Book Reviews

Atomic Physics

Physics of Atomic Collisions. J. B. Hasted. Butterworth, Washington, D.C., 1964. x + 536 pp. Illus. $26.

For several years the study of atomic collision phenomena has enjoyed a renaissance as a result of stimulation from astrophysics, aeronomy, plasma physics, and quantum chemistry. New experimental techniques have in large measure removed the earlier ambiguities attending the interpretation of experiments. New theoretical methods, taking advantage of the ubiquitous computer, have begun to close the gap which, in the thirties, restricted experiments to the noble gases and calculations to one-electron atoms.

The graduate student who is beginning research in atomic physics needs a guide to the new techniques and research that constitute the great progress made during the last 15 years. The plethora of conference proceedings contain little of value, because the papers are rarely critical reviews of the physics, nor are they critically reviewed by the editors. In the past 2 years, three new books of substantial scope have appeared, in English, to join the well-known and much used *Electronic and Ionic Impact Phenomena* by H. S. W. Massey and E. H. S. Burhop (Oxford University Press, 1952). These books are the volume reviewed here, *The Physics of Atomic Collisions; Atomic and Molecular Processes*, edited by D. R. Bates (Academic Press, New York, 1962); and E. W. McDaniel's *Collision Phenomena in Ionized Gases* (Wiley, New York, 1964). No one of these books is entirely satisfactory of itself. Bates's volume is a collection of chapters by different authors, and as such it lacks both comprehensiveness and cohesiveness; it is a collection of reviews. McDaniel's book is more like Hasted's in purpose and treatment. It is not our purpose to review it here, but those who are selecting a textbook for a graduate course in atomic collisions will want to compare the two closely.

Hasted's purpose, as given in the preface, is "to aid the young experimental physicist entering into the study of ionized gases, or of other phenomena involving atomic collisions." In an admirable effort to cover the subject as completely as possible, he organizes the book by collision process and treats some 19 classes of processes, involving electrons, ions, atoms, molecules, and photons, in about 500 pages of compact typography. The introduction provides a coherent symbolism for describing any imaginable collision process, along with a discussion of all the different units in which the probabilities of these processes are expressed. A unique innovation is a fold-out monograph for converting between these systems of units, for converting between systems for describing particle energies, and giving orders of magnitudes of different cross sections. In a way this useful chart sets the tone for the book, which is encyclopedic in its coverage but thin on physical discussions from which the student could gain deeper insight. As a guide to the recent literature, it is thorough and the references are well selected. The reader is led to papers that give details of experimental methods as well as results. But the price that has been paid for the coverage is the exclusion of the development of the physical ideas. For this the reader will probably prefer the book by Massey and Burhop, if the new edition lives up to the standard of the 1952 volume.

In some cases the desire for comprehensiveness has led the author into statements that are not merely unsupported but actually incorrect. One example (in which Hasted will find himself in the company of many otherwise well-informed physicists) is concerned with the phenomenon of spectral line reversal: "This phenomenon, in which the edges of the line appear intense whilst the centre is weak, is caused by the absorption and re-radiation of resonance wavelengths by atoms which are cooler than the primary emitters" (p. 85).

A few such errors are inevitable, of course, and since Hasted is quite well at home in his subject, by virtue of many years of active research at the place of its rebirth (University College, London), he has maintained a satisfactorily high standard of reliability in most of the text. The student's greatest complaint (after he has solved the problem of raising the equivalent of 10 quid for the American printing) will be about the lack of supporting and explanatory discussion of the physics involved. Thus, he will find himself constantly driven to the references for a full understanding, and he will find Hasted's book useful as a handbook and guide to the full literature.

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Chemical Technology

Imperfections and Active Centres in Semiconductors. R. G. Rhodes. Pergamon, London; Macmillan, New York, 1964. xii + 373 pp. Illus. $12.50.

This is the sixth volume in the International Series of Monographs on Semiconductors edited by H. K. Henisch. The preceding volumes were mostly concerned with rather specialized topics in semiconductor science and were directed principally toward the interests of the physicist. Although this volume retains the same general excellence that characterized its predecessors, it encompasses a somewhat greater breadth in its appeal, with particular attraction for the metallurgist and the chemist. This is not to say, however, that it is not also profitable reading for the solid-state physicist. A more succinct characterization—involving an increasingly popular, albeit not necessarily precise, designation—is to state that the book can be expected to have interdisciplinary appeal for semiconductor scientists, engineers, and certain technicians.

