DAE Solid State Physics Symposium – 1995

The 38th Solid State Physics Symposium, organized by the Board of Research for Nuclear Sciences of the Department of Atomic Energy, was held at the Indian Association for the Cultivation of Science, Jadavpur, Calcutta during 27–31 December 1995. The following is a brief resume of a few selected aspects of the proceedings of the symposium.

A. K. Barua (IACS) in his invited talk on 'Thin film solar cell technologies: status and prospects for cost reduction of solar photovoltaic electricity' stated that only thin film solar cells have the potential of reaching the module cost of Rs 30/pw from the present level of Rs 120–175/pw and various options are being tried out.

Satish C. Gupta (BARC) discussed the topic 'Phase transition studies using gas gun'. He described the gas gun facility (BARC) and how it is used for shock loading studies of a variety of materials up to 40 GPa for a few microseconds. Phase transition studies in shock recovered samples of GeO_2, Ti and Zr have been carried out by XRD and Raman spectroscopy. The results indicate that in GeO_2, initiation of irreversible amorphization occurs between 6.8 and 7.4 GPa. The phenomenon is completed around 10 GPa via solid–solid route. In the case of Ti and Zr, the literature indicates that different reports give different values for the transition pressure for shock-induced α–w transition. The cause for this scattering of data was investigated and it is found that the oxygen content in the sample determines the transition pressure. Other aspects of physics of phase transition like comparison with static pressure data were also described. During discussions, it was noted that computer experiments of shock-induced phase transitions in these and other materials may throw light on the dynamic nature of phase transitions.

At Indira Gandhi Centre for Atomic Research (IGCAR), two major facilities have been set up for condensed matter investigations in the recent past. Mohammed Youssuf described the high resolution X-ray diffractometer set up in the Materials Science Lab. (MSL) for high pressure experiments in the Guinier geometry. A home-made diamond anvil cell capable of generating pressures up to 60 GPa has been coupled to the diffractometer. The $K_{\alpha 1}$ molybdenum radiation can be focused to a spot size of ~ 100 μm and using a position sensitive detector with position resolution of ~ 100 μm, one can obtain high quality data in about 2 hours. The instrument has been used for studying high pressure phases of UAl_2, Ti, Al, $ThAl_2$ and fullerene C_{70}.

B. Viswanathan (IGCAR) presented the details of development of monoenergetic positron beam at MSL. The low-energy positron beam facility consists of (i) a source chamber containing a 50 μCi ^{22}Na positron source and a 1 μm thick W (100) foil moderator; (ii) electrostatic beam optics with a magnetic transport system for monoenergetic slow positrons (several eV to keV); (iii) UHV target chamber; and (iv) suitable gamma spectrometer.

M. S. Hegde (IISc), in his invited talk, dealt with studies of Giant Magneto-Resistance (GMR) in a series of compounds $Ln_{1-x}A_xMnO_3$ (Ln = La, Nd, Pr and A = Ca, Sr, Ba and Pb) carried out at his laboratory. In this connection, it may be noted that the two invited talks in the 1994 DAE Solid State Physics Symposium by Roger Cowley and R. Krishnan also dealt with GMR in alloys and multilayers. In contrast, Hegde reported higher GMR in oxygen-deficient Ln oxide, namely $La_{0.6}Pb_{0.4}MnO_{3-\delta}$, demonstrating that defects in the films induce higher GMR effect. They have also found over 85% GMR in $La_{0.7}MnO_{3-\delta}$ oxide which is unique as the oxide is self-doped. They have also observed enhanced GMR in magnetic-nonmagnetic multilayers $(La_{0.7}MnO_{3-\delta}/La_{0.85}MnO_{3-\delta})_{20}$.

