

Fundamentals of Picoscience

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The book under review consists of 37 Chapters which are further divided into IX parts, namely, Picoscale Detection, Picoscale Characterization, Picoscale Imaging, Scanning Probe Microscopy, Electron Orbitals, Atomic Scale Magnetism, Picowires, Picometer Positioning, and Picoscale Devices. As the Section headings suggest, the Book proposes to cover the methods and materials at the picometer-size scale, which is the next size range, three orders of magnitude, below nanometer.

Nanoscience has brought many new effects and inventions and is the basis for worldwide surge in nanotechnology. Currently, there are more than one million scientists involved in projects with nanoscale structures and materials. From the development of new quantum mechanical methods to far reaching applications in electronic industry and medical diagnostics, nanoscience has inspired numerous scientists and engineers to new instrumental developments and inventions. “Nano” has become the buzz word for extremely small even for the general public and many surprises can be expected in the future for structures at nanoscale.

We are entering an era of ever smaller and more efficient devices, which will rely on smaller designs and structures three orders below the nanometer scale. Do we already have instruments to probe below the nano-range? How can we develop new instruments to visualize and measure structures at the subnanometer size? Answers to these and other questions are given in this book, *Fundamentals of Picoscience*.

One picometer is the length of a trillionth of a meter. Compared to a human cell of typically ten microns, this is roughly ten million times smaller. In this state-of-the-art book, international scientists and researchers at the forefront of the field present the materials and methods used at the picoscale. They address the key challenges in developing new instrumentation and techniques to visualize and measure structures at this sub-nanometer level. The main purpose of this book is to help the young researchers to understand the implications of picoscience, e.g., to understand how picoscience is an extension of nanoscience; to determine which experimental technique to use in your research, and to connect basic studies to the development of next-generation picelectronic devices.

The book under review covers various approaches for detecting, characterizing, and imaging at the picoscale. It then presents picoscale methods ranging from scanning tunneling microscopy (STM) to spectroscopic approaches at sub-nanometer spatial and energy resolutions. It also covers novel picoscale structures and picometer positioning systems. The book concludes with picoscale device applications, including single molecule electronics and optical computers. The learned authors of each chapter of this book explain basic concepts, define technical terms, discuss theoretical background and give illustrations in reference to the context to explain the main purpose of their chapter.

Chapter 20, authored by David M. Villeneuve, refers to “Attosecond Imaging of Molecular Orbitals”. The author makes use of High Harmonic Spectroscopy to probe the position of atoms within the molecule. This is where the new field of attosecond science shows much promise. An attosecond is an SI unit of time equal to 10^{-18} of a second (one

quintillionth of a second). Lasers can now generate light pulses down to 100 attoseconds thereby enabling real-time measurements on ultra-short time scales that are inaccessible by any other methods.

It is not possible to review contents of all 37 Chapters of this book. The underlying principle of most of these Chapters is the role played by the measurement techniques in the study of picoscale structures. In fact these very techniques are used to explore matter at the nanoscale also. The invention of Scanning Tunneling Microscope (STM) has brought a revolution in measurement techniques. When STM was invented, the main feature was to observe atomic configurations of surface atoms in real space. In Chapter 22, the authors have illustrated how to study atomic-scale magnetism by Spin-Polarized Scanning Tunneling Microscopy (SP-STM). The understanding of magnetism at the ultimate atomic length scale is one of the current frontiers in solid state physics, which is the main purpose of this Chapter.

The last six Chapters of the book deserve special attention of the readers. These deal with Picoscale Devices: Mirrors with sub-nanometer surface shape accuracy; Single Molecule Electronics; Single-atom Transistors for Light; Carbon-based zero-, one-, and two-dimensional materials for Device Application; Subnanometer Characterization of Nanoelectronic Devices; and Chromophores for Picoscale Optical Computers.

The salient features of this book are enumerated as follows:

- Details all experimental techniques for picoscale studies, including atomic-scale optical and neutron holography, homodyne and

heterodyne interferometry, digital holographic microscopy, single-atom STM, orbital-mediated tunneling spectroscopy (OMTS), electron energy loss spectroscopy (EELS), transmission electron microscopy (TEM), and x-ray absorption fine structure (XAFS);

- Explains how to determine the atomic structure of proteins and individual peptides through electron diffractive imaging and coherent x-ray diffraction imaging;
- Explores the future of picoelectronic devices, such as molecular electronic applications, NEM single-atom switches, a picomotor, single-photon quantum devices, and single-photon gating systems;
- Includes introductions that explain basic concepts, defines technical terms, and gives theoretical approach to the basic phenomenon under discussion.

The Editor has done excellent job in selection of Section themes and organising the Chapters in an appropriate manner. The literature survey is very exhaustive and effort has been made to list references in full measure, giving titles of papers with page numbers and even month of publication where ever possible. There are hardly any typo mistakes that came to my notice. I hope the research community will welcome this book, claimed by the publishers as the first of its kind at global level, on Fundamentals of Picoscience.

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