Hold Dewar for a 100 MHz NMR Spectrophotometer (DST)	DST	25.280
2.	Deformation Behaviour of Composite Materials (Aluminium Alloy Matrix Composites) (DST)	DST	23.570
3.	Studies on Reliability and Availability of GPS Signals in India (DOE)	DOE	12.000
4.	A Study on the Deteriorating Effect of Selective Availability on Precise Positioning and Timing in Normal GPS and DGPS Modes (DRDO) (GA)	DRDO	10.000
5.	Establishment of Surface Analytical Facilities (UNDP)	UNDP	10000
6.	Aviation Grade Brushes - Field Trials (HAL. NASIK)	M/s HAL. Nasik	2.625
7.	Growth of Nearly Perfect Single Crystals of Oxides Like Lithium Niobate (Indo-Russia)	Indo-Russia	25.000
8.	Synthesis of High Silicon Steel by CVD (TISCO) (CP)	M/s TISCO. Jamshedpur	2.000
9.	Design, Development & Fabrication of Piezoelectric Accelerometers (5 nos) (CRRI)	CRRI. New Delhi	0.225
10.	Development of Back Contact and Encapsulating Technology on Large Area CdS/CdTe Solar Cells (Eco-Solar)	M/s Eco-Solar. Pune	6.600
11.	Development of TGS Pyroelectric Detector (DST)	DST	7.020
12.	Development and Fabrication of a System for Ion Beam Microetching of Materials for Microstructure Analysis by Transmission electron Microscopy (DST)	DST	11.440

R & D COLLABORATION

INDIA

1. S.V. University, Tirupati
   (Radio Communications)
2. Indian Railway Central organisation for Tele Com (Mobile Communication)
3. National Geophysical Research Institute, Hyderabad
4. Indian Institute of Geomagnetism, Bombay
5. Indian Institute of Astrophysics, Bangalore, (Solar and Geophysical data exchange Prog.)
6. Indian Statistical Institute, Calcutta
   (Radio wave propagation)
7. Punjabi University, Patiala
   Physical Research Lab, Ahmedabad
   NMRF, Tirupati (Radio Communications)
8. Department of Physics, Jamia Millia Islamia, New Delhi (For Phot acoustic Investigation)
9. Deptt. of Science & Technology, New Delhi
   (Acoustics)
10. Central Pollution Control Board, New Delhi
    Bureau of Indian Standards, New Delhi
    Archaeological Survey of India, New Delhi,
    J.N. Centre for Advanced Scientific Research Bangalore (For Acoustic Std)
11. Department of Physics :
    Indian Institute of Technology, New Delhi
    (Ultrasonics)
12. University of Delhi :
    (Microwave Super Conductivity)
13. Banaras Hindu University
    (High Temp. Super Conductors)
14. Tata Institute of Fundamental Research
    (Boro Carbide Super Conductors)
15. Nuclear Science Centre, New Delhi
    (High Temp. Super Conductors)
16. CEERI, Pilani (SQUID Electronics)
17. DST, New Delhi (High-Tc SQUIDS)
18. Central Electronics Ltd., Sahibabad
    (Silicon Solar Cells)
19. Rajasthan Electronics & Instrumentation Ltd., Jaipur (Silicon Solar Cells)
20. Solar energy Centre, MNES Gwal Pahari
    (Silicon Solar Cells)
21. Tata Iron & Steel Co., Jamshed Pur
    (High Silicon Steel by CVD)
22. Indira Gandhi Centre for Atomic Research
    (Beta Alumina)
23. Indian Institute of Petroleum, Dehradun
    (Porous Ceramic Particulate Filter)
24. Deptt. of Electrical Engg., IIT, Kanpur
    (Development of a-Si:H based radiation detectors)
25. Deptt. of Electronic Sciences, Kurukshetra University (Area of a-Si : H research)
26. Vikram Sarabhai Space Centre, Trivandrum (A formal M.O.U. Signed for Collaboration in the field of Metals & Alloys)
27. Hindustan Aeronautics Ltd., Bangalore
    Defence Mettalurgical Research Lab, Hyderabad, Indian Institute of Sciences, Bangalore. (Metals & Alloys)
28. I.I.T. Delhi
    Safdarjung Hospital, New Delhi
    Aggarwal orthopaedic Hospital, Gorakhpur
    Graphite India Ltd., Bangalore
    HEG Limited, Bhopal, HAL, NasiK
    (Carbon Composites)
29. University of Delhi
    (PZT films for memory Devices)
30. I.I.T. Delhi
    (Dilute magnetic Semiconductors)
31. M/s HEG Ltd., Mandideep (Near Bhopal)

(Surface Area & Porosity)

32. CEERI, Pilani
Physics Deptt. M. D. University, Rohtak
(Characterization of materials)

33. Department of Physics and Astrophysics University of Delhi, Delhi
(Electron density distribution in crystals)

34. Department of Physics, IIT, New Delhi
(Structural Study of Silicon Interfaces)

35. Department of Materials Science and Technology Sardar Patel University, Vallabh Vidya Nagar, Gujrat. (Studies on Structure of Ceramics)

36. Regional Research Laboratory, Trivandrum (X-ray diffraction Study in quartz crystals)

37. Sri Ram Industrial Enterprises Limited (Siel), N. Delhi (On line determination and Systematic recording of Sugar Contents)

OVERSEAS

1. Azikivi University, Nigeria
(Dr. G. Anene, Joined as visiting Scientist)

2. Indo-Russian-Nigerian Collaboration Programme (Compilation and editing of Russian Book)

3. PTB, Germany
(Augmentation of Standards)
(HF & MW Power Standards)
(For establishment of magnetic stds Lab)

4. PTB, Braunschweig, Germany IFA/CNR, Italy, Industrial Technology Research Institute, Taiwan (Acoustics)

5. NIST, USA under Indo-US Aid Programme (Total Spectral reflectance, Transmittance & Emittance Study)

6. CSIRO, Australia
(Inter Comparison of LF Voltage Stds)

7. NML Standards and Calibration Lab, Hongkong (Inter Comparison of HF & MW Power Stds)

8. PTB, Braunsch weig, Germany
(Josephson Voltage Standard)

9. Fraunhofer Institute for Solar energy systems, Freiburg, Germany (Silicon Solar Cells)

10. Institute of Material Research (IFAM), Dresden, Germany (Formal M.O.U. Signed for Collaboration)

11. Mechanical Engg. Laboratory, Ibarki, Japan (Formal M.O.U. Signed in the field of Metals & Alloys)

12. University of Wisconsin, Milwaukee, USA, University of California, Irvine, USA
(Metals & Alloys)

13. CEMES, Toullouse, France
(Carbon Research)

14. NATA, Australia (Proficiency testing in water analysis)

15. Thailand (Assesment of biomass)

16. Sweden (Atmospheric Chemistry)

17. NIST, Gaithersburg and University of Maryland USA (Advanced Materials Characterization)

18. Technical University Darmstad FRG
(Characterization of Semiconductor Structures)

19. Institute of Inorganic Chemistry
Russian Academy of Sciences, Novosibirsk
i. Growth of nearly perfect crystals of oxides
ii. Silicon for Applications in Solar energy

