discusses these properties in a general sense in terms of the technology of light-emitting devices and then in a more specific sense in terms of comparing materials that are used today in practical electroluminescent devices.

In the area of p–n-junction lasers, the device is traced from its early conception, a simple diffused structure, through the double epitaxial structure, the single and the double heterostructures. Throughout all of this, he discusses the properties of these various devices as well as their unique characteristics. In addition those considerations important for the continuous operation of these lasers as well as the pulsed operations are provided, along with some of the basic definitions and facts relating to the operation of p–n-junction lasers. The final chapter of the book treats applications of junction electroluminescent devices. In particular it explains the use of light-emitting diodes as indicators and as displays, showing methods for driving displays as well as practical display systems. It also describes the use of infrared emitting LED's and lasers in optical-communication and radar systems.

This book is aimed at the uninitiated technical reader, and for him will prove to be a valuable source of basic information about junction electroluminescent devices.

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## Physical Models for Semiconductor Devices

**J. E. Carroll**
253 pp. Crane, Russak, New York, 1974. $11.25

## Semiconductor Physics

**K. Seeger**
514 pp. Springer-Verlag, New York, 1973. $23.10

The rapid progress of research and technology has created a situation wherein general texts and reference works about semiconductor physics and semiconductor devices tend to get out of date very quickly. Although the best of those that have been written are still useful, notably those by William Shockley (*Electrons and Holes in Semiconductors,* Van Nostrand, 1950) and R. A. Smith (*Semiconductors,* Cambridge U. P., 1961), new and up-to-date contributions to the literature in this field are much needed.

John Carroll's *Physical Models for Semiconductor Devices* is a textbook for upper-level undergraduates and beginning graduate students. Though it is addressed more directly to students of electrical engineering and solid-state device tenology, solid-state physicists with interests in applied research in areas related to semiconductor devices will find it an extremely valuable reference work. Its attractiveness to the latter audience stems from the fact that it presents a very clear and readable exposition of the present state-of-the-art in solid-state devices and integrated circuit technology for those who, like me, have fallen a bit behind the times. In doing so, the emphasis is everywhere on the physics of the device structure rather than upon black-box circuit theory, though Carroll includes enough of the latter where it is helpful in analyzing circuit behavior.

A general introduction to semiconductor materials and an elementary discussion of electronic processes in solids is given at the beginning of the book. This is followed by a very good and quite thorough chapter on the physics of the p–n junction. Carroll treats junction transistors, both unipolar and bipolar, in considerable detail and from a refreshingly physical point of view. In this discussion a very good summary of materials problems and fabrication techniques is included. He then takes up the question of electronic and acoustic waves in crystal lattices, and he sets forth an elementary treatment of lattice dispersion, phonons, energy bands and Brillouin zones. This section is rather below the standard set by the book as a whole, largely because the low level of quantum theory the author uses requires him to resort to quite a lot of hand-waving that is not always very convincing. The work is concluded by three excellent chapters having to do with metal-oxide–semiconductor structures, hot electron devices and solid-state optical devices.

A very extensive acquaintance with quantum mechanics or statistical mechanics is not assumed, though parallel reading of recommended reference texts is suggested. The style is informal and easily readable, though Carroll's rather offhand and conversational writing sometimes leads to very imprecisely phrased and even flatly incorrect statements. Thus, the distribution function is defined as "the probability of a state at energy $E$ being occupied"; bad enough when Boltzmann or Fermi statistics are all that is required, but certainly incorrect when later repeated for Bose–Einstein systems. He leads the reader to think that $\nabla_k E$ does not have to vanish at Brillouin zone boundaries, where the intent seems to be to say that this quantity can be zero at points in the interior of the Brillouin zone as well as at the boundaries! On balance, though, this is a good and useful text that should be very successful in instilling the lore of solid-state device physics

into the audience to whom it is directed. SI units are used consistently—perhaps *too* consistently—throughout. There is a list of problems at the end of each chapter that is not very extensive, but appropriate and well planned.

