Introduction to the Electron Theory of Metals

The electron theory of metals describes how electrons are responsible for the bonding of metals and subsequent physical, chemical and transport properties. This textbook gives a complete account of electron theory in both periodic and non-periodic metallic systems.

The author presents an accessible approach to the theory of electrons, comparing it with experimental results as much as possible. The book starts with the basics of one-electron band theory and progresses to cover up-to-date topics such as high-T_c superconductors and quasicrystals. The relationship between theory and potential applications is also emphasized. The material presented assumes some knowledge of elementary quantum mechanics as well as the principles of classical mechanics and electromagnetism.

This textbook will be of interest to advanced undergraduates and graduate students in physics, chemistry, materials science and electrical engineering. The book contains numerous exercises and an extensive list of references and numerical data.

Uichiro Mizutani was born in Japan on March 25, 1942. During his early career as a postdoctoral fellow at Carnegie–Mellon University from the late 1960s to 1975, he studied the electronic structure of the Hume-Rothery alloy phases. He received a doctorate of Engineering in this field from Nagoya University in 1971. Together with Professor Thaddeus B. Massalski, he wrote a seminal review article on the electron theory of the Hume-Rothery alloys (*Progress in Materials Science*, 1978). From the late 1970s to the 1980s he worked on the electronic structure and transport properties of amorphous alloys. His review article on the electronic structure of amorphous alloys (*Progress in Materials Science*, 1983) provided the first comprehensive understanding of electron transport in such systems. His research field has gradually broadened since then to cover electronic structure and transport properties of quasicrystals and high-T_c superconductors. It involves both basic and practical application-oriented science like the development of superconducting permanent magnets and thermoelectric materials.

He became a professor of Nagoya University in 1989 and was visiting professor at the University of Paris in 1997 and 1999. He received the Japan Society of Powder and Powder Metallurgy award for distinguished achievement in research in 1995, the best year's paper award from the Japan Institute of Metals in 1997 and the award of merit for Science and Technology of High-T_c Superconductivity in 1999 from the Society of Non-Traditional Technology, Japan.

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UICHIRO MIZUTANI
Department of Crystalline Materials Science, Nagoya University

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Preface

This book is an English translation of my book on the electron theory of metals first published in two parts in 1995 and 1996 by Uchida Rokakuho, Japan, the content of which is based on the lectures given for advanced undergraduate and graduate students in the Department of Applied Physics and in the Department of Crystalline Materials Science, Nagoya University, over the last two decades. Some deletions and additions have been made. In particular, the chapter concerning electron transport properties is divided into two in the present book: chapters 10 and 11. The book covers the fundamentals of the electron theory of metals and also the greater part of current research interest in this field. The first six chapters are aimed at the level for advanced undergraduate students, for whom courses in classical mechanics, electrodynamics and an introductory course in quantum mechanics are called for as prerequisites in physics. It is thought to be valuable for students to make early contact with original research papers and a number of these are listed in the *References* section at the end of the book. Suitable review articles and more advanced textbooks are also included. Exercises, and hints and answers are provided so as to deepen the understanding of the content in the book.

It is intended that this book should assist students to further their training while stimulating their research interests. It is essentially meant to be an introductory textbook but it takes the subject up to matters of current research interest. I consider it to be very important for students to catch up with the most recent research developments as soon as possible. It is hoped that this book will be found helpful to graduate students and to specialists in other branches of physics and materials science. It is also designed in such a way that the reader can find interest in learning some more practical applications which possibly result from the physical concepts treated in this book.

I am pleased to acknowledge the valuable discussions that I have had with many colleagues throughout the world, which include Professors T. B.

Massalski, K. Ogawa, M. Itoh, T. Fukunaga, H. Sato, T. Matsuda and H. Ikuta, also Drs E. Belin-Ferré, J. M. Dubois and T. Takeuchi. I would like to thank them all for their interest and helpfulness. With regard to the actual production of this book, the situation is more straightforward. In this regard, I would especially like to thank Professor M. Itoh, Shimane University and Professor K. Ogawa, Yokohama City University, for allowing me to include some of their own thoughts in my textbook. I am also grateful to Dr Brian Watts of Cambridge University Press for his advice on form and substance, and assistance with the English of the book at the final stage of its preparation.

Uichiro Mizutani
Nagoya