20. Institute of Physical Chemistry, Technical University, Darmstad, Germany (In the field of ferroelectric liquid crystals)

21. Institutes in Brazil, Israel, U.K. and Germany (Research on Superconductivity)

22. Clarenden Laboratory, University of Oxford, U.K. (Conducting Polymers)

CALIBRATION/TESTING CHARGES
(Realised during 1.4.96 to 31.3.97)

ACTIVITY	AMOUNT (Rs)	REPORTS (No.)
I. CALIBRATION		
i. Physico Mechanical Standard		
Length Standards	68950	16
Dimensional Metrology	2551600	728
Mass, Density, Volume & Viscosity	1300950	797
Force & Hardness Standards	2152350	767
Pressure & Vacuum Standards	1387050	200
Temperature Standards	1273900	471
Optical Radiation Standards	848400	265
IR Radiation Meas. & Calib.	65750	10
UV Radiation Meas. Stds.	17650	7
Acoustic Standards	420150	109
Ultrasonics Standards	10000	5
Total	**10096750**	**3375**
ii. Electrical & Electronics Standards		
AC & LF Standards (Up to 1 KHz)	1136150	175
LF & HF Impedance Standards	140700	83
D.C. Standards	503850	78
HF & Microwave Attenuation and impedance Standards	39000	20
HF & Microwave Standards of Power, Voltage, Frequency & Noise	782250	65
Magnetic Measurement Activity	27200	10
Time & Freq. Standards	140600	52
Total	**2769750**	**483**

II. TESTING

Material Characterisation	11100	10
Chemical Analysis	385150	155
Spectroscopy (Luminescent)	2200	1
Indian Ref. Material	48100	11
X-Ray Analysis	164400	4
Electron Microscopic Analysis	21100	3
Metal & Alloys Group	4750	3
Material Division	162750	0
Carbon Technology	3000	2
Electrical Engg.	45000	5
Total	**847550**	**194**

III. JOB WORK

Central Workshop	959700	48
Thin Film	61600	6
Total	**1021300**	**54**
Grand Total	**14735350**	**4106**

CONSULTANCY

	Nature of Consultancy	Party	Value of contarct (Rs. Lac)
1.	Automation of a Feasibiligy Studies for compression Machine	AIMIL, New Delhi	0.12
2.	Development of 14" MF support Block in bakelite	Samtel Co. Ghaziabad	0.55
3.	Development of 20" Retainer	Samtel Co. Ghaziabad	0.40
4.	Development of component cover A/c case	Motherson Tools Bathkal Village Haryana	0.35
5.	Development of Piston Gauge Pressure Standards	ERTL Okhla, New Delhi	2.87
6.	Measurement of Harmonics	Asian Alloys Govindgarh Punjab	0.15
7.	Development of Piston Gauge Pressure Standards	Ordance factory Muradnagar	2.65
8.	Development of Ultrasonic probes for non destructive testing	Ada Bangalore	1.04
9.	DC Magnetic field mapping of the deflection yokes of colour picture tubes	Samtel Co. Gaziabad	0.37
10.	Design development of pressure gauge stand	Sophisticated Test Instru Centre, Cochin University Cochin	2.90
11.	Test Rig for testing of cryogenic values	Lreader Engineering Works Jallandhar	4.30
12.	Coke formation from coal tar	Graphite India Ltd., Calcutta	2.50
13.	Development of software for complete automation of thermocouple calib. system	Director, Shriram Institute, Delhi	0.20
14.	Upgradation of stiff Testing machine to make it fully automatic	CSMCRI, Min. of Water Resources, New Delhi	0.94

15.	Fabrication of 'X' Band Microwave Guide Component	M/s Bhushan & Bhushan Delhi	43,000
16.	Measurement of Harmonics and Power Factor Improvements	CBT Delhi	3,43,000
17.	Evaluation of fluorescent lamp System	Eurolight electricals Pune	4,00,000
18.	Modelling and assistance in CNC Miling	M/s Digitext Delhi	75,000
19.	Modelling and assistance in machining of die cavity	M/s Kiran Udyog Delhi	30,000
20.	Characterisation of Mercury Cadmium Telluride by high resolution 'X' ray diffraction	SSPL Delhi	2,00,000
21.	Installation of Helmholtz coil	Indian Airlines New Delhi	19,125
22.	Repair of dead weight Tester	BHEL Bhopal	26,000
23.	Optimisation of circuitry of electronic timer used for automobiles	Indcraft Exports Delhi	5,300
24.	Optimisation of Physics package of HP Rb frequency standard.	Director General of Light house and ships Delhi	1,50,000
25.	Determination of Effective area of Air Dead Weight Tester.	Premier Instruments Coimbatore	30,000
26.	Development and Assistance in machining of Lens for parking lights	Mayfair Industries Delhi	20,000
27.	Assistance in Vacuum Techniques	BHEL Bhopal	10,000
28.	Conducting Polymer for EMI Interference (Sponsored)	GE Corporate USA	US $ 30,000

ACTUAL EXPENDITURE
(1996 - 1997)

Budget Head	Rs. (Lakhs)
Salaries	1094.133
Contingencies	183.251
Maintenance	45.334
Chemicals	108.545
Work etc.	56.37
Equipment	127.179
Other	93.924
Total	1708.403
Sponsored Projects	288.496

HUMAN RESOURCES

SCIENTISTS OFFICERS

(In order of Gp. IV to Gp. III as on 1.4.97)

DIRECTOR

ESR Gopal

PHYSICO MECHANICAL STANDARDS

LENGTH & DIMENSIONS

RP Singhal, Sc F
VG Kulkarni, Sc EI
LS Tanwar, Sc EI
KP Chaudhary, Sc EI
Shanta Chawla (Smt), Sc C
M Karfa, Sc C
Rina Sharma (Smt), Sc B
V Roonwal (Smt), TOEI
NK Aggarwal, TOC
BK Roy, TOC
AK Kanjilal, TOC
SL Thind, TOC

MASS

DC Sharma, Sc EII
SN Nangia, Sc EI
Tripurari Lal, Sc EI
ML Das, Sc EI
S Sinha, Sc C
T.K. Parameshwaran, TOA

FORCE

KK Jain, Sc EII
RS Sharma, Sc EI
JK Dhawan, Sc EI
MK Chaudhary, Sc EI
Anil Kumar, Sc EI
Ganga Prasad, Sc EI
VD Arora, TOB

PRESSURE & VACUUM

AC Gupta, Sc EII
AK Bandyopadhyay, Sc EII
BR Chakraborty, Sc EII
DR Sharma, Sc EII
Pardeep Mohan, Sc EI
C Anandan, Sc EI
SM Sivaprasad, Sc C
Arjun Vijaykumar, Sc B
Sanjay Yadav, Sc B

TEMPERATURE

RK Luthra, Sc EI
Joginder Singh, Sc EII
NK Srivastava, Sc EI
YP Singh, Sc EI
Mansha Ram, Sc C
NK Kohli, TO EI
SK Nijhawan, TOC
JK Gupta, TOB

