



Springer 手册精选原版系列

凝聚态物质与材料数据手册

功能材料：半导体和超导体

【第4册】

Springer
Handbook^{of}
Condensed Matter
and Materials Data

W.Martienssen

H.Warlimont

Editors



哈尔滨工业大学出版社
HARBIN INSTITUTE OF TECHNOLOGY PRESS



Springer 手册精选原版系列

凝聚态物质与材料数据手册

功能材料：半导体和超导体

【第4册】

Springer
Handbook *of*

Condensed Matter
and Materials Data

W. Martienssen

H. Warlimont

Editors



哈尔滨工业大学出版社
HARBIN INSTITUTE OF TECHNOLOGY PRESS

黑版贸审字08-2014-009号

Reprint from English language edition:

Springer Handbook of Condensed Matter and Materials Data

by Werner Martienssen and Hans Warlimont

Copyright © 2005 Springer Berlin Heidelberg

Springer Berlin Heidelberg is a part of Springer Science+Business Media

All Rights Reserved

This reprint has been authorized by Springer Science & Business Media for distribution in China Mainland only and not for export therefrom.

图书在版编目 (CIP) 数据

凝聚态物质与材料数据手册. 第4册, 功能材料. 半导体和超导体: 英文 / (德) 马蒂安森 (Martienssen, W.), (德) 沃利蒙特 (Warlimont, H.) 主编.
—哈尔滨: 哈尔滨工业大学出版社, 2014.3
(Springer手册精选原版系列)
ISBN 978-7-5603-4458-4

I. ①凝… II. ①马… ②沃… III. ①凝聚态-材料-技术手册-英文
②半导体材料-功能材料-技术手册-英文 ③超导体-功能材料-技术手册-英文 IV. ①O469-62 ②TB34-62

中国版本图书馆CIP数据核字 (2013) 第294096号



责任编辑 杨 桦 许雅莹 张秀华

出版发行 哈尔滨工业大学出版社

社 址 哈尔滨市南岗区复华四道街10号 邮编 150006

传 真 0451-86414749

网 址 <http://hitpress.hit.edu.cn>

印 刷 哈尔滨市石桥印务有限公司

开 本 787mm × 960mm 1/16 印张 15

版 次 2014年3月第1版 2014年3月第1次印刷

书 号 ISBN 978-7-5603-4458-4

定 价 68.00元

(如因印刷质量问题影响阅读, 我社负责调换)

原版影印说明

1. 《凝聚态物质与材料数据手册》(6册)是*Springer Handbook of Condensed Matter and Materials Data* 的影印版。为方便使用,由原版1卷改为6册:

第1册 通用表和元素

第2册 材料类:金属材料

第3册 材料类:非金属材料

第4册 功能材料:半导体和超导体

第5册 功能材料:磁性材料、电介质、铁电体和反铁电体

第6册 特种结构

2. 全书目录、作者信息、缩略语表、索引在各册均完整呈现。

本手册数据全面准确,1 025 个图和 914 个表使查阅更加方便,是非常实用的案头参考书,适于材料及相关专业本科生、研究生、专业研究人员使用。

材料科学与工程图书工作室

联系电话 0451-86412421

0451-86414559

邮 箱 yh_bj@aliyun.com

xuyaying81823@gmail.com

zhxh6414559@aliyun.com

Springer Handbook

of Condensed Matter and Materials Data

W. Martienssen and H. Warlimont (Eds.)

With 1025 Figures and 914 Tables



Springer

Springer Handbook provides a concise compilation of approved key information on methods of research, general principles, and functional relationships in physics and engineering. The world's leading experts in the fields of physics and engineering will be assigned by one or several renowned editors to write the chapters comprising each volume. The content is selected by these experts from Springer sources (books, journals, online content) and other systematic and approved recent publications of physical and technical information.

The volumes will be designed to be useful as readable desk reference book to give a fast and comprehensive overview and easy retrieval of essential reliable key information, including tables, graphs, and bibliographies. References to extensive sources are provided.

