Polymers in Microelectronics: Fundamentals and Applications

By David S. Soane and Zoya Martynenko

(Elsevier, 1989)

This book is directed to polymer scientists who need an introduction to the microelectronics industry. However, as the authors themselves state, the field of polymers in microelectronics is too vast to be addressed in a single volume. The book nevertheless attempts to do that, and the result proves the former statement true.

Polymers in Microelectronics provides an overview of the basic principles of polymer science. Initially, the reader is introduced to the fundamentals of photolithographic processes (optical, UV, and e-beam lithography) followed by a discussion of the related materials and processing steps. The use of polyimide in IC fabrication is reviewed in some detail, including processing and reliability issues. The sections concerning photoresist materials, photolithographic processing, and, polyimides in IC fabrication have been adequately discussed. The authors have a thorough working knowledge of lithographic techniques and polymer chemistry for resist applications.

The section concerning polymers for IC encapsulation dwells on the current assembly processes and packaging technologies while providing scant information on the material requirements and reliability issues associated with polymers used for IC assembly and encapsulation. Clearly, a great deal of labor was expended in assembling information from different sources. However, the material is not bound by a clear vision nor a unified analysis, and as a result the material is frustratingly "hodgepodge"! Oversights such as a description of the use of titanium catalyst in silicon curing which continually interchanges tin for titanium add to the confusion.

There is a brief discussion of the use of polymers in printed circuit board applications and emerging technologies such as magnetic media, optical storage and nonlinear optical materials.

The authors' ambition to encompass the whole field of "polymers in microelectronics" is meritorious. The book would have gained in value if the authors had confined themselves to describing the polymer applications in IC wafer fabrication, since it is evident to the reader that this is their field of expertise. The book is useful as an introduction to polymer applications in wafer fabrication.

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Optical Nonlinearities and Instabilities in Semiconductors

Edited by Hartmut Haug

(Academic Press, 1988)

Seventeen chapters written by 33 authors cover the recent development of experimental and theoretical studies of the optical nonlinearities and instabilities in semiconductors. Although many authors contributed, the choice of topics and the balance between theories and experiments are well organized. The recent development of laser technologies and short-pulse optical technologies is well combined with the material technologies, e.g., the technology of layered semiconductor growth, which can now grow structures with atomic monolayer precision. As a result, not only is the electronic structure of the bulk and quantum-well semiconductors clarified, but also nonlinear and dynamical optical responses of these systems. Based on these nonlinear responses, several optoelectronic and optical devices have been proposed and are undergoing experimentation, and the publication of this review book is very timely.

After Haug's introduction (Chapter 1), experimental results of optical nonlinearities are reported for homogeneous semiconductors (Chapter 2 by Klingshirn) and for semiconductor quantum wells (Chapter 4 by Chemla, Miller, and Schmitt-Rink). Dynamical processes of the optical excitations in these systems can be observed in terms of femto-second and pico-second laser pulses as discussed in Chapters 4 and 5 by Ulbrich. Optical decay and spatial relaxation are shown to play important roles (Chapter 7 by Mahler, Kuhn, Frochel, and Hillmer).

Microscopic theory for these highly excited semiconductors is developed in terms of Green's functions for electron-hole plasmon systems (Chapter 3 by Haug) and for dense nonequilibrium exciton systems (Chapter 6 by Schäfer). In this dense exciton system, bi-excitons bring about colorful optical nonlinear behaviors, especially in wide-gap semiconductors such as CuCl and CuBr, and CdS, and CdSe (Chapter 8 by Levy, Hönerlage and Grun). The generation of phase-conjugated optical waves is tremendous due to the large optical nonlinearities in semiconductors (Chapter 9 by Claude, Chase, Hulin and Mysyrowicz).

Optical bistability and instability are discussed from both the experimental (Chapter 10 by Wherrett, Walder and Tooley, and Chapter 12 by Peyghambarian and Gibbs) and theoretical sides (Chapter 11 by Koch). Chapter 12 demonstrates optical bistable devices and logic gates for several kinds of semiconductor systems, such as bulk GaAs and GaAs multi-quantum wells.

Optical nonlinearities and bistability are shown for these systems and also for CdS_xSe_{1-x} doped glasses, the CuCl bi-exciton system, and ZnS and ZnSe thin films.

Excitons in semiconductor quantum wells under static electric fields show interesting optical responses, and their nonlinear optical response is effectively used as Self-Electro-Optic Effect Devices (SEED), as described in Chapter 13 by Miller, Chemla, and Schmitt-Rink. Optoelectronic nonlinearity is also discussed in bistable Si and InPb devices (Chapter 14 by Jager and Forsmann). Optical nonlinear responses of semiconductor lasers themselves are exciting.

Bistabilities in semiconductor laser amplifiers (Chapter 15 by Adams, Westlake, and O'Mahony) and in semiconductor laser diodes (Chapter 16 by Harder and Yariv) are reviewed. Shore and Rozzi discuss instabilities in semiconductor lasers in Chapter 17.

In conclusion, the chapters are so coherently and comprehensibly written that graduate students and engineers and scientists beginning their work in this field can read through without difficulty. Two points are unfortunately missing: nonlinear optical responses in semiconductor microcrystallites (except for a subsection in Chapter 12) and contributions from outside the United States and Western Europe.

Reviewer: Eiichi Hanamura is professor, Department of Applied Physics, University of Tokyo. His research involves solid state theory, especially optical properties of semiconductors and quantum confinement in solids and statistical physics related to nonlinear and cooperative phenomena. □

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