PR Sengupta, TOA
Gurcharanjit Singh, TOA

OPTICAL RADIATION

JS Vaishya, Sc EII
S Manrai (Smt), Sc EI
HC Kandpal, Sc EI
SSK Titus, Sc B
Jai Bhagwan, TOB

INFRARED RADIATION

SP Varma, Sc F
D Gupta, Sc EI

ULTRAVIOLET RADIATION

RS Ram, Sc EII
Om Prakash, Sc EII

ACOUSTICS

V. Mohanan, Sc EII
DR Pahwa, Sc EII
SUM Rao, Sc EII
BS Gera, Sc EII
Omkar Sharma, Sc EII
RM Khanna, Sc EII
HLB Bhaskar, Sc C
Mahavir Singh, Sc B
VK Ojha, TOA

ULTRASONICS

Janardan Singh, Sc EII
Ashok Kumar, Sc EII
SK Jain, Sc EII
Ved Singh, Sc EI
Harish Bahadur, Sc EI
Mukesh Chandra, Sc EI
NN Swamy, TOC
Subhash Chandra, TOC
Jagdish Lal, TOB
Reeta Gupta (Smt), TOB
NC Soni, TOB
VK Hans, TOA
Yudhisthar, TOA

CRYOGENICS & HUMIDITY STANDARDS

RG Sharma, Sc F
Hari Kishan, Sc EII
YS Reddy, Sc EII
BV Reddi, Sc EI
RB Saxena, Sc EI
SS Verma, Sc EI
NK Babbar, Sc EI
PL Upadhyay (Km) Sc C
TK Saxena, Sc C
MA Ansari, Sc B
GS Bhambra, TOB
Vijay Sharma, TOA

FLOW MEASUREMENTS

JN Som, Sc EII
Raj Singh, Sc EI
Virendra Babu, TOEI

ELECTRICAL STANDARDS

TIME & FREQUENCY

BS Mathur, Sc G
P Banerjee, Sc F
A Sengupta, Sc EII
GM Saxena, Sc EII
AK Hanjura, Sc EII

M Saxena (Smt), Sc EI
A Chatterjee (Smt), Sc EI
C Sri Kumar, Sc B
Gurdial Singh, TOB
AK Suri, TOB

JOSEPHSON VOLTAGE

Ashok K Gupta, Sc F
VS Tomer, Sc EII
ND Kataria, Sc EII
VN Ojha, Sc EI
VK Gumber, Sc EI
Manmohan Krishna, Sc C
Neeraj Khare, Sc C
AK Goel, TOA

DC MEASUREMENT

SK Mahajan, Sc EII
Ajit Singh, Sc B
PK Mittal, TOC
B Sircar, TOC

HF IMPEDANCE & AC, LF

Omkar Nath, Sc EII
Gurmej Ram, Sc EI
SR Gupta, Sc EI
MK Mittal, Sc EI
AK Saxena, Sc EI
Kewal Krishna, Sc EI
Naib Singh, Sc C
JC Biswas, Sc B
AR Kaushik (Smt) TOC
Mohammad Saleem, TOA

HF & MW VOLTAGE, POWER FREQUENCY & ATTENUATION

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

MAGNETIC MEASUREMENTS

PC Kothari, Sc F
RK Kotnala, Sc EI
HM Bhatnagar, Sc EI

CALIBRATION SERVICES PROGRAMME

Mahesh Chandra, Sc EII
HS Dahiya, Sc EI
ML Sharma, Sc EI
CP Singh, TOEI
SP Sharma, TOB
PC Sharan, TOB
GK Kapoor, TOA

MATERIALS DEVELOPMENT

SILICON, CERAMICS & SUPERCONDUCTORS

BK Das, Sc F
AC Rastogi, Sc F
SN Singh, Sc EII
RB Tripathi, Sc EII
ST Lakshmikumar, Sc EII

Mohan Lal, Sc EII
SN Ekbote, Sc EII
BR Awasthy, Sc EI
BC Chakravarty, Sc EI
NK Arora, Sc EI
PK Singh, Sc EI
Kiran Jain (Smt), Sc C
S Singh (Smt), Sc B
VK Sankaranarayanan, Sc B
SM Khullar, TOEI
HS Kalsi, TOEI
RC Goel, TOC
Prem Prakash, TOC
KS Balakrishnan (Smt), TOC
BS Khurana, TOC
SK Sharda, TOC
HP Gupta, TOC
Ravi Kumar, TOB
MK Banerjee, TOB
TR Pushpangadan, TOB
Mukul Sharma, TOA
ML Sharma, TOA
VK Singhal, TOA

LUMINESCENT MATERIALS

PK Ghosh, Sc F
V Shankar, Sc EII
Harish Chander, Sc EII

DISPLAY DEVICES

Subhas Chandra, Sc F
SC Jain, Sc EII
SS Bawa, Sc EII
MN Kamalasanan, Sc EII
SCK Misra, Sc EII
Suresh Chand, Sc EII
AM Biradar, Sc EII
CP Sharma, Sc EI
SA Agnihotri (Smt), Sc EI
Ramadhar Singh, Sc EI
VS Panwar, Sc EI
BD Malhotra, Sc EI
S Dwivedi, Sc EI
KK Saini, Sc C
NS Verma, Sc C
Ranjana Mehrotra (Km), Sc C
RK Sharma, Sc C
SK Dhawan, Sc C
Chander Kant, TOA
GD Sharma, TOA
VK Sharma, TOA

CARBON PRODUCTS

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

THIN FILM SYSTEMS

R Bhattacharya, Sc F
Devindra Singh, Sc EII
A Basu, Sc EII
BS Verma, Sc EII

M Kar (Smt), Sc EI
PN Dixit, Sc EI
OS Panwar, Sc EI
SS Rajput, Sc EI
TD Senguttuvan, Sc B
TK Chakraborty, TOB
TK Bhattacharya, TOA

HIGH PRESSURE TECHNOLOGY

AK Aggarwal, Sc F
BP Singh, Sc EII
SK Singhal, Sc EI
Rajeev Chopra, Sc EI
Dharam Chand, TOC
KD Sharda, TOB

METALS & ALLOYS

Anil K Gupta, Sc F
RC Anandani, Sc EI
Ajay Dhar, Sc EI
AK Srivastava, Sc B
IA Malik, TOEI
Rajiv Sikand, TOB
HB Singh, TOB
Jaswant Singh, TOB
Rakesh Khanna, TOA

LOW TEMPERATURE PHYSICS

SUPER CONDUCTIVITY

AV Narlikar, Sc G
BV Kumaraswami, Sc EII
PK Dutta, Sc EI
Ratan Lal, Sc EI
SK Aggarwal, Sc C
UC Upreti, Sc C
Anurag Gupta, Sc B
SB Samanta, TOC
VS Yadav, TOB