Preface

The Springer Handbook of Condensed Matter and Materials Data is the realization of a new concept in reference literature, which combines introductory and explanatory texts with a compilation of selected data and functional relationships from the fields of solid-state physics and materials in a single volume. The data have been extracted from various specialized and more comprehensive data sources, in particular the Landolt-Börnstein data collection, as well as more recent publications. This Handbook is designed to be used as a desktop reference book for fast and easy finding of essential information and reliable key data. References to more extensive data sources are provided in each section. The main users of this new Handbook are envisaged to be students, scientists, engineers, and other knowledge-seeking persons interested and engaged in the fields of solid-state sciences and materials technologies.

The editors have striven to find authors for the individual sections who were experienced in the full breadth of their subject field and ready to provide succinct accounts in the form of both descriptive text and representative data. It goes without saying that the sections represent the individual approaches of the authors to their subject and their understanding of this task. Accordingly, the sections vary somewhat in character. While some editorial influence was exercised, the flexibility that we have shown is deliberate. The editors are grateful to all of the authors for their readiness to provide a contribution, and to cooperate in delivering their manuscripts and by accepting essentially all alterations which the editors requested to achieve a reasonably coherent presentation.

An onerous task such as this could not have been completed without encouragement and support from the

publisher. Springer has entrusted us with this novel project, and Dr. Hubertus von Riedesel has been a persistent but patient reminder and promoter of our work throughout. Dr. Rainer Poerschke has accompanied and helped the editors constantly with his professional attitude and very personable style during the process of developing the concept, soliciting authors, and dealing with technical matters. In the later stages, Dr. Werner Skolaut became a relentless and hard-working member of our team with his painstaking contribution to technically editing the authors' manuscripts and linking the editors' work with the copy editing and production of the book.

We should also like to thank our families for having graciously tolerated the many hours we have spent in working on this publication.

We hope that the users of this Handbook, whose needs we have tried to anticipate, will find it helpful and informative. In view of the novelty of the approach and any possible inadvertent deficiencies which this first edition may contain, we shall be grateful for any criticisms and suggestions which could help to improve subsequent editions so that they will serve the expectations of the users even better and more completely.

September 2004
Frankfurt am Main, Dresden

Werner Martienssen,
Hans Warlimont



Prof. Werner Martienssen



Prof. Hans Warlimont

About the Authors

Wolf Assmus



Johann Wolfgang Goethe-University
Physics Department
Frankfurt am Main, Germany
assmus@physik.uni-frankfurt.de
<http://www.rz.uni-frankfurt.de/piweb/kmlab/Leiter.html>

Chapter 1.3

Dr. Wolf Assmus (Kucera Professor) is Professor of Physics at the University of Frankfurt and Dean of the Physics-Faculty. He is a solid state physicist, especially interested in materials research and crystal growth. His main research fields are: materials with high electronic correlation, quasicrystals, materials with extremely high melting temperatures, magnetism, and superconductivity.

Stefan Brühne



Johann Wolfgang Goethe-University
Physics Department
Frankfurt am Main, Germany
bruehne@physik.uni-frankfurt.de

Chapter 1.3

Dr. Stefan Brühne, née Mahne, a chemist by education in Germany and England, received his PhD in 1994 from Dortmund University, Germany, on giant cell crystal structures in the Al-Ta system. Following a post doc position at the Materials Department (Crystallography) at ETH Zurich he spent seven years in the ceramics industry. His main activity was R&D of glasses, frits and pigments for high-temperature applications, thereby establishing design of experiment (DoE) techniques. Since 2002, at the Institute of Physics at Frankfurt University he has been investigated X-ray structure determination of quasicrystalline, highly complex and disordered intermetallic materials.

Fabrice Charra



Commissariat à l'Énergie Atomique,
Saclay
Département de Recherche sur l'État
Condensé, les Atomes et les Molécules
Gif-sur-Yvette, France
fabrice.charra@cea.fr
<http://www-drecom.cea.fr/spcsi/>

Chapter 5.3

Fabrice Charra conducts research in the emerging field of nanophotonics, in the surface physics laboratory of CEA/Saclay. The emphasis of his work is on light emission and absorption from single nanoscale molecular systems. His area of expertise also extends to nonlinear optics, a domain to which he contributed several advances in the applications of organic materials.

