BOOK REVIEWS

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

Pulsed Neutron Scattering

Author	Colin G. Windsor
Publisher	Taylor & Francis Ltd., Halstead Press, New York (1981)
Pages	432
Price	$89.95
Reviewer	Donald R. Harris

Thermal neutron scattering techniques are increasingly important in biology, in materials science, in chemistry, and in numerous other disciplines. The neutrons for many such measurements have come from steady-state research reactors like the outstanding facility at the Institute Laue-Langevin at Grenoble, France. It has long been recognized, however, that some measurements are better carried out using pulsed neutron sources driven by accelerators or pulsed reactors, and such sources have been extensively utilized. This book appears to be the first to describe pulsed neutron scattering techniques "for condensed-matter scientists who would like to use the new pulsed neutron sources we now have in many countries."It is intended as a handbook for those wanting to use pulsed neutron techniques, and it fills this need very well.

The first chapter, after an introductory description of neutron scattering, examines a number of neutron scattering applications. These applications include diffraction studies of the structures of crystals, glasses, and liquids, using both nuclear interactions and spin (electron and atom) interactions. In addition, the use of small-angle scattering to examine large-scale structures in materials is covered; density fluctuations, particle and void size distributions, surface areas, and separations have been measured. The determination of macromolecular structures in water environments is a particularly interesting biological application covered here. Neutron inelastic scattering techniques for atomic and molecular spectroscopy are described. Naturally, with such broad coverage, it is not possible for the author to go into much detail in this chapter, but extensive reference material is provided.

The components of a pulsed neutron source are outlined in Chap. 2. These include the accelerator and target (or pulsed reactor), the neutron moderator, the collimator, the sample, and the neutron detection system or spectrometer. Electron linacs, proton linacs and synchrotrons, and pulsed reactor sources are described briefly. Electron targets and proton spallation targets are described in somewhat greater detail.

Considerably greater detail is provided for moderators in Chap. 3. Design and optimization of moderators are considered in relation to the experimental objectives of Chap. 1. A figure of merit is utilized in terms of the neutron yield from the moderator divided by the square of the time spread of these neutrons. The descriptions are aided by numerous figures and intuitive arguments. As is pointed out, "Moderator practice has always kept a step ahead of moderator theory (p. 115)," so an extensive theoretical discussion probably is not warranted. Chapter 4 considers reactor crystal monochromators and choppers because of their applications in pulsed neutron experiments and to compare steady-state reactor techniques with experimental techniques using pulsed sources.

Health hazards, shielding, and neutron detectors are treated in Chap. 5. Shielding here includes biological shielding, detector shielding, beam tube and collimator design, and beam stops. The Harwell electron linac and the Los Alamos National Laboratory proton linac facilities are used as illustrations. Data acquisition systems are considered as well as detectors. Total scattering diffractometer instrumentation receives an entire chapter, Chap. 6, as applied to powders, liquids, amorphous structures, and single crystals. This lengthy chapter contains a reasonable theoretical basis for experiment design, although the numerous equations have only sketchy derivations.

Chapter 7 examines sample preparation and mounting, sample furnaces and cryostats, sample changers, and beam monitoring. There is also an extensive section on data analysis, including corrections for multiple scattering. Particular data analysis problems are brought out for glass and liquid diffraction and for powder diffraction spectra. Direct geometry inelastic spectrometers are described in Chap. 8, and inverted geometry inelastic spectrometers are covered in Chap. 9. In both of these chapters there is considerable detail, and specific spectrometers are used to good effect for illustrative purposes.

The final chapter, Chap. 10, is entitled "Making the Most Out of a Pulsed Source," and it deals with actual or possible experiments of a novel nature. These may involve time dependence as for samples in the process of change or obtaining ultracold neutrons by reflection from moving crystals. Pulsed neutron radiography is considered including "stroboscopic" radiography. A very brief Appendix 1 deals with neutron cross sections and an even briefer Appendix 2 lists symbols, units, and numerical constants and relations.

The author's extensive experience in neutron scattering at Harwell and elsewhere has provided the basis in this book for a very useful addition to the literature. The applications of the neutron scattering field are constantly expanding, and it is important to communicate the experience gained thus far to potential users of pulsed neutron techniques.

The art work in the book is superb. This, and perhaps a somewhat limited audience, may account for the rather high price. The book fills a considerable need and is a pleasure to read, and it is highly recommended as a handbook, its avowed purpose. As a text it "covers the ground," but the sketchy nature of the coverage of basic material and derivations would provide an interesting challenge to the lecturer.