MATERIALS CHARACTERIZATION

CHEMICALS & POROSITY

DC Parashar, Sc F
HP Narang, Sc EII
JN Bohra, Sc EII
JC Trehan, Sc EII
AK Sarkar, Sc EII
R Ramchandran (Smt), Sc EII
VK Amar, Sc EI
AK Aggarwal, Sc EI
PK Gupta, Sc EI
Ranjan Kothari, Sc B
S Kalyan Kumar, Sc B
MK Dasgupta, TOB
Niranjan Singh, TOB
RC Sharma, TOA
RK Saxena, TOA

IR & EPR SPECTROSCOPY

MM Pradhan, Sc F
SK Gupta, Sc EII
RK Garg, Sc EI
Manju Arora (Km), TOA

X-RAYS

DK Suri, Sc EII
U Dhawan (Smt), Sc EI
Rashmi (Km), Sc EI

RP Pant, Sc C
DP Singh, TOA

ELECTRON MICROSCOPY

SK Sharma, Sc F
Ram Kishore, Sc EI
Kasturi Lal, Sc EI
Sukhbir Singh, Sc B
KN Sood, TOA
KB Ravat, TOA

CRYSTAL GROWTH

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

THEORY

Ramji Rai, Sc EII

RADIO AND ATMOSPHERIC SCIENCES

KK Mahajan, Sc G
SC Garg, Sc F
M.K. Tiwari Sc F
YV Ramanamurthy, Sc F
DR Lakshmi (Smt), Sc F
S Aggarwal (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 EII
SK Sarkar, Sc EII
Lakha Singh, Sc EII
RK Pasricha, Sc EII
KS Zalpuri, Sc EII
MC Sharma, Sc EII
PN Vijaya Kumar, Sc EII
MK Goel, Sc EII
PL Malhotra, Sc EI
RS Arora, Sc EI
Mahendra Mohan, Sc EI
N Kundu (Smt), Sc EI
Madhu Bahl (Smt), Sc EI
JK Gupta, Sc EI
SD Sharma, Sc EI
RS Dabas, Sc EI
DR Nakra, Sc EI
VK Pandey, Sc EI
P Subrahmanyam, Sc EI
MVSN Prasad, Sc EI
BC Arya, Sc EI
NK Sethi, Sc EI
SK Singhal, Sc EI
HK Maini, Sc EI
VK Vohra, Sc EI
P Chopra (Smt), Sc EI
Thomas John, Sc EI
CB Tandel, Sc C
Jayanta Kar, Sc C
VP Sachdeva, Sc C
Risal Singh, Sc C

Meena Jain (Smt), Sc C
RS Tanwar, Sc C
SK Shastri (Smt), TOC
Abdul Hamid, TOB
Didar Singh, TOB
Raksha Marwah (Smt), TOB
DB Sharma, TOB
VS Yadav, TOB
Iqbal Ahmed, TOB
SK Bhatia (Smt), TOA
R Kohli, TOA
KGM Pillai, TOA
DS Chaunal, TOA
Shambu Nath, TOA
AK Goghar, TOA

TECHNICAL INFRASTRUCTURE

PLANNING & COORDINATION

RS Khanduja, Sc F
PK Ashwini Kumar, Sc EII
Satbir Singh, Sc EII
FC Khullar, Sc EI
TK Chakraborty, Sc EI
SK Sharma, Sc EI
Shikha Mandal (Smt), Sc EI
Indra Tewari (Smt), Sc C
MK Chibber, TOC
SS Bhakri, TOC
AK Suri, TOA

LIBRARY

SM Dhawan, Sc F
SK Phull, Sc EII
DK Tewari, Sc EI
NK Wadhwa, Sc B
Hasan Haider, TOB
Jagdish Prasad, TOB

COMPUTER

MS Tyagi, Sc F
Ravi Mehrotra, Sc EII
Sher Singh, Sc B
Kanwaljit Singh, TOA
Ashok Kumar, TOA

INSTRUMENTATION

VR Singh, Sc F
DS Sachdeva, TOC
YPS Negi, TOB

WORKSHOP

JR Anand, Sc F
SC Gera, Sc EII
HNP Poddar, Sc EII
Ravi Khanna, TOC
Kewal Krishan, TOC
Ram Swarup, TOB

GLASS WORKSHOP

VP Varma, Sc EII
MC Jusht, TOEI
Mohan Lal, TOC
JP Vashist, TOC
Karnail Singh, TOC

SERVICES

CSP Kumar, Sc F
JC Sharma, Sc C

JS Dhama, Sc B
Shashi Bhushan, TOEI
RS Singh, TOC
SL Sharma, TOC
BK Chopra, TOB
KL Ahuja, TOB
Harbans Singh, TOB
SL Kulshrestha, Asstt. Engineer
BS Negi, TOB
Damodar Prasad, TOA
Deepak Bansal, TOA

STAFF ON DEPUTATION

VT Chitnis
AR Jain
RP Tandon
K. Varadan (Smt.)

SCIENTISTS, FELLOWS, RESEARCH ASSOCIATES & POOL OFFICERS

AP Mitra, Honorary Sc. Eminence
SK Joshi, Emer Distinguished Sc CSIR
B Buti, Emer Sc
TR Anantha Raman, Emer Sc
Ajay, Sc
Sangeeta Khare (Smt), Sc
PC Jain, Sc (DST)
R. Murli Krishna, Y.Sc (DST)
Ranjana, Bakya (Smt), Sc (DST)
Y. Aparna (Smt), RA
Sumana Bhattacharya (Smt), RA
Subrata Bose, RA
RK Dubey, RA
Indu Dhingra (Km), RA
MS Dutta, RA
Suchitra Ghosh (Km), RA
RK Gowswami, RA
RL Hota, RA
Kudari Timothi, Isaih, RA
Sandip Kohli, RA
RK Mandalappu, RA
DS Mehta, RA
VK Parashar, RA
Rashmi Paul (Km), RA
Satyendra Sharma, RA
SV Sharma, RA
Mansumi Seth, RA
Sandeep Singh, RA
H.S. Tiwari, RA
Hari Om Upadhyay, PO
VC Kulshrestha, PO

ADMINISTRATION, ACCOUNTS, STORES/PURCHASES

HR Gupta, COA
P Dass, AO
SC Santosh, Sr F & AO
S Chandrahas, F & AO
C Ramesh, SO (F & A)
Satish Kumar, SO (F & A)
H Chongloi, SO (F & A)
Dharam Raj, SO
OP Meni, SO
Vijayalakshmi D, (Km), SO
Sardara Singh, SO
AK Ghosh, TOB
S Sharma (Smt), Hindi Officer
Lamba Prem (Smt), Dy. SPO
RC Gupta, Dy. SPO
RK Bhasin, PS

Mange Ram PS
SA Joseph (Smt), PS
Shish Ram, PS
Vijay Kumar, Security Officer
Lakhpat Singh, Security Officer