Gianfranco Chiarotti



University of Rome "Tor Vergata"
Department of Physics
Roma, Italy
chiarotti@roma2.infn.it

Chapter 5.2

Gianfranco Chiarotti is Professor Emeritus, formerly Professor of General Physics, Fellow of the American Physical Society, fellow of the Italian National Academy (Accademia Nazionale dei Lincei). He was Chairman of the Physics Committee of the National Research Council (1988–1994), Chair Franqui at the University of Liège (1975), Assistant Professor at the University of Illinois (1955–1957), Editor of the journal Physics of Solid Surfaces, and Landolt-Börnstein Editor of Springer-Verlag from 1993 through 1996. He has worked in several fields of solid state physics, namely electronic properties of defects, modulation spectroscopy, optical properties of semiconductors, surface physics, and scanning tunnelling microscopy (STM) in organic materials.

Claus Fischer



Formerly Institute of Solid State and
Materials Research (IFW)
Dresden, Germany
A_C.FischerDD@t-online.de

Chapter 4.2

Claus Fischer received his PhD from the Technical University Dresden (Since his retirement in 2000 he continues to work as a foreign scientist of IFW in the field of high- T_c superconductors.) His last position at IFW was head of the Department of Superconducting Materials. The main areas of research were growth of metallic single crystals in particular of magnetic materials, developments of hard magnetic materials, of materials for thick film components of microelectronics and of low- T_c and high- T_c superconducting wires and tapes. Many activities were performed in cooperation with industrial manufacturers.

Günter Fuchs

Leibniz Institute for Solid State and Materials Research (IFW) Dresden
Magnetism and Superconductivity in the
Institute of Metallic Materials
Dresden, Germany
fuchs@ifw-dresden.de
<http://www.ifw-dresden.de/imw/21/>

**Chapter 4.2**

Dr. Günter Fuchs studied physics at the Technical University of Dresden, Germany, and received his PhD in 1980 on the pinning mechanism in superconducting NbTi alloys. Since 1969 he has been at the Institute of Solid State and Materials Research (IFW) in Dresden. His activities are in superconductivity (HTSC, MgB₂, intermetallic borocarbides) and the applications of superconductors. He received the PASREG Award for outstanding scientific achievements in the field of bulk cuprate superconductors in high magnetic fields in 2003.

Frank Goodwin

International Lead Zinc Research
Organization, Inc.
Research Triangle Parc, NC, USA
fgoodwin@ilzro.org
<http://www.ilzro.org/Contactus.htm>

**Chapter 3.1**

Frank Goodwin received his Sc.D. from the Massachusetts Institute of Technology in 1979 and is responsible for all materials science research at International Lead Zinc Research Organization, Inc. where he has conceived and managed numerous projects on lead and zinc-containing products. These have included lead in acoustics, cable sheathing, nuclear waste management and specialty applications, together with zinc in coatings, castings and wrought forms.

Susana Gota-Goldmann

Commissariat à l'Energie Atomique (CEA)
Direction de la Recherche Technologique
(DRT)
Fontenay aux Roses, France
susana.gota-goldmann@cea.fr

**Chapter 5.3**

Dr. Susana Gota-Goldmann received her PhD in Materials Science from the Université Pierre et Marie Curie (Paris V) in 1993. After her PhD, she was engaged as a researcher in the Materials Science Division of the CEA (Commissariat à l'Energie Atomique, France). She has focused her scientific activity on the growth and characterisation of nanometric oxide layers with applications in spin electronics and photovoltaics. In parallel she has developed the use of synchrotron radiation techniques (X-ray absorption magnetic dichroism, photoemission, resonant reflectivity) for the study of oxide thin layers. Recently she has moved from fundamental to technological research. Dr. Gota-Goldmann is now working as a project manager at the scientific affairs direction of the Technology Research Division (CEA/DRT).

