source of information, if they already have some knowledge, especially in the field of liquid crystals. Citation of literature seems to be fairly complete, and opens the field for further studies.

The subject index contains about 160 key words, a small number when compared with the numerous new definitions and items presented in the book. Some of the key words, such as earthquake, catastrophic theory, turbulence and others which are not explained in the text could have been dropped, others which are extensively treated are not included. Since the index contains relatively more mistakes and errors than could be detected in the various chapters this reviewer recommends a revision of the index for the next edition. This seems to be the only criticism that could be raised of this useful book.

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Point defects and defect interactions in metals. Edited by JIN-ICHI TAKAMURA, MASAO DOYAMA and MICHIO KIRITANI. Pp. 990. University of Tokyo Press and North-Holland Publishing Company, 1982. Price US $106.50, Dfl 250.00.

This book is a report of the Yamada Conference V on Point defects and defect interactions in metals held in Kyoto, Japan, in November 1981. Thus it is the latest in a series of independently published reports of international conferences on the present or closely related topics. The earlier conferences were held at Kyoto, Argonne and Jülich in 1962–64–68 and at Gaithersburg, Gatlinburg and Argonne in 1973–75–76.

In all the volume contains some 200 contributed papers. They are mainly short typical conference report papers of 3–4 pages, with a group of larger (8 page) keynote papers presumably submitted by invitation. These latter papers, although not reviews in the full sense, provide the reader with a brief statement of our current state of knowledge in various topics. The papers in the book are divided into eight major categories: *Advances in techniques*–11 papers; *Atomic defects*–55; *Point defect solute interactions*–44; *Diffusion*–16; *High-concentration alloys*–14; *Defect clusters*–16; *Interaction with dislocations and grain boundaries*–9; and *Radiation damage*–37. Further division into sub-categories is made for the three major categories above. For example, the *Radiation damage* category is divided into *Primary damage*, *Radiation-induced microstructure* and *Solution stability and segregation*. There is also a ninth category, *Future problems and comments*, to which three of the prominent participants have contributed very brief assessments of the conference achievements and attempt to point the way ahead.

The contributed papers cover a very wide range of experimental techniques for the detection and analysis of point defects and their interactions. Of these techniques, some will already be familiar to most scientists with an interest in the solid state. These include resistivity studies, thermal expansion measurements, X-ray Bragg and diffuse scattering, transmission electron microscopy and Mössbauer spectroscopy. Other techniques reported which are probably less widely familiar include ion-channelling, nuclear magnetic resonance, ultrasonic attenuation, positron annihilation (lifetime, line shape and angular correlation) and muon spin resonance techniques. Clear exposition of the applications of these techniques to defect studies are found in some of the larger papers. Other papers are devoted to purely theoretical studies. For example, in the category of *Atomic defects*, there are papers concerned with: the calculation using self-consistent pseudo-potential theory of the electronic structure and formation energy of a vacancy in aluminium; the electronic structure of impurities in the transition metals; the lattice vibrations around point defects; and several other topics.

A good feature of the book is the extensive report of the discussion evoked by the various papers. The discussions, which total some 112 pages, are presented as a series of questions and answers for individual papers and are grouped together at the end of each sub-category. The requirement of submitting questions and answers in writing has in most cases resulted in a greater understanding (though not necessarily agreement) between the contributor and questioner than is often the case during oral discussions. Occasionally, however, the *reader* is still left in some doubt through the misprinting of words in either question or answer, *e.g.* on p. 139 in discussion of paper on p. 113 we have 'Our calculated results show the small *electric* binding energy between a vacancy and an In impurity in Zn and the small negative binding energy in Cd'... electric = positive...?

As with all large conference volumes there is a significant variation in the standard of the contributed papers, both in scientific content and in the clarity of their presentation. It is also a very large book, 990 pages, but it has been given both an author index and a very good and detailed subject index. The final result is that the book with its approximately 200 papers and their attendant discussion comprises a worthwhile conference report but does not reach the editors' aim (flyleaf notes) of being 'a general text presenting the current state of the existing fundamental knowledge of point defects and their interactions in metals'.

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Radiation effects computer experiments. By J. R. BEELER JR. Vol. 13 of **Defects in solids.** Edited by S. AMELINCKX, R. GEVERS and J. NIHOUL. Pp. xviii + 881. Amsterdam: North-Holland, 1983. Price US $168.00, Dfl 395.00.

