Introduction to the Modern Theory of Metals

Alan Cottrell

(The Institute of Metals, London, 1988), approx. 260 pages.

ISBN: 0-904357-97-X

This is a broadly based tutorial overview of the physics of metals, based on their electronic structure. The book aims to bridge the gap between the physics and materials science communities. While the theories treated go back as far as the beginning of the century, most of the discussion centers on developments within the last 30 years. The complementary free-electron and tight-binding paradigms for the electronic structure are given extensive discussion, with more emphasis on the free-electron approach.

The first chapter introduces the origins of both metallic and insulating behavior from several points of view, including the one-electron band picture, electron-electron interactions, and the dielectric theory. Localization effects are discussed as well. Several succeeding chapters discuss the rationale for treating metals as free-electron materials. The topics include the weak ionic pseudopotential, screening effects, and a brief account of Fermi liquid theory. This discussion leads into a treatment of cohesion in simple metals based on the Wigner-Seitz method and the pseudopotential theory. The energetics of several types of imperfect configurations, including vacancies, stacking faults, and liquids are described within this picture. Cohesion in transition metals is subsequently treated via simple square-band models of the electronic density of states in tight-binding models, as well as more detailed approaches describing structural energies. Corrections to the simple tight-binding theory based on more quantitative calculations are described.

The last three chapters emphasize three types of metallic properties: alloy heats of formation, surface electron distributions, and superconductivity. The Hume-Rothery rules for alloy formation are described, along with more recent calculations seeking to provide justification for them. Simplified d-band pictures appropriate for transition metals, and the empirical "Miedema" theory, are also presented. Surface energies and work functions are treated within the context of both "jellium" and tight-binding theories. In addition, surface geometries and adsorption are briefly discussed. The last chapter outlines the BCS theory of superconductivity, and describes possible mechanisms of high temperature superconductivity.

A very attractive feature of this book is its emphasis on the interface between physics and materials science. Thus, defect properties and empirical approaches are treated in more detail than in most comparable books. Methodologies which are useful in treating defect problems, such radial interatomic forces, are described and, where possible justified. The treatment of the moment method for tight-binding models is also a welcome inclusion. Unfortunately, the widely used "embedded-atom" method is omitted.

The theoretical treatment is given a strong observational background, which makes for very enjoyable reading. The level of the book emphasizes simple physical pictures; it should be accessible to beginning students in both physics and materials science. In this regard, Cottrell includes 13 appendices that provide background material on the fundamentals of quantum mechanics and several topics in solid state physics.

Reviewer: A.E. Carlsson is associate professor of physics at Washington University in St. Louis. His specialty is the theory of bonding in transition metals and semiconductors.

Electronic Ceramics - Properties, Devices and Applications

Edited by Lionel M. Levinson

(Marcel Dekker, Inc., New York, 1988), 533 pages.

ISBN: 0-8247-7761-1

Electronic ceramics is one of the most rapidly developing fields of science and technology today. *Electronic Ceramics - Properties, Devices and Applications* provides an excellent introduction to the field of electronic ceramics for people with diverse backgrounds.

The book consists of eight chapters, written by different authors who have published extensively in their respective subject areas. The eight chapters describe the following subjects: (1) ceramic packaging for integrated circuits, (2) piezoelectric ceramics, (3) magnetic ceramics, (4) ceramic capacitor technology, (5) surge protective devices (mainly ZnO varistors), (6) thick film technology, (7) electro-optic ceramics and devices, and (8) high temperature superconductors.

A thorough review of the history of ceramic packaging technology is presented. Although future trends in integrated circuit packaging are addressed, greater emphasis of this topic would have been desired. The chapter on piezoelectric ceramics does not cover traditional piezoelectric materials and properties, but emphasizes the fracture behavior of these materials and the development of piezoelectric and electrostrictive composites. The chapters on magnetic ceramics and ceramic capacitor technology discuss the most important issues of these two technologies and give insight to future directions in these fields.

An excellent review of ZnO varistor technology is given by F. Martzloff and L. Levinson in the chapter on surge-protective devices. Thick film paste formation, firing, laser trimming, resistors, dielectrics, solderable electrode pastes, and copper material systems are among the topics covered in the chapter on thick film technology. A very thorough treatise on electro-optic ceramics and devices is presented by C. Haertling; the chapter emphasizes the fabrication and properties of PLZT. J. Bray and H. Hunt, authors of the chapter on high temperature superconductors, readily acknowledge that their chapter may be obsolete by publication time for this fast moving field. Nonetheless, a concise overview of type I and type II superconductors is given, and the initial developments of the "123" material are reviewed.

Overall, the book gives a fine review of electronic ceramics today, with a pertinent blend of theoretical and practical examples. Although ferroelectric thin film technology was in its infancy as the book was being compiled, a discussion of this high impact technology would have been appropriate. A positive aspect of the book is that many of the references are current (from 1985 and 1986) for the publishing date. Thus, *Electronic Ceramics - Properties, Devices and Applications* is highly recommended as a reference to the rapidly developing field of electronic ceramics.

Reviewer: Bruce A. Tuttle is a senior member of the technical staff at Sandia National Laboratories. His R&D activities include grain-boundary-controlled electronic ceramic materials, optoelectronic components, and ferroelectric thin films.

Chemical Sensing with Solid-State Devices

Marc J. Madou and S. Roy Morrison

(Academic Press, San Diego, CA, 1989), 557 pages.

ISBN: 0-12-464965-3

The field of chemical sensors is rapidly growing and highly diverse. The stated purpose of Madou and Morrison's book is to guide its audience, namely scientists and engineers with background in the physical sciences, through this multidisciplinary world. The book is well suited to this task, particularly for those who are