Sivaraman Guruswamy

University of Utah
Metallurgical Engineering
Salt Lake City, UT, USA
sguruswa@mines.utah.edu
<http://www.mines.utah.edu/metallurgy/MML>

**Chapter 3.1**

Dr. Guruswamy is a Professor of Metallurgical Engineering at the University of Utah. He obtained his Ph.D. degree in Metallurgical Engineering from the Ohio State University in 1984. He has made significant contributions in several areas including magnetic materials development, deformation of compound semiconductors, and lead alloys. His current work focuses on magnetostrictive materials and hybrid thermionic/thermoelectric thermal diodes.

Gagik G. Gurzadyan

Technical University of Munich
Institute for Physical and Theoretical
Chemistry
Garching, Germany
gurzadyan@ch.tum.de
<http://zentrum.phys.chemie.tu-muenchen.de/gagik>

**Chapter 4.4**

Gagik G. Gurzadyan, Ph.D., Dr. Sci., has extensive experience in nonlinear optics and crystals, laser photophysics and spectroscopy. He has authored several books including the Handbook of Nonlinear Optical Crystals published by Springer-Verlag. He worked in the Institute of Spectroscopy (USSR), CEA/Saclay (France), Max-Planck-Institute of Radiation Chemistry (Germany). At present he works at the Technical University of Munich with ultrafast lasers in the fields of nonlinear photochemistry of biomolecules and femtosecond spectroscopy.

Hideki Harada

High Tech Association Ltd.
Higashikaya, Fukaya, Saitama, Japan
khb16457@nifty.com
<http://homepage1.nifty.com/JABM>



Chapter 4.3

Dr. Hideki Harada is chief advisor of magnetic materials and their application and President of High Tech Association Ltd., Saitama, Japan. He is Chairman of the Japan Association of Bonded Magnet Industries (JABM) and received his Ph.D. in 1987 with a work on electrostatic ferrite materials. He worked in research and development of magnetic materials and cemented carbide tools at Hitachi Metals where he also was on the Board of Directors. He received the Japanese National Award for Industries Development Contribution.

**Bernhard Holzapfel**

Leibniz Institute for Solid State and
Materials Research Dresden – Institute of
Metallic Materials
Superconducting Materials
Dresden, Germany
B.Holzapfel@ifw-dresden.de
<http://www.ifw-dresden.de/imw/26/>

Chapter 4.2

Dr. Bernhard Holzapfel is head of the superconducting materials group at the Leibniz Institute for Solid State and Materials Research (IFW) Dresden, Germany. His main area of research is pulsed laser deposition of functional thin films and superconductivity. Currently he works on the development of HTSC high J_c coated conductors using ion beam assisted deposition or highly textured metal substrates. His work is supported by a number of national and European founded research projects.

**Karl U. Kainer**

GKSS Research Center Geesthacht
Institute for Materials Research
Geesthacht, Germany
karl.kainer@gkss.de
<http://www.gkss.de>

Chapter 3.1

Professor Kainer is director of Institute for Materials Research at GKSS-Research Center, Geesthacht and Professor of Materials Technology at the Technical University of Hamburg-Harburg. He obtained his Ph.D. in Materials Science at the Technical University of Clausthal in 1985 and his Habilitation in 1996. In 1988 he received the Japanese Government Research Award for Foreign Specialists. His current research activities are the development of new alloys and processes for magnesium materials.

Catrin Kammer

METALL – Intl. Journal for Metallurgy
Goslar, Germany
Kammer@metall-news.com
<http://www.giesel-verlag.de>



Chapter 3.1

Catrin Kammer received her Ph.D. in materials sciences from the Technical University Bergakademie Freiberg, Germany, in 1989. She has been working in the field of light metals and is author of several handbooks about aluminium and magnesium. She is working as author for the journal ALUMINIUM and is teaching in material sciences. Since 2001 she is editor-in-chief of the journal METALL, which deals with all non-ferrous metals.