Donald R. Harris received his BS in physics and his MS in mathematics and physics. He received his PhD in nuclear engineering from Rensselaer Polytechnic Institute (RPI), where he is now an associate professor of nuclear engineering and director of the RPI reactor facility. His interests include reactor core analysis, nuclear data measurement and calculation, transport methods, shielding, and criticality safety. He was formerly at Bettis Atomic Power Laboratory, where he was a fellow, and at Los Alamos National Laboratory, where he was leader of the Nuclear Data Group from 1971 to 1975.

MOS (Metal Oxide Semiconductor) Physics and Technology

Authors	E. H. Nicollian and J. R. Brews
Publisher	John Wiley & Sons, Somerset, New Jersey (1982)
Pages	906
Price	$70.00
Reviewer	A. R. Wazzan

A treatise of outstanding quality and depth, the text is addressed to the scholar in the field but contains elementary material (including both semiconductor physics and semiconductor technology) addressed to the novice or beginning student. Those who need education in this area will have some difficulty understanding the finer concepts of this treatise. The beginning student is better served by consulting standard elementary texts on solid state and semiconductor physics. However, be that as it may, the authors do a fine job of briefly introducing semiconductor physics concepts essential to understanding metal oxide semiconductor (MOS) technology.

In any given text in the physical sciences, there are those authors who stumble with the mathematics, the physical phenomena, or with the technological developments in the field—Nicollian and Brews are not among them. The authors of *MOS Physics and Technology* treat all three aspects with balance and due care. The authors relate microscopic charge behavior to macroscopic circuit characteristics and measurements. Interpretations of fundamental and far-reaching physical phenomena in terms of simple but illustrative electrical circuit concepts are not only informative, but are also refreshing. The "band-bending approximation," all too important to MOS modeling and understanding, as in many device applications and MOS capacitor measurements, is repeatedly discussed with good clarity. Ionizing radiation effects in semiconductors and MOS devices, of much interest to some readers of *Nuclear Technology*, are but briefly discussed.

The MOS capacitor, operating principles, and electrical characteristics are discussed and formulated in Chaps. 2, 3, and 4.

In Chap. 2 the depletion layer charge density, the electron and hole densities, and the band bending in the silicon substrate of the MOS capacitor are determined as functions of gate bias. Using these expressions, the one-dimensional Poisson equation is solved for potential and charge density at the silicon surface, both with and without applied bias. Only steady time-independent gate voltage (gate bias) is considered here.

Chapters 3 and 4 use solid state concepts discussed in Chap. 2 to determine the low- and high-frequency capacitance-voltage (C-V) characteristics of the simple MOS capacitor. The material through Chap. 4 develops the analysis necessary and essential for understanding many of the measurement methods using low- and high-frequency C-V characteristics.

Silicon band bending is discussed in Chap. 3. There are two ways of *directly* measuring silicon band bending as a function of gas bias: the charge density-voltage (Q-V) method and the low-frequency C-V method. An *indirect* method, the high-frequency capacitance method of determining silicon band bending uses comparison of a theoretical high-frequency capacitance-time independent band bending $(C\text{-}\psi_s)$ curve with a measured high-frequency C-V curve. In this chapter a small alternating-current (ac) voltage is superimposed on the gate bias, and the C-V characteristics of the MOS capacitor are determined under the condition that both electron and hole distributions in the silicon respond *instantaneously* to the ac gate voltage. This chapter, along with Chap. 4, lays the groundwork for the interpretation of measurements using the MOS capacitor.

In Chaps. 4 and 5, bulk and interface traps are discussed and used to interpret the behavior of the MOS capacitor in strong and weak inversions and in the depletion mode. The role of bulk traps in the steady-state response (microscopic) of the MOS capacitor to small signals (the ac gate voltage) is analyzed.

Chapter 4 considers in greater detail the response of both majority and minority carriers to the ac gate voltage. This response determines the high-frequency C-V characteristics of the MOS capacitor in inversion. The equivalent circuit for the MOS capacitor is used throughout this chapter because it is easier to relate measured admittance to an equivalent circuit than to a complex algebraic formula. All analyses are restricted to small-signal steady-state responses and for *uniform* doping concentration only; the effect of nonuniform impurity distributions on the C-V curve is but briefly discussed.