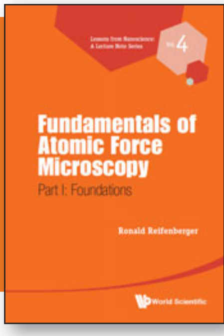


Fundamentals of Atomic Force Microscopy—Part I: Foundations

Ronald Reifenberger

World Scientific, 2015
340 pages, $115.00 (e-book $36.00)
ISBN 978-981-4630-34-4

This book is a set of lectures covering a course on atomic force microscopy (AFM). The overall structure of the book is excellent. It gives a good description of supplementary information needed for the average graduate student to understand the physics of AFM. The density of information, however, is quite heterogeneous. For example, the very important Derjaguin approximation is given with no derivation. At the same time, there is an entire chapter devoted to the topic of van der Waals force, which is rather tangential for force microscopy. The interaction between two nonpolar molecules is described down to the Schrödinger equation, which seems to be excessive.

Every chapter has examples and a summary of the important points, as well as problems to help students understand the material better. The chapters also include suggestions for further reading that are provided through subchapters.

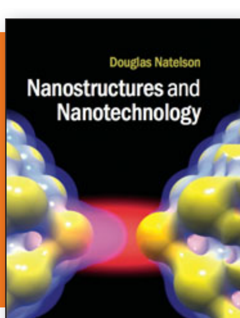
After a brief introduction (chapter 1), there is a description of intermolecular and interparticle interactions (chapters 2, 3, and 4). These are topics typically not covered in a traditional set of courses. At the same time, knowledge of these forces is paramount for an understanding of force microscopy, regardless of whether we are speaking about fundamentals or practical applications. In practical use, the AFM technique can easily produce countless artifacts. Separating artifacts from real images is an art that requires a good understanding of the contrast formation, which is based on the force interaction between the AFM probe and sample surface.

Chapter 5 briefly describes the elastic response of homogeneous and isotropic materials as well as an introduction to contact mechanics. Chapter 6 is devoted to the quasistatic mechanics of the AFM cantilever. The word "quasistatic" indicates oscillations up to hundreds of kilohertz, which is sufficient for the majority of AFM operations. Chapter 7 describes the structure and basic components of an AFM in detail. The next chapter, "Contact Mode AFM," discusses one of the most basic and popular modes for AFM operation. The force spectroscopy mode is also included in this chapter, where the reader will find out how to calculate and map the elastic modulus, adhesion map, etc. These parts are not typically considered as a variation of the contact mode. Even the noncontact mode and lateral force mode are all considered within this chapter, which might be confusing.

Chapter 9 is devoted to various calibration techniques that are needed for quantitative measurements with AFM. A part of this chapter is used to describe a method for optimization of feedback gains during practical scanning. The last chapter is essentially a manual for the use of free online software describing the motion of the AFM probe during scanning. This software will be useful for students, in particular, those who have recently started to work with AFM.

This book makes an attempt to describe both fundamentals and some practical topics of AFM. Because of the limited space, this book is not self-sufficient. Many topics are described at an introductory level, and further reading is needed for those who want a deeper understanding. The literature listing at the end of each chapter is a comprehensive source for further reading.

__Reviewer: Igor Sokolov__ is a professor at Tufts University, Medford, Mass., USA.



Nanostructures and Nanotechnology

Douglas Natelson

Cambridge University Press, 2015
639 pages, $85.00 (e-book $68.00)
ISBN 9780521877008

The basics of nanoscience and the origin of physical properties at the nanoscale are clearly discussed in the 12 chapters in this book, aiming for a balance between depth and understanding. Theories behind fundamental nanoscience concepts are linked with real applications. This book is useful for students in physics, materials science, and chemistry.

The first chapter gives a brief introduction to nanotechnology, length scales of materials, and the structure of the remaining chapters in this book. The second chapter discusses the basics of solid-state physics such as theory of free electrons and different types of lattices. The third chapter talks about metals, semiconductors, and insulators with their band structure and models. Preparation of doped semiconductors employing ion implantation (with experimental setup), magnetic semiconductors, and topological insulators are discussed briefly. The fourth chapter is dedicated to the various processes to prepare nanomaterials, device fabrication tools, and characterizing tools.