Wolfram Knabl

Plansee AG
Technology Center
Reutte, Austria
wolfram.knabl@plansee.com
<http://www.plansee.com>



Chapter 3.1

Dr. Wolfram Knabl studied materials science at the Mining University of Leoben, Austria and received his Ph.D. at the Plansee AG focusing on the development of oxidation protective coatings for refractory metals. Between 1996 and 2002 he was responsible for the test laboratories at Plansee AG and since October 2002 he is working in the field of refractory metals, especially material and process development in the technology center of Plansee AG.

**Alfred Koethe**

Leibniz-Institut für Festkörper- und
Werkstoffforschung
Institut für Metallische Werkstoffe
(retired)
Dresden, Germany
alfred.koethe@web.de

Chapter 3.1

Dr. Alfred Koethe is physicist and professor of Materials Science. He retired in 2000 from his position as head of department in the Institute of Metallic Materials at the Leibniz Institute of Solid State and Materials Research in Dresden, Germany. His main research activities were in the fields of preparation and properties of ultrahigh-purity refractory metals and, especially, of steels (stainless steels, high strength steels, thermomechanical treatment, microalloying, relations chemical composition/microstructure/properties).

**Dieter Krause**

Schott AG
Research and Technology-Development
Mainz, Germany
dieter.krause@schott.com

Chapter 3.4

Dieter Krause studied physics at the universities of Erlangen and Munich, Germany, where he received his Ph.D. for work on magnetism and metal physics. He was professor in Tehran, Iran, lecturer in Munich and Mainz, Germany. As scientist and director of Schott's corporate research and development centre he was involved in research on optical and mechanical properties of amorphous materials, thin films, and optical fibres. Now he is consultant, chief scientist, and the editor of the "Schott Series on Glass and Glass Ceramics – Science, Technology, and Applications" published by Springer.

Manfred D. Lechner

Universität Osnabrück
Institut für Chemie – Physikalische
Chemie
Osnabrück, Germany
lechner@uni-osnabrueck.de
<http://www.chemie.uni-osnabrueck.de/pc/index.html>



Chapter 3.3

Professor Lechner has a PhD in chemistry from the University of Mainz, Germany. Since 1975 he is Professor of Physical Chemistry at the Institute of Chemistry of the University of Osnabrück, Germany. His scientific work concentrates on the physics and chemistry of polymers. In this area he is mainly working on the influence of high pressure on polymer systems, polymers for optical storage and waveguides as well as synthesis and properties of superabsorbers from renewable resources.

Gerhard Leichtfried

Plansee AG
Technology Center
Reutte, Austria
gerhard.leichtfried@plansee.com
<http://www.plansee.com>



Chapter 3.1

Dr. Gerhard Leichtfried received his Ph.D from the Montanuniversität Leoben and is qualified for lecturing in powder metallurgy. For 20 years he has been working in various senior positions for the Plansee Aktiengesellschaft, a company engaged in refractory metals, composite materials, cemented carbides and sintered iron and steels.

**Werner Martienssen**

Universität Frankfurt/Main
Physikalisches Institut
Frankfurt/Main, Germany
Martienssen@Physik.uni-frankfurt.de

Chapters 1.1, 1.2, 2.1, 4.1

Werner Martienssen studied physics and chemistry at the Universities of Würzburg and Göttingen, Germany. He obtained his Ph.D. in Physics with R.W. Pohl, Göttingen, and holds an honorary doctorate at the University of Dortmund. After a visiting-professorship at the Cornell University, Ithaca, USA in 1959 to 1960 he taught physics at the University of Stuttgart and since 1961 at the University of Frankfurt/Main. His main research fields are condensed matter physics, quantum optics and chaotic dynamics. Two of his former students and coworkers became Nobel-laureates in Physics, Gerd K. Binnig for the design of the scanning tunneling microscope in 1986 and Horst L. Störmer for the discovery of a new form of quantum-fluid with fractionally charged excitations in 1998. Werner Martienssen is a member of the Deutsche Akademie der Naturforscher Leopoldina, Halle and of the Akademie der Wissenschaften zu Göttingen. Since 1994 he is Editor-in-Chief of the data collection Landolt-Börnstein published by Springer, Heidelberg.

