Book & Video Reviews

The Tip of the Iceberg

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Silicon Sensors. By *S. Middelhoek* and *S. A. Audet*. Academic Press, London 1989. xi, 376 pp., hardcover, £ 37.50. – ISBN 0-12-495051-5

The book "Silicon Sensors" is the seventh in the AP-series Microelectronics and Signal Processing and thus aims to highlight the important role that sensors play in information processing. This role is outlined in general in Chapter 1, emphasizing definitions, domain conversion, terminology, nomenclature, technologies, and materials. All other chapters are mainly focused on silicon as a material basis for many types of sensors developed up to now. This devotion to silicon is not surprising because the first author is well known as the head of the sensor group of the University of Delft; this group has exploited nearly all silicon material properties for a large range of sensors. The related physical effects are used as a guideline for dividing the book into the remaining chapters.

In Chapter 2 silicon sensors are described which are sensitive both to radiant signals from electromagnetic radiation (including visible light) and to interaction with nuclear particles. The basic physical theory is given along with examples of practical devices such as photoconductors, photodiodes, phototransistors, and radiation detectors. In addition, sensors are described which indirectly make use of the photosensitivity of silicon devices, for example, position-sensitive detectors.

Chapter 3 is devoted to silicon sensors for the measurement of mechanical signals, which are mostly based on the piezoresistive property of (doped) silicon. Silicon sensors with added piezoelectric materials, such as ZnO, are also described in addition to capacitive pressure sensors and cantilever-based force and acceleration sensors. In the latter cases silicon's excellent mechanical properties as well as the anisotropic etching possibilities of specific three-dimensional structures in silicon are exploited. The etch techniques are more explicity treated in Chapter 7, concerning the various silicon technologies.

Chapter 4 describes the sensors for thermal signals, mainly based on the well-known Seebeck, Peltier, and Thomson effects. These effects are extensively covered in the theoretical part of this chapter, focusing on the possibilities of silicon as a basic material for temperature sensors. Examples are thermistors, silicon spreading resistors, diodes, and transistors. Also, various types of sensors are described which indirectly make use of semiconductor temperature sensitivity, such as flow sensors, vacuum sensors, and infrared sensors.

Chapter 5 describes magnetic sensors, whose behavior is largely based on the Lorentz force on charge-carriers traveling in a magnetic field. The different types of magnetic sensors are divided in this chapter into two groups: the so-called Hall plates and the magneto resistors. Further magneto diodes and transistors, whose operation is based on the modulation of the original electronic device characteristics upon external magnetic fields are also considered. In addition, sensors such as proximity and angle detectors, which indirectly make use of magnetic effects, are covered.

In Chapter 6, the chemical sensors are described. Silicon as such, is not sensitive in any way to chemical species. All silicon based chemical sensors contain an additional material which interacts with the chemical environment, such as palladium for the measurement of hydrogen and Al_2O_3 for the measurement of pH.

In both cases silicon combined with a transistor structure for electronic impedance transformation serve as the substrate. Because the resulting gas-sensitive and ion-sensitive FET devices are the most popular and well described in the literature their description covers most of the pages of this chapter. Minor attention is paid to the chemo-resistors and -capacitors, to the polarographic sensors as well as to the well-known tin oxide and related gas sensors.

Probably because the authors do not work with chemical sensors, no attention is paid to polymeric membranes containing specific ionophores, which are photolithographically deposited onto FET devices, SAW devices, and various optical devices. Since a wide variety of these membranes are presently being developed, they should be included in a chapter on chemical sensors. The same critique can be given for planar all-silicon reference electrodes, which are very important in relation to the solid-state chemical sensors, and for the development of integrated sensor-actuator systems as examples of chemical feedback; neither technology is mentioned here at all.

Chapter 7 is focused on sensor technology and divided into three main areas: silicon planar technology as known from microelectronics, thin film deposition technologies that are compatible with silicon planar technology, and anisotropic etching technology, which leads to a specific sensor technology, called micromachining.

Finally, Chapter 8 describes the electronic circuits which are specifically developed for sensor interfacing, including bus systems. Sensors integrated with electronic circuits for

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offset reduction, temperature compensation, multiplexing, etc., are called smart sensors. These capabilities are specific to silicon sensors, which make these sensors so well established.

The book ends with two appendices, one listing all occurring effects in the solid state that can be used for the direct conversion of non-electrical signals to electrical signals, and the other providing the definitions of specific sensor characteristics such as accuracy, offset, sensitivity, etc.