RETIRED

V Prabhakaran, Tech. VIII
Ram Parshad, W/Shop Asstt.
BS Yadav, SMA
SC Verma, TOB
Jagdish Kumar, PS
Ram Chand, Tech. VIII
AN Khural, SMA
Inder Raj, SMA
R Venkatachari, Sci. EII
NS Bangari, TOEI
Meer Singh, Sec. Asst. Gr. II
Basant Ram, Tech. VIII
R.D. Yadav, Tech. VIII
Ganaour Mehta, Tech. VIII
BR Dandona, Assistant
PK Bhardwaj, Sr. Steno
RK Sisodia, Tech. VII'
MR Nagar, Sci. EI
RC Bhateja, TOC
Sachche Ram, Security Guard
VK Batra, Sci. F
SK Sarkar, Sc F
Ran Singh, Daftry (S.G.)
Janak Kalra, Assistant
HR Mehta, Sr. F & AO
MK Dasgupta, Sci. F
TR Tyagi, Sc. F
Ruda Ram, Tech VII
TR Tomar, TOB
JP Sharma, TOB
KC Joshi, Sci. F
Narendra Kumar, Sci. EII
OP Bhola, TOEI
DV Sharma, PS
Daljit Singh, Tech. VIII
OP Tagra, TOC
Shyam Lal, SO
VD Dandavate, Sci. F
NS Natarajan, Sci. EII
BD Bhatt, Tech. VIII
KL Bagga, Tech. VIII
Rati Ram, Tech. VIII
VP Arora, SMA

OBITUARIES

Masi Charan, W/S Asstt, June 1
Uttri Prasad, Tech. VII, June 8
Upender Paswan, W/S Asstt June 28
Ranbir Singh, Safaiwala, September 25
Kundan Singh, Recordkeeper, October, 15
Shiv Charan, W/S Asstt, December 3
KL Sharma, Tech. VIII, February 7
Jhuthar Singh, Security Asstt, March 13

STAFF STRENGTH
(as on 1.4.97)

Category		Grade	Number
(A)	**SCIENTIFIC & TECHNICAL STAFF**		
1.	Scientific Staff	Gr IV	280
2.	Technical Staff	Gr III	149
		Sub- Total (1+2)	**429**
3.	Engineering Cadre Staff	Gr V	—
4.	Supporting Technical Staff	Gr II	345
5.	Supporting Technical Staff	Gr I	111
		Sub- Total (3+4+5)	**456**
		Total (A)	**885**
(B)	**ADMINISTRATIVE & NON-TECHNICAL STAFF**		
6.	Administrative (Gazetted)	Group A	5
7.	Administrative (Gazetted)	Group B	15
8.	Administrative (Non-Gazetted)	Group C	147
9.	Non-Technical Staff	Group D	119
		Total (B)	**286**
		Grand Total (A) + (B)	**1171**

Ph.Ds. Awarded

S. No.	Name	Title	University	Guides
1.	Suchita Ghosh	A Study on the maintainance of venus mightside ionosphere	Delhi University	Dr. K.K. Mahajan NPL Dr. N. Nath Delhi University
2.	Jaya Naithani	Atmospheric boundary layer studies over the Indian Antarctic Station, Maitri.	Delhi University	Dr. H.N. Dutta NPL Dr. K.M. Aggarwal Delhi University
3.	P.L. Malhotra	A study of production rates (QO), loss rates (BO) and scale heights (HO) in F1-F2 transition region around sunspot minimum conditions.	Delhi University	Dr. A.P. Mitra NPL
4.	Ram Chavi Sharma	A study of minor constituents in the atmosphere using solar infrared spectro - radiometer.	Maharsi Dayanand University Rohtak	Dr. A.B. Ghosh NPL Prof. R.D. Singh M.D. University Rohtak
5.	D.S. Mehta	Effect of source correlation on the spectra of radiated fields	Meerut University	Dr. K.C. Joshi NPL Dr. M.K. Sharma Meerut University
6.	Ravindra Nath Sharma	Structural and electronic properties of metal insulator semiconductor (MIS) structures based on yttrium oxide thin films on silicon	BITS, Pilani	Dr. A.C. Rastogi NPL
7.	V.K. Parashar	Studies on the Sol-gel processing of glass/ceramics	IIT, Delhi	Dr. O.P. Bahl NPL N.K. Jha, IIT, Delhi

HONOURS AND AWARDS

1. Dr. Krishan Lal was awarded Daulat Singh Kothari Memorial Lecture Award by the Indian National Science Academy, New Delhi, for 1996 (delivered in October 1996 in INSA).
2. Dr. Krishan Lal has been elected as Secretary, Asian Crystallographic Association.
3. Dr. Krishan Lal has been elected as Vice President, Metrology Society of India.
4. Dr. A.K. Agrawal has been elected Joint Secretary, Metrology Society of India.
5. Dr. R.P. Pant has been elected Joint Secretary, Indian Society of Magnetic Fluid Research.
6. Mr. K.B. Ravat was awarded best SEM micrograph award in Materials Science Category at the XX National Conference of the Electron Microscope Society of India held at Calcutta during December 5-7, 1996.
7. Dr. D. Gupta was elected Fellow of Metrology Society of India.
8. Mr. R.M. Khanna was awarded 1994 J. Dasgupta Award of the Indian Meteorological Society for best publication in Indian Journals in field of Meteorological Instrumentation, Observation Methods and Satellite System.
9. Dr. P. Banerjee and Dr. A. Sengupta elected Fellow of the Institution of Electronics and Telecommunication Engineers India.
10. Dr. A.C. Rastogi delivered the honour lecture at the Materials Research Society of India (MRSI) Annual General Meeting held at Bhabha Atomic Research Centre (BARC) Feb. 1997 on Nanostructured semiconductor materials for optoelectronic Devices application.
11. Dr Mohan Lal's name has appeared in 'The marquis who's who' USA in the world, 14th Edition 1997.
12. Dr. S.P. Varma was: cited in WHO's WHO in the WORLD, 14th Edition, 1997.
13. Dr. D.K. Suri's name has been included in the 14th Edition of Marquis "Who's Who in World, 1997".
14. Dr. S.N. Singh was made visiting fellow of Sardar Patel University, Ballabh Vidhyangar, Gujrat.
15. Dr. A.V. Narlikar received the Homi Jehangir Bhabha Medal (1996) of the Indian National Science Academy.
16. Dr. A.V. Narlikar nominated as a Member of the Board of School of Physics, the Central University Hyderabad for a period of 3 years.
17. Dr. K.K. Mahajan appointed in the Board of Editors, Indian Journal of Physics.
18. Dr. M.K. Raina and K.K. Mahajan included in the Twentieth Century Distinguished Who's Who published by South Asia (overseas) Publication Company, Delhi.
19. Dr. D.R. Lakshmi was nominated as a Member of the Research Advisory Committee of Indian Institute of Geomagnetism, Mumbai.
20. Dr. V.R. Singh was elected as a fellow of IEEE (USA).
21. Dr. V.R. Singh was elected as a chairman of IETE Delhi Centre for 1996-97 and a member of ExeCom of IEEE Delhi for 96-97.
22. Dr. V.R. Singh was elected as a Joint Secretary of Instrument Society of India and Convenor of National Symposium on Instrumentation. 1997.