**Toshio Mitsui**

Osaka University
Takazuka, Japan
t-mitsui@jttk.zaq.ne.jp

Chapter 4.5

Toshio Mitsui is an emeritus professor of Osaka University. He studied solid state physics and biophysics at Hokkaido University, Pennsylvania State University, Brookhaven National Laboratory, the Massachusetts Institute of Technology, Osaka University and Meiji University. He was the first to observe the ferroelectric domain structure in Rochelle salt with a polarization microscope. He proposed various theories on ferroelectric effects and biological molecular machines.

Manfred Müller

Dresden University of Technology
Institute of Materials Science
Dresden, Germany
m.mueller33@t-online.de



Chapter 4.3

Dr.-Ing. habil. Manfred Müller is a Professor emeritus of Special Materials at the Institute of Materials Science of the Dresden University of Technology. Before his retirement he was for many years head of department for special materials at the Central Institute for Solid State Physics and Materials Research of the Academy of Sciences in Dresden, Germany. His main field was the research and development of metallic materials with emphasis on special physical properties, such as soft and hard magnetic, electrical and thermoelastic properties. His last field of research was amorphous and nanocrystalline soft magnetic alloys. He is a member of the German Society of Materials Science (DGM) and was a member of the Advisory Board of DGM.

Sergei Pestov

Moscow State Academy of Fine Chemical
Technology
Department of Inorganic Chemistry
Moscow, Russia
pestovsm@yandex.ru



Chapter 5.1

Dr. Pestov is a docent of the Inorganic Chemistry Department and a head of group on liquid crystals (LC) at the Moscow State Academy of Fine Chemical Technology. He earned his Ph.D. in physical chemistry in 1992. His research is focused on thermal analysis and thermodynamics of systems containing LC and physical properties of LC. He is an author of a Landolt-Börnstein volume and two books devoted to liquid crystals.

**Günther Schlamp**

Metallgesellschaft Ffm and Degussa
Demetron (retired)
Steinbach/Ts, Germany

Chapter 3.1

Günther Schlamp received his Ph.D. from the Johann-Wolfgang-Goethe University of Frankfurt/Main, Germany, in Physical Chemistry. His industrial activities in research include the development and production of refractory material coatings, high purity materials and parts for electronics, and sputter targets for the reflection-enhancing coating of glass. He has contributed to several Handbooks with reports on properties and applications of noble metals and their alloys.

**Barbara Schüpp-Niewa**

Leibniz-Institute for Solid State and
Materials Research Dresden
Institute for Metallic Materials
Dresden, Germany
b.schuepp@ifw-dresden.de
<http://www.ifw-dresden.de>

Chapter 4.2

Barbara Schüpp-Niewa studied chemistry in Gießen and Dortmund where she received her Ph.D. in 1999. Since 2000 she has been a scientist at the Leibniz-Institute for Solid State and Materials Research Dresden with a focus on crystal structure investigations of oxometalates with superconducting or exciting magnetic ground states. Her current research activities include coated conductors.

Roland Stickler

University of Vienna
Department of Chemistry
Vienna, Austria
roland.stickler@univie.ac.at



Chapter 3.1

Professor Stickler received his master and Dr. degree from the Technical University in Vienna. From 1958 to 1972 he was manager of physical metallurgy with the Westinghouse Research Laboratory in Pittsburgh, Pa. In 1972 he accepted a full professorship at the University of Vienna heading a materials science group in the Institute of Physical Chemistry, and from 1988 he was head of this institute until his retirement as professor emeritus in 1998. He was involved in research and engineering work on superalloys, semiconductor materials and high melting point materials, investigating the relationship between microstructure and mechanical behavior, in particular fatigue and fracture mechanics properties. He was leader of a successful project on brazing under microgravity conditions in the Spacelab-Mission. Further activities included the participation in European COST projects, in particular as chairman of actions on powder metallurgy and light metals. He has authored and coauthored more than 250 publications in scientific journals and proceedings.

