Ion Beams in Nanoscience and Technology

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Preface

Energetic ion beam irradiation is the basis of a wide plethora of powerful research and fabrication techniques for materials characterisation and processing on a nanometre scale. Ion implantation is increasingly employed to tailor various material properties, focused ion beams can be used to machine away and deposit material on a scale of nanometres, and the scattering of energetic ions is a unique and quantitative tool for process development in high speed electronics. More recent developments are the use of MeV proton beams and other ions to fabricate 3D nanostructures with extreme aspect ratios for tissue engineering and nanofluidics lab-on-a-chip devices.

The potency of these energetic ion beam techniques lies in the electrostatic Coulomb interaction between energetic ions and individual atoms of the material. This allows substantial amounts of energy and momentum to be transferred to a single atom or electron in a way that is not possible with other probes such as energetic electrons, photons, etc. Since the start of the development of ion accelerators in the 1930s that were capable of producing high quality ion beams, energetic ion beam methods have played a leading part at the very forefront of the development of our modern high technology society. The technology behind these accelerators has developed in synergy with this technological development of materials. Dedicated ion implantation machines evolved from the early isotope separators by addition of sophisticated target handling systems. At the same time, spurred on by the quest for higher energy ions for fundamental nuclear science, higher energy machines evolved from the single-ended belt-driven machines to tandem accelerators. Since about the mid 1970s, more machines were installed for materials research than nuclear research. The requirements of energy stability and small machines led to introduction of the pellet-chain charged (Pelletron) and more recently rectifier-capacitor machines (first used by Cockroft and Walton in the beginning of the 1930s).

Certainly, the development of today's powerful personal computers and mobile communications would not have been possible without the use of energetic ion beams in nanotechnology. At the time of writing this book preface, society is facing new challenges, such as the development of sustainable technologies, pandemic disease control, and environmental issues. The broad range of applications and the usefulness of nanoscience and -technology methods using ion beams makes them really useful tools for meeting these challenges. Already they have been employed for developing by mutagenisis high-yielding and resistant cash crops and developing efficient coatings for solar energy conversion.

In this work, established scientists from around the world have contributed deep knowledge in their respective fields. The goal is to produce a work that is not only a guide to practitioners, researchers, and students across the whole cross-disciplinary span of nanoscience and technology, but also serves to stimulate work in new areas where energetic ion beam methods can contribute to front-line research. Throughout the book the general recommendations of the International Union of Pure and Applied Physics (IUPAP) about units have been followed.

We are especially grateful to Professor Sir Michael Thompson for kindly accepting our invitation to write the Foreward to this book. Sir Michael was one of the early pioneers in the field of ion beams in nanoscience. Testimonials to his influence and relevance in the field are that his research on defects and radiation damage, understanding of the sputtering process, and also the scattering of ions from the surface layers in materials are reoccurring themes in many contributions to this book.

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