The verdict with regard to Karlheinz Seeger's *Semiconductor Physics* is less clear. It is a very thorough, comprehensive and scholarly treatment of the fundamental theory of semiconductors as it now stands, and as such it is bound to be an extremely useful and valuable reference volume. But I am doubtful that it will be extensively adopted in the fulfillment of its stated primary objective of serving as a text for a graduate-level course for physicists or electrical engineers.

It is necessary to read only a few paragraphs to realize that it has been translated from the original German by an *Übersetzer* whose fanatical intent was the literal rendition of the English equivalent, and whose concern with flow, stylistic elegance and communication of concept was—if it existed at all—minimal. The result is a book that, while not exactly hard to understand, is lumpish and uninteresting to read. The author's way of making qualitative explanations often exacerbates this feature of the text. His first chapter, in which he presents the elementary concepts of electron and hole behavior will, I am afraid, send most of the graduate students I know running for cover. The coverage of subject matter is very thorough, embracing all aspects of electronic and optical behavior of semiconductors, including many-valley and warped-sphere transport theory, galvano-magnetic, thermomagnetic, thermoelectric, magneto- and piezoresistive effects, breakdown, recombination, surface properties, and optical properties including luminescence and laser action. The level at which these subjects are discussed is high, indeed probably too high for best results in graduate level courses at most universities. The pages bristle with formidable equations that are rendered even more intimidating by Seeger's notation. His symbols for vector dot and cross products are non-standard and confusing, and he insists on always writing the magnitude of the electronic charge as $|e|$. Familiarity with quantum theory and statistical mechanics is assumed from the outset; the author's remark that "the book may be supplemented by a solid-state physics course" should be taken to mean that a good solid-state physics course is an iron-bound prerequisite. There are no problems included, and while it is true, as the author states, that good selections can be made from books like *Problems in Solid State Physics,* (H. J. Goldsmid, ed., Academic, 1969) it is not quite fair to expect students who have already paid $23.10 for a text to acquire

a supplementary problem book as well.

Despite these problems, the book is a very comprehensive and authoritative account of the formalism of semiconductor physics and on an advanced level, the present state of experimental understanding. Viewed from this angle, it probably has no equal. Despite its shortcomings as a textbook, it is a reference volume that I will find invaluable, and that should be very frequently consulted by those who are doing any sort of research work in semiconductor physics.

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## Transfer of Radiation in Spectral Lines

**V. V. Ivanov**
461 pp. US Dept. of Commerce, 1973. (Available from US Government Printing Office, Washington, D.C.) $7.45

Much of our understanding of astrophysical plasmas is based on line spectra. Too often the assumption is made, for simplicity, that the emitting gas is optically thin, that is, thick enough to emit radiation but thin enough that one ignores the effect of successive absorption and emission of photons by the gas. Another frequent assumption is that the medium is optically thick but, for simplicity, in a state of local thermodynamic equilibrium. The general case of an optically thick non-equilibrium plasma is of greater intrinsic interest than either of these two approximations but is much more difficult to treat, so much so that progress in the field is now in the hands of a few determined specialists.

This book is concerned with the equilibrium state of an optically thick gas controlled by its own internally-generated radiation field. The book is a revised and extended version of *Radiative Transfer and the Spectra of Celestial Bodies,* by V. V. Ivanov (Moscow, 1969), and contains roughly 100 additional pages devoted to results published between 1968 and 1971.

The author treats in great analytical detail the transfer of line radiation through a gas composed of idealized two-level atoms. This idealized problem deserves attention because it is central to the mathematical theory of the transfer of radiation in spectral lines, and because it provides underpinning for current research carried out with the use of digital computers.

The development is based on the analytical methods of E. Hopf, V. A. Ambartsumian, S. Chandrasekhar and V.