Pancho Tzankov

Max Born Institute for Nonlinear Optics
and Short Pulse Spectroscopy
Berlin, Germany
tzankov@mbi-berlin.de
<http://staff.mbi-berlin.de/tzankov/>



Chapter 4.4

Pancho Tzankov studied laser physics at Sofia University, Bulgaria, and received his Ph.D. in physical chemistry from the Technical University of Munich, Germany. He is now a postdoctoral fellow at the Max Born Institute in Berlin, Germany. His research activities involve development of new nonlinear optical parametric sources of ultrashort pulses and their application for time-resolved spectroscopy.

Volkmar Vill

University of Hamburg
Department of Chemistry, Institute of
Organic Chemistry
Hamburg, Germany
vill@chemie.uni-hamburg.de
<http://liqcryst.chemie.uni-hamburg.de/>



Chapter 5.1

Professor Volkmar Vill received his Diploma in Chemistry in 1986, his Diploma in Physics in 1988 and his Ph.D. in Chemistry in 1990 from the University of Münster, Germany. In 1997 he earned his Habilitation in Organic Chemistry from the University of Hamburg where he is Professor of Organic Chemistry since 2002. He is the author of the LiqCryst – Database of Liquid Crystals and the Editor of the Handbook of Liquid Crystals, of Landolt-Börnstein, Organic Index, and Vol. VIII/5a, Physical Properties of Liquid Crystals.

Hans Warlimont

DSL Dresden Material-Innovation GmbH
Dresden, Germany
warlimont@ifw-dresden.de



Chapters 3.1, 3.2, 4.2, 4.3

Hans Warlimont is a physical metallurgist and has worked on numerous topics in several research institutions and industrial companies. Among them were the Max-Planck-Institute of Metals Research, Stuttgart, and Vacuumschmelze, Hanau. He was Scientific Director of the Leibniz-Institute of Solid State and Materials Research Dresden and Professor of Materials Science at Dresden University of Technology. Recently he has established DSL Dresden Material-Innovation GmbH to industrialise his invention of electroformed battery grids.

Acknowledgements

2.1 The Elements

by Werner Martienssen

We thank Dr. G. Leichtfried, Plansee AG, A-6600 Reutte/Tirol for recently determined new data on the refractory metals Nb, Ta, and Mo, W.

4.1 Semiconductors

by Werner Martienssen

In selecting the “most important information” from the huge data collection in Landolt–Börnstein, the author found great help in the new *Semiconductors: Data Handbook* [1]. Again, the data in this Springer Handbook of Condensed Matter and Materials Data represent only a small fraction of the information given in *Semicon-*

ductors: Data Handbook, which is about 700 pages long. I am much indebted to my colleague O. Madelung for kindly presenting me the manuscript of that Handbook prior to publication.

[1] O. Madelung (Ed.): *Semiconductors: Data Handbook*, 3rd Edn. (Springer, Berlin, Heidelberg 2004)

4.5 Ferroelectrics and Antiferroelectrics

by Toshio Mitsui

The author of this subchapter thanks the coauthors of LB III/36 for their helpful discussions and suggestions. Especially, he is much indebted to Prof. K. Deguchi for his kind support throughout the preparation of the manuscript.

Contents

List of Abbreviations	19
-----------------------------	----

第1册 通用表和元素

Part 1 General Tables

1 The Fundamental Constants	
<i>Werner Martienssen</i>	3
1.1 What are the Fundamental Constants and Who Takes Care of Them?	3
1.2 The CODATA Recommended Values of the Fundamental Constants	4
References	9
2 The International System of Units (SI), Physical Quantities, and Their Dimensions	
<i>Werner Martienssen</i>	11
2.1 The International System of Units (SI)	11
2.2 Physical Quantities	12
2.3 The SI Base Units	13
2.4 The SI Derived Units	16
2.5 Decimal Multiples and Submultiples of SI Units	19
2.6 Units Outside the SI	20
2.7 Some Energy Equivalents	24
References	25
3 Rudiments of Crystallography	
<i>Wolf Assmus, Stefan Brühne</i>	27
3.1 Crystalline Materials	28
3.2 Disorder	38
3.3 Amorphous Materials	39
3.4 Methods for Investigating Crystallographic Structure	39
References	41