The fifth chapter explains various defects and interactions between different

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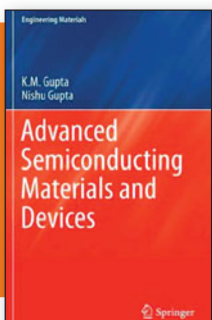
species in materials. In the sixth chapter, electronic transport and magnetic influences (e.g., the Hall effect) in micron- and nanoscale materials are examined with the help of classical and quantum mechanical treatments. The seventh chapter covers the fundamentals and applications of magnetism, characterization of magnetic properties down to small scales, and magnetoelectronic devices. The eighth chapter deals with the interaction of electromagnetic radiation with matter, photonics technology, and nonlinear effects.

The ninth chapter discusses applications and characteristics of micro- and nanomaterials in dynamic mechanical devices. Probing the local interactions of matter employing scanning probe microscopy, micromechanical systems, and application of microelectromechanical systems are discussed with the experimental setup and their functionality. Chapter 10 briefly discusses fluid dynamics at the micro- and nanoscale and applications. Different types of flow in various structures such as laminar flow, surface interactions, and electrolytes are explained with beautiful diagrams and real images. Applications of nanofluids and microfluidic devices such as flow sensors are discussed in the second half of the chapter.

Chapter 11 covers the relevance of nanotechnology to biology, including detection, and monitoring of biological information. The last chapter discusses the realistic near-future applications of nanotechnology in materials science and in the energy, electronics, information technology, and biology industries, as well as hazards and dangers. References are very relevant and up to date. At the end of each chapter are several exercise problems.

Fundamentals of nanotechnology and its applications are well discussed in this book. I strongly recommend this book to all undergraduate and postgraduate students interested in nanotechnology.

Reviewer: K. Kamala Bharathi *is with the National Institute of Standards and Technology/University of Maryland, USA.*



Advanced Semiconducting Materials and Devices
K.M. Gupta and Nishu Gupta

Springer, 2016
573 pages, $129.00 (e-book $99.00)
ISBN 978-3-319-19757-9

In considering the plethora of textbooks on semiconductor devices, one cannot fail to use such well-known ones as Sze (*Semiconductor Devices: Physics and Technology*) and Streetman/Banerjee (*Solid State Electronic Devices*) as benchmarks. Indeed, *Advanced Semiconducting Materials and Devices* by Gupta and Gupta claims to cover a wider remit than such standard texts, and in doing so could fill a real niche.

After a short introduction, the basics of semiconductor theory are covered in much the same way as in other texts, moving on to simple devices such as the *p–n* junction and transistors. Following a short section on fabrication technologies, the later chapters are devoted to recent advances, special devices, and nanostructures. Unfortunately, these later chapters are rather weak and disordered, with short paragraphs and a few bullet points on each subject. These seem superfluous in the era of Internet search engines, where one could find a recent review in seconds. They are far too superficial and inadequately referenced to be of any real use. To take a rather extreme example, less than half a page is dedicated to semiconductor nanocrystals, the same amount of space that is given to light-emitting diodes on cricket stumps in the introduction.

This text also suffers from the sloppy use of language. In the introductory chapter, it is stated that atoms are indivisible in one sentence, and that they contain protons, neutrons, and electrons in the next. We are told silicon and germanium are "not useful" in their intrinsic form and semiconductors do not follow Ohm's Law. There is an element of truth to each statement, of course: atoms do not usually divide in semiconductors (except in some novel radiation detectors); one generally dopes silicon and germanium in semiconductor devices to enhance their utility, and semiconductors do not follow Ohm's Law under high fields. However, there is also radioactive decay that produces soft errors in modern devices, there are intrinsic detectors, and there is low field linearity in ohmic semiconductors.

The use of colloquial language throughout is also inappropriate. For example, metals have "too many" electrons, and silicon forms a "nice" gate material and has a "reasonable" bandgap. In the case of the latter, this is qualified as "not too high so that room temperature cannot ionize it, and not so low that it has a high leakage current." This is plain wrong: the dopants in silicon are ionized at room temperature, not intrinsic carriers across the bandgap, as this would lead to high leakage currents.

The text includes some basic example questions, and there are many lists and tables of material properties and their applications.

The quality of some of the figures is very poor. They are clearly scanned from elsewhere without any acknowledgments. Several are hand drawn or scanned off blemished paper. Incredibly, in a text of almost 600 pages there is no index.

It is hard to see the purpose of such a text alongside the aforementioned texts. Both of them cover semiconductor materials and devices in far more depth and with very few errors.

Reviewer: Oliver Williams *is a Reader in Experimental Physics at Cardiff University, United Kingdom.*

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