The study of radiation effects in solids involves the interactions of energetic primary radiation particles with one or,

more often, a series of atoms or ions within the irradiated body. Further, each of these primary interactions may produce displaced atoms (ions) of sufficient energy to become primary knock-on particles which themselves propagate through the solid undergoing further collisions and interactions giving rise to displacement cascades. In order to characterize the radiation-induced defect structure, the numbers, character, distribution and properties of the point defects and point-defect clusters produced by these interactions must be known. Also required is a knowledge of the interactions of the point defects with each other and with the existing defect structure, foreign (impurity) atoms, dislocations etc., in the irradiated material. Finally, the application of these studies to practical problems such as the development of engineering materials for nuclear (fission or fusion) reactors requires a knowledge of the annealing characteristics of the defects at elevated temperatures and the long-term effects of irradiation upon the mechanical properties of the solid. Thus the field of radiation effects involves a range of complex physical problems for which, in general, no analytical solutions can be found. However, the individual elements of the problems, for example the binary collision between two atoms, are relatively simple and well understood and, by simulating the physical processes in a computer, a numerical solution to the entire problem is readily obtained. Such computer experiments have contributed greatly to our understanding of various physical phenomena. The present book is intended as 'an introductory handbook to guide persons who want to learn how to develop and use computer experiment programs to simulate defect production and annealing in solids'.

The book starts at a very basic level with Chapter 1 introducing the concepts of the computer experiment and the model crystal and outlining the forms of particular computer experiments appropriate to radiation effects studies. Computer experiments involving defect production, defect annealing and defect properties and interactions are introduced and it is pointed out that a firm knowledge of defect properties and interaction is a necessary basis for the other two types of experiment. This chapter also leads the reader through several other concepts such as random and correlated migration, annihilation and clustering, all related to the dynamics of defect population, and displacement field and configuration energy as intrinsic properties of the static defect.

Chapter 2 deals with the various types of computation method available and gives basic examples of computer experiment program construction. Dynamical, Monte Carlo and variational methods are described in a clear and readable fashion though the latter only very briefly. The concepts of the computational cell, periodic boundary conditions, elastic continuum boundary conditions, static and thermal crystals, and various useful computation schemes are outlined. The computational cell is treated in some depth with computer routines and results presented for b.c.c., f.c.c. and h.c.p. crystals. These ideas lead naturally on to the subject of defect property computations which is treated in Chapter 3. Again an elementary introduction is given which includes discussions of the perfect crystal and the possible types of defect in crystals. Defect energies (configuration, formation and migration) are introduced and the computation methods for determining them are outlined. The reader is then made familiar with the specific computer models of the (perfect crystal) metals to be studied, each metal model

being completely specified by (a) its structure, (b) its lattice constant and (c) the atom-pair or interatomic potential. Metal–impurity interactions are also specified by the relevant atom-pair potential. A range of potentials from the literature are presented; four for b.c.c. iron and five for tungsten but unfortunately there is little discussion of their relative merits.

The following six chapters (408 pages) constitute a book within a book. With headings: Vacancies and divacancies; Self-interstitials; Impurity atoms; Defect migration; Vacancy clusters; and Interstitial clusters they form an atlas of the results in these topics of computer experiments conducted by various workers including the author and his colleagues. The work is presented in considerable detail and is of value as a summary of defect property computations. However, while clearly fitting with the scope of the title of this book, these chapters are not necessarily apposite to the author's intention for the book given above. Chapter 10, which deals with Frenkel-pair production, almost falls into the same category but as well as presenting a collection of results of Frenkel-pair-production simulations it also deals with computational procedures and hard- and soft-sphere replacement collision chains. Chapters 11 and 12 are concerned with collision cascade production. Chapter 11 describes the construction of a binary collision approximation (BCA) program for the simulation of cascade formation. Again the description is clear and concise and the prospective computer experimenter is provided with some computational procedures and subroutines that will assist him to make his own programs efficient. The limitations of the BCA method are explored in Chapter 12 by comparing cascade formation simulations made using BCA and dynamical computer programs. Chapters 13 to 16 deal with both defect annealing and aspects of defect production. The defect annealing program, outlined in Chapter 13, allows modification of the current defect population at any time during the annealing simulation by the addition of previously simulated displacement spikes or cascades and by the intermittent production of Frenkel pairs to simulate electron irradiation. Actual computer simulations of defect annealing, electron irradiation during high-voltage electron microscopy, and self-ion irradiation are presented and discussed in Chapters 14–16.