J. Koshy's (RRL, Trivandrum) talk dealt with synthesis of a *new family* of complex perovskites $REBa_2MO_{5.5}$ (RE = rare earth, M = Zr, Sn and Hf). These materials are found to be chemically compatible with YBCO and BISCCO superconductors even under extreme processing conditions, and characteristically possess low dielectric constant ($\varepsilon \sim 10$) and loss factor ($\tan \delta \sim 10^{-5}$) at GHz, making them suitable substrates for YBCO and BISCCO superconductors for microwave applications. Some 45 new materials of this class are reported; lattice constant is typically of the order of 8.5 Å. Superconducting films of YBCO with $T_{c(0)} = 92$ K and Bi (2223) $T_{c(0)} = 110$ K with critical current density $> 10^4$ A/cm^2 at 77 K have been developed over the substrates by dip coating and screen printing techniques. YBCO thin films have also been developed on these substrates by laser ablation, giving highly-oriented (001) films with superconducting transition $T_{c(0)} = 92$ K and critical current density of 10^5 A/cm^2 at 77 K. One of the important points made by Koshy was that they find that even with 80% volume fraction of insulator to 20% of superconductor, the material remains superconducting.

Abhijit Mookerjee (S. N. Bose Centre, Calcutta) reviewed various theoretical approaches to the study of 'Phase stability of alloys' and detailed two main approaches, namely, that of Connolly–Williams for ordered alloys and the concentration wave approach in a perfectly disordered paramagnetic system. Results obtained in the case of a number of binary alloys, CuZn, CuNi, etc. and AgPd were presented. Mookerjee talked of setting up a perturbation of an ordered structure in a totally disordered background and wondered whether the system can support such a perturbation. In commenting on the relative stability of various alloys, he emphasized that the quantitative theories have to possess high accuracies for their credibility to be maintained.

Conducting polymers, to be commercialized, pose many problems including (i) instability in a specific environment, (ii) difficulty in processing. The conduction mechanism itself may be based on solitons, polarons or bipolarons which generally depends on doping, a common method of sensitizing. In spite of difficulties, polymers are attractive since they possess low density, flexibility in processing and devices, moderate environmental stability and are of low cost. Several processes exist for synthesis of conducting polymers: (a) by C–C conjugation as in polyacetylene, (b) delocalization of π electrons, thus allowing for penetration of non-bonding electrons, e.g. ethyl sulphide, and (c) electrochemical synthesis. Augmentation of conductivity is either by (a) doping (b) self-doping or no-doping polymers and (c) by reduction of band gap in polymers.

Intrinsically, the conjugated polymers like polyacetylenes are semiconductors and one needs to dope them to enhance conductivity. However, doping to large concentrations drastically affects mechanical, chemical, thermal and environmental stability of the polymer. Sukumar Maiti (IIT-Kh) discussed alternate roots to enhance conductivity, by reducing band gaps. He described four options: (a) introduction of quinoid character, (b) alteration of aromatic and quinoid character, (c) increasing non-aromatic character, and (d) alternative strong donor and acceptor moieties. He discussed the options by illustrations of several narrow bandgap polymers that have been recently synthesized at IIT, Kharagpur, resulting in band gaps of ~ 0.80 eV.

Conducting polymers have been used in fabrication of biosensors recently. In the so-called amperometric sensors, the conducting polymer acts as an electronically conducting matrix for immobilization of enzymes. In the so-called conductimetric sensors, the polymers play a dual role – namely as an immobilizer of the enzyme and a transducer. A. Q. Contractor (IIT-K) described the variety of enzyme substrate systems studied, which has resulted in a generic conductimetric sensor concept with glucose-oxidase, urease, lipase and pepsin.

S. V. Subramanyam (IISc) described the research efforts in synthesis of highly conducting amorphous carbon, a new phase of carbon, using pyrolysis, high pressure and temperature and plasma-assisted polymerization. His group has developed carbon films whose conductivity can be varied from near-insulating phase to about 6000 scm^{-1} depending on the preparation process. Density of film is nearly 1.7 gm/cc, that is, lighter than graphite and the film is lustrous; it exhibits constant conductivity over a wide temperature range of nearly 1000 K as well as over a wide pressure range. The material has been characterized by a variety of techniques. The Raman line occurs at ~ 1300 cm^{-1} which does not agree with that of either diamond or graphite. Secondly, ion mass spectrometry indicated that the film is composed of C_2 clusters. Cyclic voltametry has been carried out to study absorption and desorption of various gases. The material exhibits inertness over wide pH values. Questions which arose were: 'Why are these films so highly conducting?; Why is conductivity temperature independent?; Why is it so inert?, etc'. The group has sought for a patent for synthesis of this unusual, highly conducting, highly stable, highly temperature independent, magnetic field independent form of a new phase of carbon. In the years to come, they expect that the film may have various applications for anticorrosion coating, stripper foils, etc.