VISITS ABROAD

1 Dr. D.C. Parashar, Sci F visited Thailand from 30-4-96 to 2-5-96 to attend the IPCC/DECO meeting of experts on emission factors for methane from wetland rice cultivation.

2. Dr. D.R. Pahawa, Sci E-II and Sh. R.M. Khanna Sci E-II were deputed to Russia from 25-5-96 to 31-5-96 to attend International symposium on acoustic remote sensing & associated techniques of the atmosphere.

3. Sh. M.K. Mittal, Sci E-I was deputed to Germany for two months from 17-5-96 under NPL-PTB technical cooperation programme.

4. Dr. O.P. Bahl, Sci F visited France for 45 days from 3rd June, 1996 for carrying out research under IFCPAR project on "Influence of the surface energetics of the enforcement on the development of microstructure of the matri & fibre/matri invention in composites.

5. Dr. V.N. Ojha, Sci E-I was deputed to Germany from 1-6-96 for a period of 3 months under NPL-PTB technical cooperation programme.

6. Dr. K.K. Mahajan, Sci G visited USA from 17-21st June, 1996 to present a paper on solar 22, 96.

7. Dr. B.S. Gera, Sci E-II visited Italy for 3 months from 3-6-96 to participate in a field experiment on the dopper acoustic of ABC at Institute Di Fisica Dell atmosphere.

8. Dr. B.S. Mathur, Sci F Visited PTB Germany & UK from 16th June 1996 to 28th June 1996 to observe various project as a member of steering commitee.

9. Dr. Krishan Lal, Scientist (Director's Grade) visited Australia and Newzealand from 16-6-96 for four weeks time as a member of Indian delegation for R&D Technology management.

10. Dr. S.K. Singhal, Sci E-I was deputed to South Korea for 3 months from 20-6-96 to do research at KIST under INSA-KOSEF exchange programme.

11. Dr. Ranjit Singh, Sci C was deputed to Germany from 17-21 June, 96 to attend CPEM 96 and visit to PTB Germany.

12. Dr. V. Mohnan, Sci E-II and Dr. Omkar Sharma, Sci E-II were deputed to Germany from 22-7-96 to 17-8-96 and 22-7-96 to 23-10-96 respectively for familiarisation with latest noise measurement techniques and others standardization activities at NPL under NPL-PTB Technical Cooperation programme.

13. Dr. D.R. Laxmi, Sci F visited France from 28th Aug. to 5 Sept. to attend General assembly of URSI.

14. Mr. Ganga Prasad, Sci C was deputed to PTB, Germany from 5-8-96 to 28-11-96 for force measurement calibration cell under NPL-PTB Technical Cooperation Programme.

15. Dr. S.L. Jain, Sci E-II visited Germany from 22-26 July 1996 to attend Inter. Laser sodar Conference

16. Prof. E.S.R. Gopal, Director, NPL visited U.K. from 11-23 July 1996 to visit University of

Oxford to hold discussions under the on going collaborative project synthesis, characterization and application of some conducting polymers.

17. Dr. H.C. Kandpal, Sci E-II was deputed to Germany from 26-8-96 to 21-9-96 to seek advice from experts working in the area of colour & reflectance for measurement and establish facilities for calibration & colour measuring instruments used by plastic, Paint textile industries etc.

18. Dr. R.S Arora, Sci E-I was deputed to U.K. from 7th Aug. 1996 to attend the Int. SCAR Conference.

19. Dr. Krishnan Lal, Scientist (Director Grade) visited U.S.A. from 8-17 Aug. 1996 to attend congress of Int. union of crystallography and Germany from 18-24 Aug. 1996 to review the Indo German project entitled X-ray different studies on GaAs at Univ. of Damstad.

20. Dr. K.K. Mahajan, Sci G, visited Italy from 19-27 Aug. 1996 to attend IRI 96 Task force meeting and france from 28th Aug to 5th Sept. 1996 to attend URSI General Assembly.

21. Dr. P. Banerjee, Sci E-II was deputed to France from 28-8-96 to 14-9-96 to attend URSI General Assembly, visited Bipm/LPM to explore Joint Collaboration and UK from 15-20 Sept. 96 to visit NPL, Teddingten.

22. Dr. B.S. Mathur, Sci G visited France from 25-8-96 to 5-9-96 to attend URSI General Assembly as vice Chairman of Commission and Netherlands from 13-9-96 to attend ILAC conference.

23. Prof. ESR Gopal, Director, NPL visited USA from 25 Aug. to 6 Sep. 1996 to attend NCSL conference, visited Univ. of California to explore possibilities for SSRI cooperation.

24. Dr. D.C. Sharma, Sci E-II visited Germany from 1-9-96 to 12-10-96 under CSIR-DAAD invitation programme for the year 1996-97

25. Dr. P.C. Kothari, Sci E-I and Dr. R.K. Kotnala, Sci E-I visited Germany from 1-9-96 to 12-10-96 and 1-9-96 to 13-12-96 respectively under NPL-PTB Technical Cooperation programme.

26. Dr. K.S. Zalpuri, Sci E-II was deputed to France from 9 to 11 Sept. 1996 to attend the meeting on INDOEX programme

27. Dr. G. Bhagvanarayanan, Sci E-I was deputed to Germany for 2 months under CSIR-DAAD exchange programme.

28. Dr. (Mrs.) Kundu, Sci E-I was deputed to Italy, France and USA from 17th Sept. 1996 to 4th Oct. 1996 to attend Quadrennial symposiam, visit to observatories meuden: Paris and to visit University of Wiscousin to Study the latest instrument connected with observatories

29. Dr. S.C. Jain, Sci E-II was deputed to Italy and France from 12 Sept. to attend XVIII Quadrennial Ozene Symp from 12-20 Sept 1996 under IFCPAR project respectively

30. Mr. S.S. Verma, Sci E-I, was deputed to Japan from 23 Sept. 1996 to 5th October 1996 for Training in Japan in the area of Ozene Layer protection in Asian Countries under calonpo plan.

31. Dr Krishan Lal, Scientist, Director's Grade, visited Japan from 27 Sept 1996 to 4th Oct. 1996 to Chacir a session at the CODATA symposium Sharing and utilization of scientific and engineering DATA and attended CODATA conference & general assembly at Tskuba

32. Prof. ESR Gopal, Director visited France from 25-26 Sept 1996 to attend the council meeting of BIPM

33. Dr. (Mrs.) K.S. Bala Krishnan, Sci C was deputed to Czech republic for 8 month from 30-9-96 under CSIR-Czech Republic exchange programme.

34. D.C. Parashar, Sci F visited Mauritius from 8-12 Jan. 97 to attend SASCOM/SAIPO workshop

35. Mr. Sukhbir Singh, Sci B was deputed to Japan from 12-26 March to attend ASIAN seminar on new direction in transmission electrom microscopy and none characterization of materials

36. Dr. A.C. Gupta, Sci E-II was deputed to Japan from 2-10 March, 97 to visit National Research Lab Metrology and discuss future callaboration & modalities for comparision between NPL and NRLM

37. Dr Krihan Lal, Sci (Director Grade) visited France from 17-2-97 to 21-2-97 to attend meeting of directors of National Metrology Institutes meeting of the consultative programme.