The reader is provided with a glossary of terms and abbreviations used in the book and with an adequate index. Unfortunately, the glossary is not exhaustive since 'hlc' which is not given in the glossary is first used on page 66 and is not defined as 'half lattice constant' until page 127 in a table heading or page 137 in the text. A fault which is not very serious but does make difficulties for the reader is that the editors have not always solved the problem of presenting the large numbers of illustrations and tables with the relevant passages of text. This is particularly noticeable in Chapters 3, 4 and 7 where, as one of many examples, the text referring to the configuration termed 'symmetrical, point E, interstitial in h.c.p.(m)' appears on pages 297 and 302. Pages 298–302 all contain figures and tables for a 'point D split interstitial' and the relevant pages containing figures and tables for point E are 303–307.

Any book dealing with such a specialized area as computer experiments in radiation effects can be expected to attract only a very limited readership. This book will be no exception but it certainly would be of use to anyone thinking of entering this field from either computer- or defect-

oriented backgrounds. A disappointing feature of the book is the lack of full-length listings of the author's own defect production and annealing programs (*e.g.* DYNAM and RINGO) to which many references are made.

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Vectors and tensors in crystallography. By DONALD E. SANDS. Pp. xvi + 228. Reading, MA: Addison-Wesley Advanced Book Program/World Science Division, 1982. Price $26.50.

Vectors and tensors are important in the mathematical description of crystallographic phenomena. For example, the repetition of a motif by translation can be represented by a vector, while other physical properties of crystals such as thermal conductivity, strain or optical activity can only be described by tensors.

As far as the reviewer knows, only a few treatises of crystallography offer instructions on how to manipulate vectors and tensors in general coordinate systems. Donald E. Sands's new book is just such a treatment of vector and tensor analysis in rectilinear systems. It is intended especially for crystallographers and, therefore, the emphasis is on crystallographic applications; but the methods developed are essential in any other problems that pertain to non-orthogonal systems.

The content of the book is well arranged and each chapter is completed by exercises. These exercises constitute a source of help for the scientist who is confronted by a problem that might yield to vector and tensor methods. Answers, hints and suggestions are given in an appendix. From the beginning, terms such as covariant and contravariant as well as Einstein's summation convention are consistently used. This requires some particular attention on the part of the reader, but it offers a considerable economy of notation.

Chapters 1, 3 and 4 present the fundamentals of vector and tensor analysis in rectilinear systems and can be regarded as the core of the book. Chapter 1 develops the vector algebra of such systems; several 'products' of vectors and the metric tensor are introduced. With these definitions chapter 2 shows how lines and planes may be characterized. The transformation theory, the exact definition of a tensor and its rank are presented in chapter 3. Then, eight sections of special applications follow, for example, anisotropic temperature factor, principal-axes transformation and rigid-body motion. Chapter 4 deals with a tensor treatment of symmetry. Among other things, Seitz operators are explained and point-group symmetry in both direct and reciprocal spaces as well as space-group symmetry are discussed. A table of all standard symmetry operators in direct and reciprocal space is given. The fifth chapter provides examples of physical properties of crystals that can be described by tensors. Chapter 6 summarizes some specific experimental techniques for observing the diffraction of X-rays by crystals. Especially for crystallographers who have to operate single-crystal diffractometers the sections on Eulerian and κ geometry might be very useful. Finally, chapter 7 is a brief survey of curvilinear spaces.

This book, of course, does not claim to be an encyclopedia of vector and tensor formulas, but it should be a convenient and handy reference for everyday use in crystallography or in other fields where rectilinear axes are appropriate. The occasionally complicated symbolism is clearly typeset and only a few errors have escaped the editorial filter. The comprehensive glossary of symbols at the beginning is extremely helpful, because, in books like this one, notational problems are inevitable.

Donald E. Sands's book could serve as a suitable textbook for a graduate course in vector and tensor analysis. It seems also appropriate as a companion to any book that teaches the crystallographic principles. It has been designed to be suitable for self-study. Therefore, this book can be heartily recommended to every crystallographer, students of crystallography and other solid-state scientists.

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Books Received

The following books have been received by the Editor. Brief and generally uncritical notices are given of works of marginal crystallographic interest; occasionally a book of fundamental interest is included under this heading because of difficulty in finding a suitable reviewer without great delay.

Crystal lattices, interfaces, matrices. By W. BOLLMANN. PP. vii + 360. Published by the author, 1983. Obtainable in N. America from Polycrystal Book Services, PO Box 27, Western Springs, IL 60558, USA, price US $45.00 *plus* mail & handling costs; or, in all other countries, from Professor W. Bollmann, 22 Chemin Vert, CH-1234, Pinchat, Geneva, Switzerland, price (including mail & handling costs): European countries SwF 70.00, non-European countries SwF 80.00. A review of this book, by M. S. Delaney, has been published in the April issue of *Journal of Applied Crystallography*, page 123.