In this issue

Characterization and modification of materials by energetic ions

Progress in materials science and devices owes a lot to nuclear accelerators and ion beam based technologies. Low energy (keV) ion accelerators have become part of industries and medium energy (MeV) accelerators are now becoming available for commercial exploitation. With the availability of high energy heavy ions from accelerators, high energy ion beams are proving to be of immense use in various fields, particularly for characterization and surface modification, besides the conventional use in device fabrication. The special section in this issue of *Current Science* deals with the role of energetic ions from a few MeV to a few hundred MeV. The accelerators at Nuclear Science Centre (New Delhi), Tata Institute of Fundamental Research (Mumbai), Institute of Physics (Bhubaneswar), IIT (Kanpur), Bhabha Atomic Research Centre (Mumbai), Variable Energy Cyclotron (Kolkata) and Cyclotron (Chandigarh) provide ions of energy of a few MeV and higher.

Basically there are two aspects of energetic ions in materials science: characterization and modification of materials. The special section covers the characterization techniques such as Proton Induced X-ray Emission (PIXE), Rutherford Backscattering Spectrometry (RBS), RBS channeling, Elastic Recoil Detection Analysis (ERDA), their applications in various problems, Swift Heavy Ions (SHI) induced modification of materials and the basic mechanism of ion matter interaction. Modifications in the materials can be produced by elastic collisions as well as by inelastic collisions. These two are competing processes in energy loss of ions in materials. Domination of one process over the other depends on ion energy. Low energy (typically up to 10 keV/amu) ions produce point defects, cluster of defects by elastic collisions and subsequent cascade collision. High energy (typically higher than 100 keV/amu) heavy ions produce columnar type defects apart from the point defects. At the different accelerator centres mentioned above, a large number of research programmes are going on in the field of SHI in different types of materials. Several *in situ* and on-line facilities have been installed at NSC for probing materials modification and characterization during irradiation. Some of these facilities, their uniqueness in characterizing materials and the modifications that SHI brings about in a material medium are discussed.

Avasthi and Assmann discuss (**page 1532**) the special suitability of ERDA for depth profiling of light elements like hydrogen to very heavy elements up to mass 150 with single element resolution in the light mass region in materials. The uniqueness of this technique when used with detector telescopes lies in its on-line monitoring capability of materials evolution due to ion beam-induced modification such as interface mixing, electronic sputtering and radiation damage during irradiation itself. The PIXE technique, more suitable for MeV range proton beam is discussed (**page 1542**) by Govil. The capability of this technique for multielemental analysis and simultaneous detection of elements in surface and near surface region of materials with sensitivity approaching 0.1 ppm level has made this technique a versatile analytical tool for trace element analysis. The diverse areas, which have immensely benefited by this technique, are semiconductors and biological, environmental, geological, metallurgical, archeological and forensic sciences. Modification and characterization of materials in the near surface region using a few MeV ion beams has become an important research area for both materials engineering and understanding of ion matter interaction. Studies of such surface phenomena like diffusion, epitaxial layer growth on surfaces, analysis of strain and defects, surface modifications by ion beams and exploration of coherent dynamic effects due to cluster-ion irradiation are discussed by Dev (**page 1550**). Dense electronic excitation that ions in the energy range exceeding a MeV/amu induce in materials and the associated modification that arise due to the transfer of this energy to the lattice, are considered by Kanjilal (**page 1560**). Depending on the type of ion and its energy, he shows how the physical properties of different materials like high temperature superconductors, semiconductors, metallic systems, colossal magnetoresistance materials, polymers and graphite evolve during irradiation. Irradiation effects of SHI in the energy range of 30 to 100 MeV in a few systems like gallium arsenide, silicon and silicon diodes are considered by Bhoraskar (**page 1567**). Ion energy and fluence dependence of the defect structure in these samples characterized *ex situ* has revealed that intense electronic, energy loss of SHI in the materials medium can even result in annealing of defects, migration of defects and engineering of defect structure for device application. The articles in this special section thus bring out the uniqueness of ion beam-based studies in revealing the several characteristics of materials and providing the means of engineering materials for specific applications in ways not accessible to conventional classical techniques.

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