38. Mr R.C. Sharma, T.O.A was deputed to Mynmar from 6th March, 97 for 36 days to participate in the summer campaign for methane omission measurement for rice method.

39. Dr V.N. Ojha, Sci E-I was deputed to Japan from 3rd March 97 to visit electro lab as quest researcher.

40. Prof. ESR Gopal, Director visited Japan from 17th March to 23rd March 97 as a leader of Indian delegation for 3rd joint seminar on manufacturing advance composite materials and visit to IS424 automobile company etc

41. Mr Rajiv Sikand, To-P was deputed to Japan from 30-3-97 to 4-4-97 to attend Int seminar on precision forging.

42. Dr A.K. Gupta, Sci F visited Germany from 29-3-97 to 28-5-97 to work on going coperative project entitled "Development of new A1-L1 Materials with low density & high stifness at 1FAM.

42. Dr. Mahesh Chandra, Sci E-II, was deputed to Phillipines from 7-11 Oct. 1996 to participate in the APMP committee meeting and PPEC conferance.

43. Dr. R.P. Singhal, Sci E-II visited Germany from 7th Oct. to 2nd Nov. 1991 to study state of art of calibration & measurement set up in dimension measurement at PTB under NPL-PTB technical Cooperation Progs.

44. Dr. A.K. Gupta, Sci F visited Japan from 15-31 Oct 96 to visit forgoing and automobile Industries sponsored by AIST.

45. Dr. S.K. Agarwal, Sci C was deputed to Japan from 15-10-96 to 14-1-97 to do research work in the area of Super Conductivity at Science University of Tokyo under INSA/JSPS exchange progs.

46. Dr. D.P. Bhatt, Sci C visited Japan from 21-24 Oct. 96 to attend Int. Symposium at Tsukuba

47. Dr. J.R. Anand Sci F with HNP Poddar visited Singapore under NPL-PID technical Cooperation Progs..

48. Mr Prabhat Kumar, Sci E-I was deputed to Thailand from 28th Oct 96 to 2nd Nov 96 to participate in the sub regional paing workshop on measurement of methane emission from rice paddies.

49. Dr. Krishan Lal, Scientist Directors Grade visited South Korea from 29-31 Oct 96 to attend the ICMETTAL Fttals meeting.

50. Prof. ESR Gopal, Director visited Japan from 19-27 Oct 1996 to hold discussions at UEC under CSIR-AIST Progs.

51. Dr. R.P. Tandon, Sci E-II was deputed to South Korea from 17-24 Nov 96 to visit seoul National University to deliver few lectures & hold discussions to evolve a collaboration in the area of electro ceramics.

52. Dr. V.R. Singh, Sci F visited Netherlands Belgium from 31st Oct-8th Nov 1996 to attend IEEE Int. conference, visit to ICATHO LIEIC UNIV. & DELFT for discussions

53. Dr. B.S. Mathur, Sci G visited Ganvea from 4-8th Nov. 96 to attend the Int. Conference on legal metrology.

54. Dr. K.S. Zalpuri, Sci E-II visited USA from 3-13 Nov. 96 to acquire expertise in handling equipments for sagar/kanya.

55. Dr. O.P. Bahl, Sci F visited Japan from 13 Nov. - 19Nov. 97 to present a paper at carbon Research Centre, visit to HOKa aido university and Mistub. Chemical factory

56. Dr. D.C. Parashar, Sci F visited Thailand from 11-13 Nov 96 to attend annual workshop of Asian Regional progs in Energy Environment and Climate.

57. Mr. S.M. Dhawan Sci F visited Pakistan from 10-12 Nov. 97 to attend workshop on International property rights CIPRS

58. Dr. A.K. Hanjurah, Sci E-I visited Saudi Arabia for one year from 20-11-96 on Foreign assignment under CSIR-SASC Progs.

SPECIAL LECTURES

DATE	SPEAKER	TOPIC
23.4.96	Dr. N.S. Sundaresan Krishnamurti Foundation Andhra Pradesh	Conducting Polymers in Bio-Sensors
2.5.96	Dr. S. Gosh University of Auckland New Zealand	Intermolecular interactions in Conducting Polymers
30.7.96	Dr. K. Prabhakaran Senior Research Scientist Nippon Telegraph and Telephone Corporation, Japan	Surface Reaction and Nonstructure Formation in Si and Ge System
5.8.96	Dr. Toshiyuki Yamada President, Research Center Sony Corporation, Japan	Seminar on Sony's R & D Activities
16.8.96	Dr. Dinesh K. Sood Royal Melbourne Institute and Technology, Australia	Micromechanics-A new Frontier for 21st Century
1.11.96	Dr. K. Rajesh Visiting Fellow Dept. of Chemical Science & Technology, Faculty of Engineering Khushu University Fukuoka, Japan	Optical Alignment of Liquid Crystals & Related Research Trends in Japan
14.11.96	Dr. Kalpana S. Katti North Dakota State University U.S.A.	Determination of Nanoscale Physical Properties in Perovskites via Transmission EELS
29.11.96	Prof. K. Balik Czech-Republic	Research of Carbon Materials in institution of Rock and Structure Materials
2.12.96	Dr. H.H. Weetall National Institute of Standards & Technology, U.S.A.	Biosensors: Present State of the Art and Future Prospectives
3.12.96	Dr. H.H. Weetall National Institute of Standards & Technology, U.S.A.	Laser Trapping for the Immunoassay of Antigens at Attomolar Concentrations

2.12.96	Dr. Bruno Btsch U S I, Germany	Charaterization of Surfaces and Surfaces Reactions-An overview of Methods of Surf. Analysis
12.12.96	Prof. E.Z. Kurmaev	X-Ray Emission Spectra and Electronic Structure of Advanced Materials
20.12.96	Dr. Dieter Kley Director, Institute for Chemistry of the polluted atmosphere Juelich	The Juelich International Ozone Sonde Comparison Experiment (JOSIE)
17.12.96	Dr. P.J. Crutzen NL, Director, Max-Planck Institute for chemistry, Mainz, Germany	30 years of Progress in Atmospheric Chemistry
8.1.97	Prof. Vikram L. Dalal Lowa State University	Recent Trends in Amorphous Siliconics
11.1.97	Prof. Charles H. Townes Nobel Laureate	The Center of our Galaxy
21.1.97	Prof. Hasse Technical University Darmstdt, Germany	Organic Materials for Applications in electronics and Photos
27.1.97	Prof. J.N. Sherwood Vice Principal, Dept. of Pure & Applied Chemistry University of Strathclyde, U.K.	The Potential of Highly Polar Organics Crystals for Optical and Acoustic Optic Devices
29.1.97	Prof. O.V. Lounasmaa Ex-Director, Low Temperature Laboratory, University of Technology, Finland	Multichannel SQUID Instruments and their use for Neuro-Magnetic Research
3.2.97	Dr. T.L. Gulyaeva Institute of Terrestrial Magnetism Ionosphere and Radio Wave Propagation, Russian Academy of Science, Moscow	Impact of Large Geomagnetic Storms on Human Mortality
5.2.97	Dr. A.S. Rao David Taylor Research Center U.S.A.	Non Oxide Ceramics