To cover completely the subject of imperfections and active centers in crystals would be a stupendous task. Such consideration must be concerned not only with the nature of the de-

fects, including the evidence for their existence, and methods for establishing their density, but must also include discussion of such related categories as the means by which the defects are created, how they can be avoided, and their influence on basic properties of the crystal. To abstract the principal features from such an extensive discipline and to present the details in a coherent exposition, and within the confines of a volume that hopefully can be acquired by the average scientist, calls for considerable organizational ability on the part of the author. Rhodes has met this challenge quite admirably. By restricting the scope to phenomena of importance in germanium and silicon, he has achieved significant abridgment. This does not preclude references to other materials when a point is to be illustrated; indeed numerous results are quoted for alkali halides as well as various metals, but it does avoid consideration of various phenomena unique to certain compounds—for example, polar effects and faceting.

The organization of the book is such that the introductory chapter, which is devoted to definitions and qualitative explanations of various concepts, is followed by three chapters concerned with dislocations and their detection and with various aspects of plastic deformation. The next three chapters treat the growth of single crystals, the distribution and control of impurities, and the chemical and physical behavior of impurities, including diffusion and precipitation phenomena. The next chapter reviews, in fair detail, the salient findings from radiation damage studies on germanium and silicon, including annealing behavior. The final chapter deals with etching and the nature of various types of etch pits and includes a list of some of the principal etchants for germanium and for silicon.

Throughout the volume metallurgy and chemistry are emphasized—for example, in the discussion of the physics of transport processes we must accept the author's word when he makes the following statement in the preface: "It has been assumed that the reader will have some prior acquaintance with the subject of semiconductors. Electronic transport processes and solid-state device behaviour have already been comprehensively discussed in the literature and are adequately covered in the other monographs of this Series." In fact, in view of the scope of the book, the discussion of electrical properties is, for the most part, adequate to bring out the influence of the chemical and physical defects. But, in several places, the rudimentary presentation might lead uninitiated readers astray. For example (p. 209), Rhodes gives an expression for resistivity which is valid when both holes and electrons participate in the conduction process, although he states that the equations are valid only in the *extrinsic* conduction range (that is, one type of carrier only). On the next page he gives an expression for the Hall coefficient which is valid strictly for a single-type carrier. This restriction might, however, be missed if the reader is unfamiliar with the equation. Recent findings concerning certain "hard" superconductors have apparently been responsible for the statement: "The possibility also exists that the dislocations act as high-conductivity channels, the electrons moving from one free bond to another along the dislocation line" (p. 263). But here we are dealing with semiconductors, and I assume the author does not mean to imply that inducing the right dislocation in the right semiconductor might yield a superconductor.

But these are isolated instances. The book is exceptionally well put together, with an unusual paucity of ambiguities and typographical errors. It is valuable as an up-to-date review article, containing some 550 references (of which 425 cover work during the last decade). Its lucid and detailed presentation will make the volume useful as a teaching aid for students, scientists, engineers, and technologists whose interests encompass semiconductors and related solid-state fields.

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Mathematics

Differential Equations with Applications. Herman Betz, Paul B. Burcham, and George M. Ewing. Harper and Row, New York, ed. 2, 1964. xiv + 354 pp. Illus. $7.50.

In this country there seems to be a trend toward divorcing mathematics from its applications. This is an unfortunate trend which would present a subject like differential equations as a sterile and static logical exercise in axiomatics instead of presenting it as a dynamic and fertile subject whose existence and development is inexorably intertwined with the physical sciences. Therefore, it is good to see the second edition of a book on differental equations, for this is a book in which a great variety of applications form an integral part of the presentation. In the first edition, the applications covered included motion of a particle, mechanical and electrical vibrations of one and two degrees of freedom, and the law of mass action, and biological genetics. In the second edition, rocket motion and planetary motion have been added.

In most respects the second edition is better than its predecesor. The authors have put somewhat more emphasis on "concepts" and less on "formal dexterity." This is to be commended. However, in my opinion, the authors could have gone even farther in this direction. Somewhat more emphasis could have been placed on the fundamental existence theory. There is no reason why theory and application cannot be treated in the same book.

In balance, the book is a good one and should continue to find considerable use in a first course in differential equations for scientists and engineers.

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Physics

Laser Abstracts. vol. 1. A. K. Kamal. Plenum Press, New York, 1964. viii + 177 pp. $12.50.

Several bibliographies of publications related to lasers have been published during the last few years. However, the number of papers listed is large, and the reader must rely on the information contained in the titles in deciding which papers he wishes to investigate. A collected set of abstracts seems desirable, as long as the number of volumes required does not become too large.

Kamal's *Laser Abstracts* appears to give quite complete coverage of the papers in the field up to mid-1963. The large majority of the 731 abstracts are well written and accurate. On the average, the abstract is about twice as long as the reference citation. The cross indexes provided by the publisher