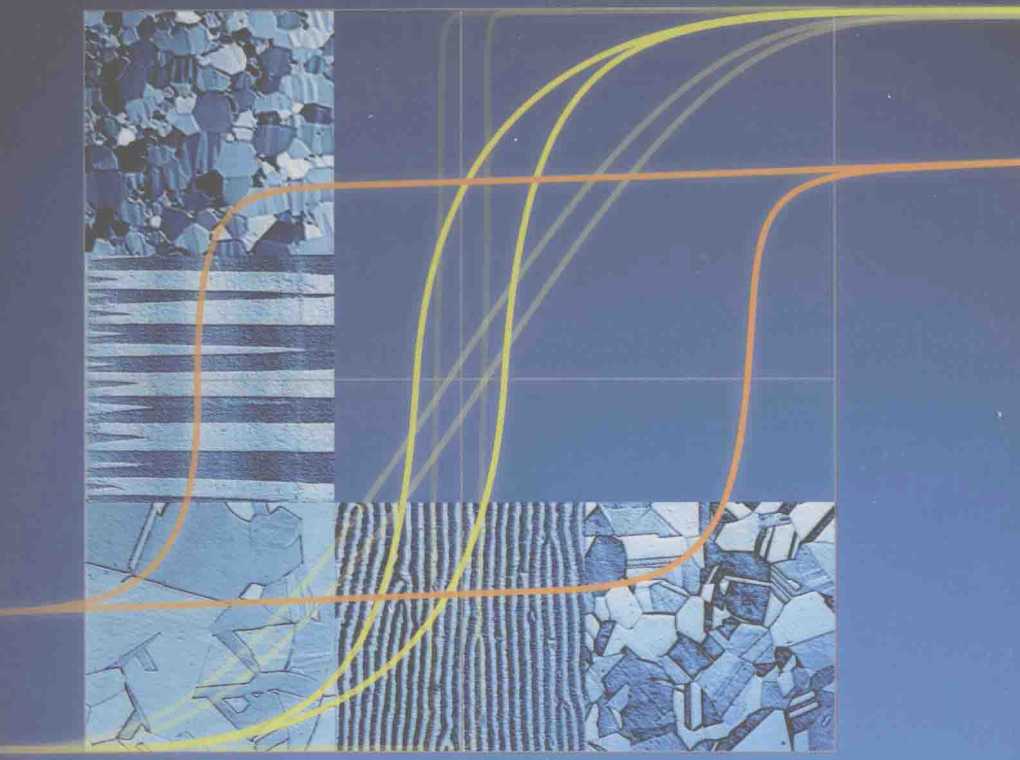

Rainer Hilzinger, Werner Rodewald

MAGNETIC MATERIALS

Fundamentals, Products, Properties, Applications

VACUUMSCHMELZE

Magnetic Materials

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by Rainer Hilzinger and
Werner Rodewald

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Dr. Rainer Hilzinger, former Chief Technology Officer and Development Director at VACUUMSCHMELZE, is a Member of the American Physical Society and the German Physical Society. He has published more than 65 scientific publications and is the holder of a number of patents. He was awarded the Georg-Sachs-Prize by the German Society for Materials Science (DGM) in 1983. Under his direction, many new materials have been developed and brought into commercial application.

Dr. Werner Rodewald, former Head of Fundamental Research and Development of Rare-Earth permanent magnet materials at VACUUMSCHMELZE, is also a Member of the German Physical Society. Until 2005, he was member of the IEC Technical Committee TC68-WG5, which compiles standards and measuring methods for permanent magnets. In addition, he has managed national and international projects with partners from universities and industry and has published many technical articles.

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Preface

Magnetic materials have become a key component in a large variety of electrical and electronic devices and have also gained a significant commercial relevance. VACUUMSCHMELZE is one of the few companies worldwide that produces magnetic materials with a very broad range of properties: from soft magnetic materials with tailored hysteresis loops or with the highest permeabilities, to strong permanent magnets having extremely high coercive field strengths and energy products.

This book updates the previous editions of "Soft Magnetic Materials" which had been compiled and edited by Dr. Richard Boll, and which for many years had been a standard guide to soft magnetic materials and their major applications.

This publication is a completely revised and substantially extended version of the last edition of 1990. New inclusions are nanocrystalline soft magnetic materials, permanent magnetic materials such as the RE-TM magnets based on Sm-Co and Nd-Fe-B alloys, and certain ductile permanent magnets. As a number of additional materials have been introduced, the title has been changed to "Magnetic Materials".

The current edition is arranged in three parts:

Part 1 introduces the reader to the fundamentals of magnetism and the basic processing routes and their impact on the properties of magnetic materials. The principles of the magnetization process are outlined and the different groups of soft and hard magnetic materials are discussed. In addition, the characteristics of the magnetic circuit, the effect of the specimen shape on the magnetic properties and the basic relationships between magnetic and electrical properties are reviewed, with an emphasis on the magnetization conditions and the different methods of magnetic measurements.

Part 2 covers the magnetic materials produced by VACUUMSCHMELZE, the typical properties of the different material grades and their characteristic curves. Specific attention is given to the metallurgy and the basic processing technologies, such as vacuum induction melting, hot and cold forming, heat treatments, rapid solidification or powder metallurgy and sintering processes. Numerous tables and characteristic curves are included which can support engineers in the design of magnetic circuits and assist in the appropriate selection of the correct magnetic materials for the large diversity of technical applications, e.g. in magnet assemblies or inductive components.

Part 3 summarizes selected examples and case studies of applications of magnetic materials, in order to demonstrate the impact of magnetic materials on our daily life. In many cases, these magnetic materials are the key components for the following devices and applications: Magnetic Shielding, Residual Current Devices, Current Transformers for Electronic Electricity Meters, Current Sensors with a Magnetic Probe, Common Mode Chokes, Power Transformers, Automotive Applications, Wind Turbines, Permanent Magnet Motors, Wigglers, Undulators and Free Electron Lasers.

We hope that this new edition will help to improve the basic understanding of soft and hard magnetic materials and assist designers to innovate with optimised and cost effective designs.

This book has been produced with the input of many colleagues from VACUUM-

SCHMELZE who deserve our sincere gratitude. We especially acknowledge the help of those colleagues who commented on the drafts of the individual chapters. In particular, we would like to thank Jim Nunn for his constructive amendments and his advice on the correct use of English terms.

The final expression of thanks goes to our wives Renate and Ingrid for their patience and continuous encouragement during the preparation and writing of this book.

Hanau, August 2012
Rainer Hilzinger and Werner Rodewald

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