Nandini Trivedi's (TIFR) invited talk on 'Superconductor–insulator transition in disordered electronic systems' gave a clear exposition of the study of effect of disorder on superconductivity in low-dimensional systems. This topic is of great topical interest (see e.g. *Phys. Rev. Lett.*, 1995, **74**, 1500) in the context of study of layered hi-T_c superconductors and disordered and amorphous films. Analytical approaches cannot tackle this problem. Nandini Trivedi discussed her studies based on the fermionic model that can support superconducting, insulating and metallic phases and presented results based on their quantum Monte-Carlo studies.

Sriram Ramaswamy (IISc) spoke on 'Colloids far from equilibrium' which dealt with the study of structure, dynamics and phase transitions of colloidal suspensions by time-dependent statistical mechanics. R. Mukhopadhyay (BARC) on 'Quantum molecular tunneling in solids: Inelastic neutron scattering study', wherein results obtained during this decade on nature of tunneling rotational excitations of NH_4^+ ions in dilute solutions in alkali metal–halide lattices by high resolution inelastic neutron spectroscopy were presented. In particular, the role of crystalline strains created by doping by large alkali atoms and implications on nuclear spin conversion processes were noteworthy.

Chanchal Majumder (S. N. Bose Centre), in his evening talk on 'Bose–Einstein condensation', starting from the Bose–Einstein formula which had been used for predicting existence of such a condensate for critical values that were related to thermal Debye wavelengths, discussed various aspects and properties of the condensate. The condensate had to be demonstrated in an ideal weakly interacting particle system, namely, a dilute gas system, in which composite particle stabilities had to be taken into account. One of the important experimental achievements in physics has been the observation of Bose–Einstein condensate of a gas of ^{87}Rb atoms, a culmination of efforts of over a decade. M. H. Anderson *et al.* at University of Colorado, Boulder, USA were able to provide proof of observation of the condensate at a density of 3×10^{12} atoms/cc and at a temperature of 170 nano Kelvin by ingenuous experimental efforts through laser and evaporative cooling of neutral alkali atoms in a magneto-optical trap. The experimental observation has since been confirmed in other alkali atom systems (see e.g. *Phys. Rev. Letts.*, 1995, **75**, 1687).

In the 'Science' round up of the year, the condensate has been referred to as 'molecule of the year'. To quote from popular news 'This is a new form of matter, named after Satyendranath Bose and Einstein, a superchilled gas in which atoms move at the same speed and in the same direction. In normal gas, atoms scatter wildly but this new matter could allow scientists to create a new tool – an atomic laser capable of removing atoms one by one or even "writing" atoms into semiconductors'.

The evening lecture on the second day was on 'Frontiers in quantum chromo dynamics, top quark *et al.*' by Bikash Sinha (SINP & VECC). Among the six expected number of quarks, the 'top quark' proved to be elusive. The story of the unfolding of the drama of elementary particles, culminating in the discovery of the top quark this year in the debris of proton–antiproton collider experiments at the Fermilab in USA – observation of a needle in a hay-stack – was the content of the talk by Bikash Sinha in his inimitable style. He said that the story of pursuit of knowledge of structure of matter has been the story of technological development of accelerators, the tools of the 'looking glass'. In the phase space defined by the energy (temperature), strangeness and baryon density, he discussed various aspects of occurrence of the early universe scenario, nuclear matter, neutron stars, hadronic gas and the quark–gluon plasma. One looked for 'signatures' of constituents of matter like photons. He referred to a series of equilibration times in the scenario and mentioned that there seems to be signature of first-order phase transitions involving existence of quark–gluon-plasma with hadronic matter. He dealt with experimental details of the Fermi Lab experiments to spot the *t* signal which has established that the 'top' quark has a large mass and in about 10^{-23} s it decays before hadronization. The Geneva, US and Japanese collaborational experiment has led to a mass value of 173 GeV for the top quark. He referred to the New Megascience facilities which are still to take shape like LHC at CERN to look for Higg's particle, top quarks in abundance and relativistic heavy ion beams. Sinha made an important observation, namely, that by the time the LHC and RHIC came up, if India were to take part in this endeavour, the current research scientists in the 25–30 years of age group have to take up leadership in this endeavour.

