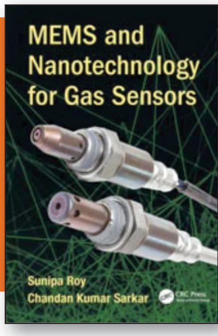


MEMS and Nanotechnology for Gas Sensors
Sunipa Roy and Chandan Kumar Sarkar
CRC Press, 2015
242 pages, $103.96 (e-book $90.97)
ISBN 9781498700122

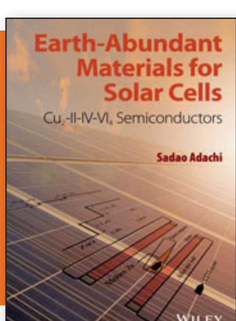
Basic concepts of microfabrication technology and nanocrystalline metal oxide-based gas sensors are discussed in detail in the 12 chapters of this book. It is written for research-level students in various disciplines such as physics, materials science, chemistry, and mechanical engineering.

Chapter 1 starts with a detailed introduction to clean room technology and concepts. A brief history with an introduction to microelectromechanical systems (MEMS) and materials used in MEMS is discussed with appropriate illustrations. Chapter 2 covers various substrates (Si, Ge, GaAs) used for MEMS. The effects of surface contaminants as well as various cleaning and etching (e.g., wet and dry etching) processes are discussed in detail. Chapter 3 discusses various physical (thermal evaporation, sputtering, molecular epitaxy) and chemical vapor (plasma-enhanced CVD) deposition methods with diagrams showing appropriate experimental setups. Different metallization processes are discussed briefly. Chapter 4 covers properties of photoresists and their different types, along with various photolithographic processes.

Chapter 5 starts with a brief introduction to micromachining for gas sensors and talks about bulk and surface micromachining. Illustrations explaining the etching process and patterns are very useful. Chapter 6 discusses microheaters for gas sensors: types, properties, and needs. Software used and the physical properties affecting the heater properties are also discussed, accompanied by models and equations. Chapter 7 is an introduction to semiconductor gas sensors, their fundamentals, and their classification with working principles and variable parameters. Different types of gas sensors such as resistive-type and metal oxide-type are briefly discussed. Thick and thin films and various growth processes employed for gas-sensor fabrication are discussed in detail. Chapter 8 talks about graphene, including its different physical, chemical, and mechanical properties. Growth and characterization of graphene and its application for gas sensors are well discussed. The high-quality scanning electron microscope and transmission electron microscope images are very useful. Chapter 9 covers nanocrystalline ZnO-based microfabricated gas sensors. ZnO-based device structures and different growth mechanisms at low and high temperatures are discussed in detail. Chapter 10 briefly discusses volatile organic compounds, their different nanostructures, and their fabrication processes. Chapter 11 explains signal processing and different interfacing techniques along with appropriate flow diagrams. Chapter 12 talks briefly about the applications of MEMS and nanotechnology. References at the end of each chapter are relevant and include recent works.

It would have been helpful if the authors had included some problems and solutions in each chapter in order to make the book more useful to students. However, this book is an outstanding, broad overview of basics, concepts, specific materials used for each sensing application, and techniques employed in current, emerging, and possible future MEMS applications. I strongly recommend this book to all research students interested in MEMS and gas sensors.

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



Earth-Abundant Materials for Solar Cells: Cu_2-II-IV-VI_4 Semiconductors
Sadao Adachi
Wiley, 2015
528 pages, $185.00 (e-book $148.99)
ISBN 978-1-119-05277-7

The worldwide demand for energy may rise to 30 terawatts by 2050. To meet this demand, solar energy can contribute substantially: 120,000 terawatts come from the sun at any given time. However, materials must be developed that can efficiently convert solar radiation to electricity, are available in large quantities, inexpensive, and safe to handle. Current technology is based on silicon, which has a solar conversion efficiency of 25%, but processing it is expensive because (1) it requires high temperatures and (2) the material has to be thick to absorb light due to the small absorption coefficients. Alternative materials—gallium arsenide, cadmium telluride, and copper indium gallium selenide—contain elements that are much less abundant in the earth's crust than silicon, which is the second most abundant element and constitutes 28% of the earth's crust. Hence research on safer materials prepared from cheaper and more easily available materials such as perovskites and dye-sensitized solar cells is gaining importance.