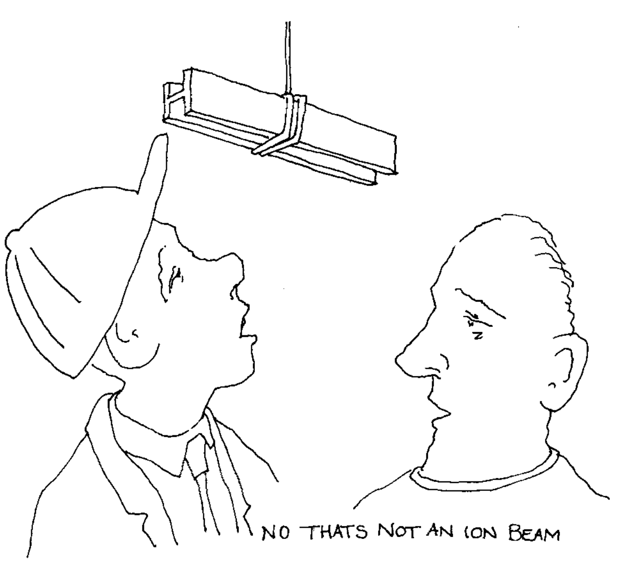
The book is based on a teaching course given at the University of Delft by the first author. This does not mean that the book is only useful for graduate students. Because the book covers all aspects of silicon sensors from fundamental knowledge of material and physical effects to technology and applications, the book is very useful for physicists, chemists and engineers involved in the field of sensor research, development, and application.

Piet Bergveld
Electrical Engineering, University of Twente
P.O. Box 217, NL-7500 AE Enschede (Netherlands)

Ion Beam Processing Technology Handbook Edited by *J. Cuomo, Stephen M. Rossnagel* and *Harold R. Kaufman*, Noyes Publication, Park Ridge 1989, xviii, 438 pp., bound, US $ 72.00.—ISBN 0-8155-1199-X

This handbook is an attempt to put all the newly developed ion beam technologies, applications, and theories together. The book covers the contemporary sources of ion beam processing technology for basic sputter etching and sputter deposition of thin films, for the modification of thin film properties, and for the synthesis of thin film materials.

Twenty chapters are divided into three major parts. The first part deals principally with broad beam ion sources, characterized by high fluxes and large work areas. These sources include the ECR ion source, the Kaufman-type single- and multiple- grid sources, gridless sources such as the hall effect or closed-drift source, and hybrid sources such as the ionized cluster beam system.



Part II presents sputtering phenomena from the basic background information through the characterization tools for the study of ion beam sputtering, including laser-induced fluorescence spectroscopy (LFS), multiphonon resonance ionization (MPRI), multiphoton ionization (MPI), and secondary neutral mass spectroscopy (SNMS).

Part III condenses numerous effects of the energetic bombardments on the film properties, emphasizing the modification of various film properties and synthesis of diamond and diamond-like thin films by ion beam techniques. Also included are molecular dynamics simulations for the theoretical study of the film growth modification by ion bombardment.

Overall, the book is an excellent up-to-date introduction to ion beam processing technology. However, ion beam depositions should be included in the ion beam technology. Despite these minor omissions, the book is useful as a text for introductory courses at the graduate level in ion beam processing. Also, this book is equipment oriented, making it appropriate for the most innovative workers in the field.

Isao Yamada
Ion Beam Engineering Experimental Laboratory
Kyoto University
Sakyo, Kyoto 606 (Japan)

The Fractal Approach to Heterogeneous Chemistry. Surfaces, Colloids, Polymers. Edited by *David Avnir*. John Wiley & Sons Ltd., Chichester 1989, xvii, 441 pp., bound, £ 75.—ISBN 0-471-91723-0

To fully appreciate this volume one must go back in time before the fractal approach was developed and try to imagine how you would attack the wide variety of problems which are addressed within, involving complex geometries and processes restricted by complex geometries. I remember one meeting in 1972 where several Nobel Laureates could only wave their hands and use a variety of words (like wispy), but no mathematics, to describe turbulent diffusion fronts for a problem of opening a bottle of perfume in a windy room. The article by *Sapoval* et al. easily treats diffusion fronts, and through scaling arguments finds a remarkable and unexpected connection to percolation problems in a gradient. The percolation cluster, with its intrinsic self-similarity, is one of the most famous examples of a fractal. *Havlin*'s article discusses not only percolation, but diffusion on percolation clusters, as well as on other fractal shapes. *Kopelman*'s article gives a beautiful example of energy transfer on a real percolation cluster. He prepares the critical mixture of the naphthalene species $C_{10}H_8$ and $C_{10}D_8$ to form a random binary lattice where the former species percolates through the latter. Energy transfer dynamics are then investigated via an exciton fusion reaction which, through a resonance criteria, is restricted to the $C_{10}H_8$ lattice. The experiment leads to