The evening lecture on the third day was on 'Hundred years after the discovery of X-rays and fifty years after the discovery of nuclear magnetic resonance' by R. Chidambaram (Chairman, AEC). Condensed matter physics had its beginnings in the determination of crystal structure by Bragg, Bragg and Laue in 1912 by X-ray diffraction. 1995 happens to be the centenary year of the discovery of X-rays. While locating the positions of heavy elements in a crystal lattice was possible by X-ray diffraction, location of the ubiquitous hydrogen and other light elements was not possible till the advent of neutron diffraction. Nuclear magnetic resonance technique developed 50 years ago could throw light on location of hydrogen and its environs. Chidambaram covered a very wide canvas going back to the days of Roentgen in 1895 to the present day of use of high brilliance synchrotrons.

With the advent of X-ray beam from synchrotrons during the past 20 years, it is observed that the brilliance on samples at these sources has doubled almost every two years and hence this has increased a trillion times over these 20 years. It is believed that the next century will have as many applications of synchrotrons as the conventional source in the past 100 years.

Chidambaram also referred to the very wide range of use of X-rays in the three major fields, namely, diffraction, spectroscopy and imaging. The applications that have emerged in microscopy, tomography, holography and medical fields were briefly touched upon. He also referred to the role of X-ray telescopes in understanding cosmological aspects as well as the role of X-rays in radiation therapy. Chidambaram emphasized the need for increased collaboration and sharing of each other's facilities and even the compulsions that dictate the need for international collaboration in fields like high energy physics or elementary particle physics.

The proceedings of the symposium have shown that the border line between 'solid state physics' and 'materials science' is very thin and may disappear in the near future, thanks to the prevailing winds of change, emphasizing the role of applied work. Till recently we were preoccupied with 'ideal' systems occasionally touching on effect of variation of thermodynamic parameters, chemical composition or stoichiometry. Emergence of hi-T_c materials brought this very much as a part and parcel of solid state investigation. But now, it appears, we are encroaching on other aspects like effect of particle size variation or effect of disorder both qualitatively and quantitatively. Simple analytical and computational schemes are inadequate, making it essential to resort to Monte Carlo and other simulational studies. Another aspect that emerged was the need to go for multidisciplinary approaches like enzyme or polymer chemistry, band structure and microelectronics to design and fabricate today's sensors.

In conclusion, the symposium'95 was an enjoyable meet technically and otherwise, thanks to the extraordinary efforts put in by the hosts.

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SCIENTIFIC CORRESPONDENCE

Enechelon faults

I have a few observations to make about Sm. Ramasamy's article 'Enechelon faults along west coast of India and their geological significance' (*Curr. Sci.*, 1995, **69**, 811–814).

1. The statement 'Laccadives and Maldives is separated by 9° channel is incorrect, and it should be 8° channel instead'. This 8° channel used for international navigation (route) between Africa/Gulf countries and Colombo and far east is also very close to the line separating the Exclusive Economic Zone of Lakshadweep (India) and Maldives.
2. The Chagos–Laccadive Plateau extends for a length of approximately 2250 km (between 8°S and 14°N latitude) and is geographically divided into Chagos-archipelago at the southern portion, Maldive islands up to 8°N and Minicoy–Lakshadweep group of islands and banks in the northern parts. In Figure 2 of the article the location of the islands is shown wrongly. Lakshadweep islands are shown as Maldives and vice versa.
3. The Precambrian NE–SW trending regional dextral strike slip faults of the continental part have been transformed into Pleistocene sinistral faults in the West Coast and are extending up to the Lakshadweep/Maldive Ridge; this observation by the author is based mainly on IRS satellite imagery. The offshore extension of these faults and lineaments up to Lakshadweep Ridge should be confirmed only after extensive study by magnetic, gravity and deep seismic surveys of the marine domains represented by continental shelf, slope and Lakshadweep trough between Mangalore and Trivandrum, which is carpeted by a thick pile of Pleistocene to recent sediments and the basement is very complicated.

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