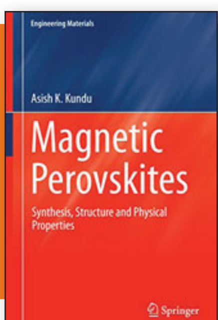
This book focuses on inorganic semiconductors made of nontoxic and abundant materials. They contain copper and other elements. The elements chosen are zinc, cadmium, and mercury (under II); silicon, germanium, and tin (under IV); and sulfur, selenium, and tellurium (under VI), thus accounting for 27 semiconductors discussed comprehensively. These have a near-optimal direct-bandgap energy of ~1.5 eV, a value at which the conversion efficiency is maximum. Their absorption coefficient is high so that thin materials can be used.

The introductory chapter defines, with sample calculations, parameters such as abundance values, spectral efficiency, effective cubic lattice constant (used in later chapters to correlate properties of these 27 semiconductors), the effective medium approximation, and interpolation schemes. This is followed by six chapters on structural, thermal, elastic, band structure, optical, and carrier transport properties. Chapter 2 summarizes data on crystal structure and includes comparisons with III–V and II–VI semiconductors. The next chapter presents phase diagrams and properties of practical importance such as specific heat, Debye temperature, thermal expansion, and thermal conductivity, again comparing other semiconductors. The data on elastic constants, hardness, and lattice dynamic properties, covered in chapter 4, are useful to have in one place. The next chapter on band structure combines theory with empirical correlations of energy gap with molecular weight and effective cubic lattice constant. The chapter on optical properties is relevant to solar cells and optoelectronic applications. The final chapter on carrier transport properties includes discussions on electron and hole Hall mobilities and conduction mechanisms.

A special feature is the attention devoted to material parameters—stoichiometry, alloying, doping, grain boundaries, graded structures—and heat treatment.

There are 26 categories of solar cells, including those made of earth-abundant materials, ranging in efficiency from 10.6% to 46%, each with its own technical and economic challenges. A brief summary would have been helpful comparing them and placing the Cu_2-II-IV-VI_4 semiconductors in context. This book is an authoritative source of information due to the in-depth discussions and adequate references, figures, tables, and appendices.

***Reviewer: N. Balasubramanian** is an independent research scholar working on renewable energy and ultrafine-grain materials in Bangalore, India.*



Magnetic Perovskites: Synthesis, Structure and Physical Properties

Asish K. Kundu

Springer, 2016
167 pages, $129.00 (e-book $99.00)
ISBN 978-81-322-2759-5

This book presents some recent advancements in the area of magnetic perovskites and gives an introduction to the physics of complex magnetism (phase separation, spin glass, frustration). It is written from a materials science perspective and is essentially based upon scientific publications from the author. Thus, it only contains the results of a few recently studied compounds and may need to be updated in the future. Nevertheless, it can serve as an introduction to students starting in the field of magnetic perovskites. The book is organized into four chapters.

Chapter 1 briefly introduces the materials. After describing the importance of perovskites and a description of the structure, the author presents the synthesis. It is, however, restricted to single-crystal cobaltites; it is surprising that the author does not even mention thin-film growth techniques despite the huge amount of work in that area, as well as the potential applications in oxide electronics. The chapter ends with a list of key properties reported, corresponding only to those detailed in the book.

Chapter 2 presents results of electronic phase separation and glassy behavior. The first example is manganites, $A_{1-x}B_xMnO_3$ (A = La, Pr, Nd, Gd, and Y and B = Ca, Ba, Sr), which exhibit electronic phase separation. An example of glassy behavior in $A_{0.7}Ba_{0.3}MnO_3$ (A = La, Nd, and Gd) is also given. The second example is a cobalt-centered perovskite that displays electronic phase and spin-glass behavior.

Chapter 3 discusses the A-site cationic ordering and disordering effects on magnetotransport properties of cobaltites. This section starts with a clear description of ordered and disordered perovskites. The description of disordered ABO_3 perovskites was not necessary, and this content could have been merged with chapter 1 and the introduction of perovskites. The most interesting part is the disordered perovskites, the presentation of various parameters that influence the phase ordering, and the physical properties. Again, this listing is based on a series of particular compositions, and not the key parameters responsible for the disorder, which at the end are difficult to extract clearly.

Chapter 4 is devoted to bismuth-centered perovskites. After a very short introduction to multiferroicity, this chapter lists various complex compounds and their magnetic properties without including the most studied phase, $BiFeO_3$. A brief part is also dedicated to thin films.

This book is best suited to graduate students in solid-state physics or chemistry. Although it does not contain homework problems or exercises, some undergraduate students still might find it interesting, particularly those who have practical exercises in a laboratory. Despite the bias toward the author's work, it is a passable introduction to magnetic phenomena in perovskites.

***Reviewer: Wilfrid Prellier** of the Laboratory of Crystallography and Materials Science, ENSICAEN/CNRS/Normandie Université, France.*