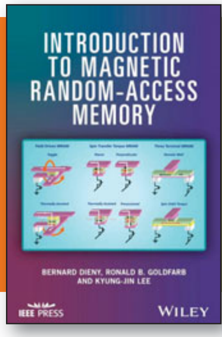


Introduction to Magnetic Random-Access Memory

Bernard Dieny, Ronald B. Goldfarb, and Kyung-Jin Lee

Wiley-IEEE Press, 2016
264 pages, $125.00 (e-book $100.99)
ISBN 978-1-119-00974-0

This is an interesting book that gives a deep introduction to and explanation of the physics behind spintronics and magnetic properties of materials used in magnetic random-access memories (MRAMs). It gathers the theoretical concepts of magnetism along with the technological developments of electronic devices for memory and storage applications. It is mainly intended for graduate students, microelectronics/materials engineers, and researchers working on magnetic memory devices.

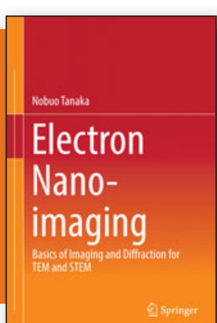
The book is structured in three parts. The first two chapters are focused on spintronic transport phenomena and magnetic materials used for storage and memory devices. Chapter 1 introduces spintronics and the magnetoresistance effect, presenting the quantum formalism required to describe both giant magnetoresistance and tunneling magnetoresistance phenomena. Chapter 2 discusses properties of the materials used in magnetic tunnel junctions for MRAM devices.

The second part provides a more in-depth introduction to the theory of magnetism, how it can be sensed and developed in nanostructured materials, and the main concepts required to understand magnetic storage and memory devices.

The third part, consisting of the last three chapters, is dedicated to nonvolatile magnetic memory devices, covering the evolution, integration, and compatibility with complementary metal oxide semiconductor circuitry, as well as future perspectives beyond MRAM. Chapter 5 presents a historical overview of the evolution of MRAMs and different types of structures used in magnetic nonvolatile memory devices, comparing them in terms of fabrication and operational properties. The different functions that each memory device should address, such as storage, read/write process retention, and endurance, are detailed. Chapter 6 discusses the integration of MRAM focusing on back-end technology. Chapter 7 considers the circuitry challenges of combining these spintronic components with memory and logic circuits.

This is a well-structured book, full of information and with brief introductions, which allows the reader to easily identify the content and purpose of each chapter. It contains many figures but few tables. The bibliography is suitable, although it lacks recent works. It is not sufficient as a textbook because of inadequate problems and homework sets; instead, it is meant as a reference tool for researchers and engineers looking for a working knowledge of magnetic memory devices.

Reviewer: Joana Vaz Pinto *is an assistant professor at the Universidade Nova de Lisboa, Portugal.*



Electron Nano-Imaging: Basics of Imaging and Diffraction for TEM and STEM

Nobuo Tanaka

Springer, 2017
333 pages, $99.00 (e-book $74.99)
ISBN 978-4-431-56500-0

As a materials scientist who not only uses transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) for materials characterization, but also teaches classes on electron microscopy, I enjoyed reading this book. It covers a wide range of applications, from basics on electron microscopy and diffraction, to more advanced, newly developed techniques for imaging and diffraction. The book is divided into three parts: Part I covers nano-imaging in TEM mode, Part II covers nano-imaging in STEM mode, and Part III contains a series of appendices with background theory on imaging and diffraction.

The first three chapters focus on basics of imaging and diffraction, with an emphasis on the concepts of imaging in TEM mode compared to an optical (light) microscope, while the appendices have more rigorous math on Fourier transforms and image formation with electromagnetic lenses and the role of aberrations. Chapters 4–7 cover resolution, high-resolution lattice imaging, and the effects of lens aberrations and voltage instabilities.

Chapter 8 describes several advanced imaging techniques, starting with the physics of electron energy-loss spectroscopy and the use of this technique in imaging by energy-filtered TEM. This chapter also describes electron tomography to obtain 3D reconstruction images from a series of images taken from the same area of a sample but at different angles.

Part II describes imaging in STEM mode with a detailed comparison to a scanning electron microscope (SEM). Chapters 9–11 describe image formation in STEM by the scanning of a small spot of the electron beam over an area of the sample. These chapters also present image contrast in STEM and the difference between bright-field STEM and annular dark-field STEM. Chapter 12 presents imaging theory in STEM.