Part 2 The Elements

1 The Elements	
<i>Werner Martienssen</i>	45
1.1 Introduction	45
1.2 Description of Properties Tabulated	46
1.3 Sources	49
1.4 Tables of the Elements in Different Orders	49
1.5 Data	54
References	158

第2册 材料类：金属材料

Part 3 Classes of Materials

1 Metals

<i>Frank Goodwin, Sivaraman Guruswamy, Karl U. Kainer, Catrin Kammer, Wolfram Knabl, Alfred Koethe, Gerhard Leichtfried, Günther Schlamp, Roland Stickler, Hans Warlimont</i>	161
1.1 Magnesium and Magnesium Alloys	162
1.2 Aluminium and Aluminium Alloys	171
1.3 Titanium and Titanium Alloys	206
1.4 Zirconium and Zirconium Alloys	217
1.5 Iron and Steels	221
1.6 Cobalt and Cobalt Alloys	272
1.7 Nickel and Nickel Alloys	279
1.8 Copper and Copper Alloys	296
1.9 Refractory Metals and Alloys	303
1.10 Noble Metals and Noble Metal Alloys	329
1.11 Lead and Lead Alloys	407
References	422

第3册 材料类：非金属材料

2 Ceramics

<i>Hans Warlimont</i>	431
2.1 Traditional Ceramics and Cements	432
2.2 Silicate Ceramics	433
2.3 Refractory Ceramics	437
2.4 Oxide Ceramics	437
2.5 Non-Oxide Ceramics	451
References	476

3 Polymers

<i>Manfred D. Lechner</i>	477
3.1 Structural Units of Polymers	480
3.2 Abbreviations	482
3.3 Tables and Figures	483
References	522

4 Glasses

<i>Dieter Krause</i>	523
4.1 Properties of Glasses – General Comments	526
4.2 Composition and Properties of Glasses	527
4.3 Flat Glass and Hollowware	528
4.4 Technical Specialty Glasses	530
4.5 Optical Glasses	543
4.6 Vitreous Silica	556
4.7 Glass-Ceramics	558

4.8 Glasses for Miscellaneous Applications	559
References.....	572

第4册 功能材料：半导体和超导体（本册）

Part 4 Functional Materials

1 Semiconductors

<i>Werner Martienssen</i>	575
1.1 Group IV Semiconductors and IV-IV Compounds.....	578
1.2 III-V Compounds	604
1.3 II-VI Compounds	652
References.....	691

2 Superconductors

<i>Claus Fischer, Günter Fuchs, Bernhard Holzapfel, Barbara Schüpp-Niewa, Hans Warlimont</i>	695
2.1 Metallic Superconductors	696
2.2 Non-Metallic Superconductors	711
References.....	749

第5册 功能材料：磁性材料、电介质、铁电体和反铁电体

3 Magnetic Materials

<i>Hideki Harada, Manfred Müller, Hans Warlimont</i>	755
3.1 Basic Magnetic Properties	755
3.2 Soft Magnetic Alloys	758
3.3 Hard Magnetic Alloys	794
3.4 Magnetic Oxides	811
References.....	814

4 Dielectrics and Electrooptics

<i>Gagik G. Gurzadyan, Pancho Tzankov</i>	817
4.1 Dielectric Materials: Low-Frequency Properties	822
4.2 Optical Materials: High-Frequency Properties	824
4.3 Guidelines for Use of Tables	826
4.4 Tables of Numerical Data for Dielectrics and Electrooptics	828
References.....	890

5 Ferroelectrics and Antiferroelectrics

<i>Toshio Mitsui</i>	903
5.1 Definition of Ferroelectrics and Antiferroelectrics	903
5.2 Survey of Research on Ferroelectrics	904
5.3 Classification of Ferroelectrics	906
5.4 Physical Properties of 43 Representative Ferroelectrics	912
References.....	936