6.2.97	Prof. Chain Sukenik Bar Lian University Israel	Preparation an Application of Organic Monolayer Films
6.2.97	Dr. Marc Monthioux CEMES, CNRS Toulouse France	Exploitation of TEM in Under Standing of Carbonization and Graphitization Phenomena
12.2.97	Dr. Marc Mothioux CEMES, CNRS Toulouse France	Pyrolytin carbon interphases in ceramic matrix composites Microscopic effects from Microscopic causes
26.2.97	Dr. F.J. Lubken Physikalisches Institute Universitat, Bonn Germany	The polar measopause region at high latitudes : New experimental results from the coldest place on earth
25.3.97	Dr. P. Zaumseil Institute for Semiconductor Physics, Frankfurt Germany	High Temperature In-Situ Investigation of Si (1-x) Gex and Si (1-Y) Cy Layers on Si Substrates

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TRAINING PROVIDED

1. In the training course which was held at NPL from 7-11 April 1997, entitled, "Training Course on Greenhouse gases from Agricultural Sources" Training was given to participants on the measurements of greenhouse gases from Agricultural Sources at NPL, IARI, Pusa New Delhi and NBRI Karnal during the Course. Participants were drawn from Nepal, Srilanka, Bangla Desh, Mauritius, Newzeland, Thailand, Phillippines, Pakistan and India.
2. Two SC/ST students of Secondary level attend the one week familiarization programme at NPL.
3. Three students from different Engg. Institute carried out project work at NPL towards the fulfilment of their course.
4. A one week training programme in Dimension Metrology & Temperature Std. was arranged from 22-4-96 to 26-4-96 for the office from Bharat Electronics Limited Ghaziabad.
5. Graduate Students (10 in numbers) of various colleges of Delhi University were trained on Infrared Instrumentation, techniques, and spectroscopic testing.
6. Training in use and application of dimensional measurement instruments and calibration of length and angle standards were imparted to persons from developing countries, industry, testing and calibration laboratories in India.
7. 6 weeks training was provided to Mr. S. Kumar, B.E. student of Electrical & Electronic Engineering Department of BITS, Pilani
8. Sri K.C. Bahuguna of Institute of Armament Technology, Girinagar, Pune was trained in the field of Lasers and Electro-Optics. His dissertation was examined and finally he was awarded M. Tech degree from University of Pune.
9. Supervision of the project work entitled Design and fabrication of a Gunn Oscillator as a Microwave Source of the B.E. Final Year students, Mr. Dheeraj Kaul, Mr. Sammer Goel and Mr. Sidharth Govil of the University of Pune for the partial fulfilment of the requirements for the award of the B.E. Degree in Electronics and Tele-communications.
10. Training and the data was provided to Mr. A.K. Srivastava for his M. Phil Dissertation from J.N.U. on "General climatology over the Indian Antarctic Station, Maitri".
11. Training provided to outside person Dr. G. Anene, visiting scientist from Nigeria for "studies of F1-F2 transition region using theoretical ionogram technique.
12. 11 students from different Engineering Institutes carried out project work at NPL towards fulfilment of this course.
13. Three students from different Engineering Institutes carried out project work at NPL towards fulfilment of the course work.
14. Six students from different Engineering Institute carried out project work at NPL towards fulfilment of the course work.
15. Dr. R. Gopalakrishnan, Department of Physics, Anna University, Madras, who was awarded Young Scientist Fellowship by the Tamil Nadu State Council for Science and Technology, Madras underwent training during 2nd May to 31st July, 1996 in X-ray Diffraction and Topography
16. Dr. M.T. Sebastian, Scientist, Regional Research Laboratory, Trivandrum was in NPL to work on X-ray Lang topographs from quartz crystals with insitu microwave field from January 19, 1997 to February 18, 1997.

SYMPOSIA/WORKSHOP/SEMINAR

1. One day workshop titled "Work Culture and Conflict Management" was organised on 8th & 9th May 1996, for scientist E-I of NPL staff. The speaker was Sh. S.S. Rangnekar, Bombay.
2. An evening lecture titled "Management of Stress" was delivered by Sh. S.S. Rangnekar for the executives and their wives. on 8th May, 1996.
3. One day workshops on "Patent Awareness" by Indian Women Scientist Association was held on 24-7-96 at NPL.
4. Workshop on "INDOEX" programme in India held at NPL from 19th. to 21th August, 1996.
5. Fifteenth National Symposium on Cryogenics held at NPL from 12th to 14th September, 1996.
6. Asian Least Cost GreenHouse Gas Abatement Strategy (ALGAS) 2nd National Inventory Workshop was organised at NPL from 11-16 Nov. 1996 under the guidance of Dr. A.P. Mitra, FRS.
7. NPL-Industry Interaction in collaboration with Quality Marketing centre Fbd. & Faridabad industrial Association. 7 Oct. 96
8. Seminar on Fero-Electric and Dielectric. 8-11 Oct. 96
9. 2nd National Inventory Workshop (ALGAS) 18-19 Nov. 96
10. Conference on Human Dimension 25-29 Nov. 96
11. 3rd International Conference on Semiconductor Materials and Technology 19-12 Dec. 96

International Conferences/Seminars/ Symposia

1. Krishan Lal Certified Reference Materials, **International Conference on Advances in Metrology and its Role in Quality Improvement and Global Trade,** New Delhi, 1996.
2. Krishan Lal, Recent Advances in Characterization of Advanced Materials, **Meeting-cum-Workshop, Technical Advisory Group, International Centre for Materials Evaluation Technology (UNIDO Sponsored), Taejon** (1996).
3. Krishan Lal, High Resolution X-Ray Diffraction Study of Real Structure of Semiconductor Single Crystals, **Asia Pacific Society for Advanced Materials Symposium, Bangalore** (1996).

National Conferences/Seminars/Symposia

1. Krishan Lal, High Resolution X-Ray Diffraction Investigation of Single Crystals for Fundamentals as well as Applied Research, **83rd Session of indian National Congress Association, Patiala,** 1996.
2. Krishan Lal, Structural Characterization of Semiconductor Crystals, **AICTE Short-term Training Programme on Advanced Techniques for Characterization of Materials, New Delhi,** 1996.
3. Krishan Lal, Dynamical diffraction of X-rays, **XXVII National Seminar on Crystallography. Varanasi,** 1996.
4. Krishan Lal, Current Trends in Materials Characterization for Advanced Research and Development in Sensors, **Fourth National Seminar on Physics and Technology of Sensors, Vallabh Vidya Nagar, 1997-Inaugural Talk.**
5. Agrawal, A.K., Ganju Sunita and Krishan Lal, Quantitative Determination of Anions in Water by Ion-Chromatographic Technique. **Conference on Metrology in Relation to Environment, New Delhi,** March 12-14, 1997.