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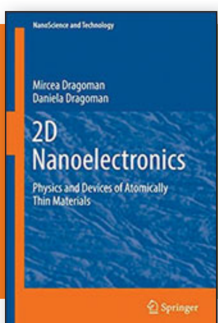
Chapter 13 gives a good outlook for the future in TEM and STEM. The main objectives are to increase beam brightness and decrease aberrations of the lenses used to converge the electron beam. This chapter also describes current attempts for correction of chromatic aberration being developed and presents a bright future for elemental mapping and analytical microscopy with even higher resolution, both spatially and in energy.

Part III (chapters 15–31) describes the theory of imaging with electro-magnetic lenses, the application of Fourier optics to electromagnetic lenses, contrast transfer function, lens aberration, and image processing methods, as well as diffraction theory for a plane wave (TEM) and in convergent-beam electron diffraction. With these theoretical chapters located at the end of the book, the author is able to focus on the concepts important to imaging at the nanoscale in Parts I and II.

The included figures, both electron microscopy photographs as well as schematics, are useful to understand the material covered. The references in each chapter are up to date. The problems included in the book are helpful for students, although I would have liked to have seen more problems in each chapter. The theoretical background is appropriate for graduate students in physical science.

I strongly recommend this book as a resource for electron microscopists with a basic knowledge of TEM and STEM who are interested in advanced imaging and diffraction techniques. The book is up to date on recent developments in electron microscopy.

***Reviewer: Lourdes Salamanca-Riba** is a professor in the Department of Materials Science and Engineering, University of Maryland, USA.*



2D Nanoelectronics: Physics and Devices of Atomically Thin Materials

Mircea Dragoman and Daniela Dragoman

Springer, 2017
199 pages, $149.99 (e-book $109.00)
ISBN 978-3-319-48435-8

This is an excellent book on devices based on graphene and other two-dimensional (2D) materials, such as MoS_2, including their physics and applications. The book contains three chapters covering the fabrication and characterization of 2D materials, transistors, and other nanodevices and acts as a user guide for researchers working with atomically thin materials in applied physics.

Chapter 1 consists of four parts discussing physics and applications of graphene-based nanostructures and their applications in optoelectronics and sensors. The chapter starts with bondings between atomic orbitals, interaction between carbon atoms, their allowed energy states, and the density of charge carriers derived using a quantum mechanical approach. Functionality of graphene-based field-effect transistors (FETs), diodes, detectors and receivers, sensors, and photonic devices are discussed. Allowed energy states, density of states, carrier density, mobility, and other physics parameters in these nanodevices are derived by employing the tight-binding approximation, Drude model, and Dirac spinor method. Gate voltage-dependent current–voltage (I–V) characteristics of graphene FETs are well explained. Conduction mechanisms, current density equations, and I–V characteristics of various types of graphene-based diodes are also covered.

Chapter 2 deals with various growth process mechanisms of 2D materials, such as chemical vapor deposition, physical vapor deposition, bottom-up approach, and top-down method. Growth of transition metal dichalcogenides (TMDs), semimetal chalcogenides, and 2D alloys are covered. Typical mechanical properties and optical properties are tabulated with the help of literature. Band diagrams of several TMDs, thickness-dependent band structures, band structures of bilayer-monolayer TMDs, vertical heterostructures, photoexcited heterostructures, and van der Waals heterostructures are discussed.

Electronic devices such as transistors, diodes, and optoelectronic devices based on atomically thin materials are covered in chapter 3. Schottky barriers at monolayers, unwanted tunnel currents, mobility, and other electrical properties in different device structures are briefly described. Highly bendable MoS_2 FETs, dual-gate MoS_2 FETs, radio-frequency MoS_2 transistors, and self-aligned FETs and their I–V characteristics with typical working conditions are described. Electronic injection and band diagrams of graphene-based heterostructures, MoS_2/WSe_2, black phosphorous/$SnSe_2$, and nonvolatile memory based on MoS_2/graphene heterostructures are discussed. Absorption spectrum of MoS_2 monolayers and exciton binding energy of some TMDs are briefly described. Graphene/MoS_2 photodetectors and their quantum efficiency, expression for gain, and the functionality of such photo-devices are clarified. In_2Se_3 and WSe_2-based photodetectors and the world's thinnest lens made with a MoS_2 layer are also mentioned.

This is an outstanding book covering a range of nanodevices based on 2D materials. Fundamental properties and fabrication methods of recent 2D materials are well covered. It is targeted toward researchers rather than students. There are no solved problems or homework problems. Up-to-date references are given at the end of each chapter. The written material is augmented with many excellent figures, diagrams, illustrations, and images. I strongly recommend this book to researchers interested in device fabrication based on 2D materials.

***Reviewer: K. Kamala Bharathi** is an assistant professor at the SRM Institute of Science and Technology, India.*

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