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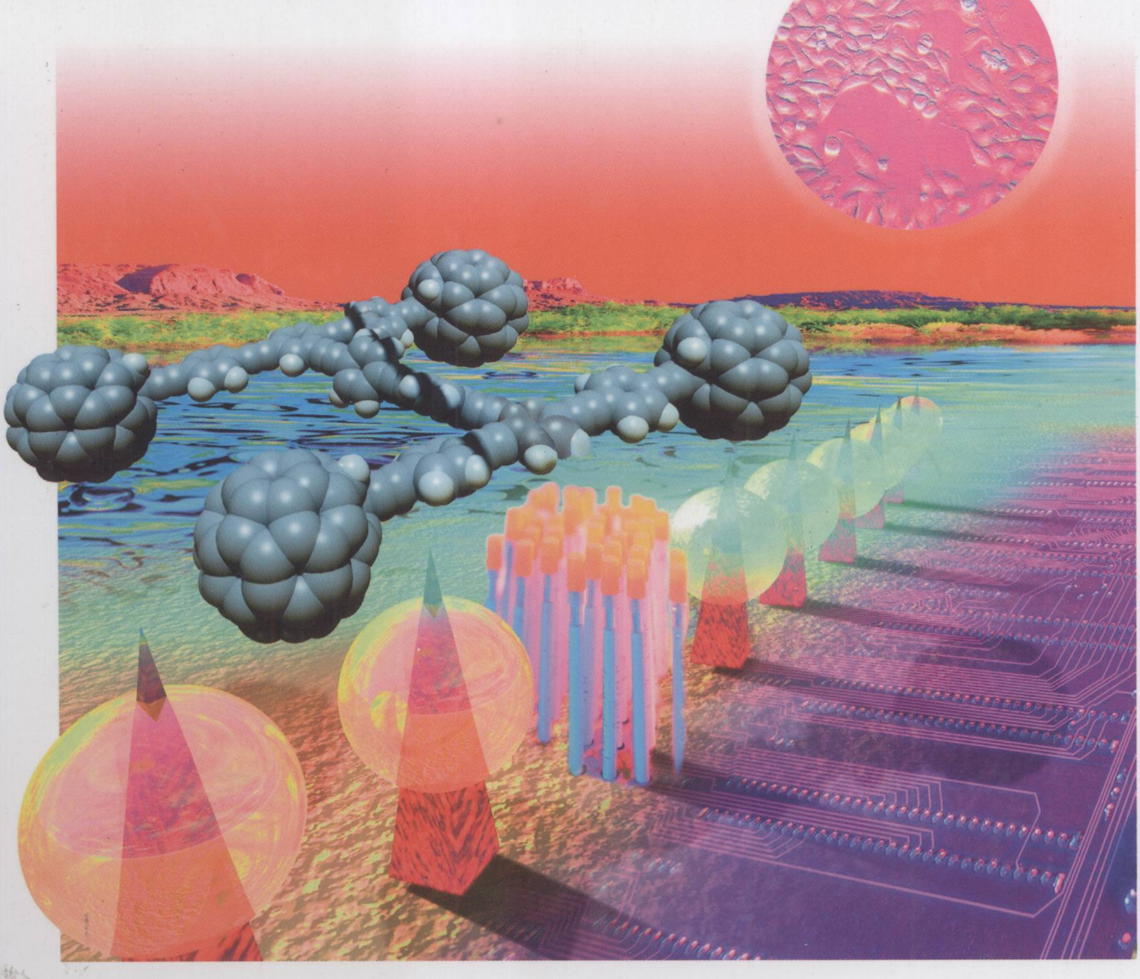

*G. Schmid, H. Krug, R. Waser, V. Vogel, H. Fuchs,
M. Grätzel, K. Kalyanasundaram, L. Chi (Eds.)*

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The Editor

Prof. Dr.-Ing. Rainer Waser
RWTH Aachen
Institut für Elektrotechnik II
Sommerfeldstr. 24
52074 Aachen

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Preface

Beyond any doubt, Information Technology constitutes the area in which nanotechnology is most advanced. Since its origination during the 1960s, semiconductor technology as the driving force of information technology has advanced and continues to advance at an exponential pace. Today, semiconductor-based information technology penetrates almost all areas of contemporary society – and we are still only at the beginning of a new era. Within the coming decades completely new applications may emerge such as personal real-time translation systems, fully automatic navigation systems for cars, intelligent software agents for the internet, and autonomous robots to assist in our daily lives.

The main ingredient of the tremendous evolution of semiconductor circuitry has been the technological opportunity of ever-shrinking the minimum feature size in the fabrication of semiconductor chips. This led to a corresponding increase in the component density on the chips, decreasing energy consumption of the individual logic and memory cells, as well as higher clock frequencies and the development of multi-core architectures. All this added up to a doubling of the computer performance of chips approximately every 18 months, known as Moore's law. During the first decades of development, semiconductor technology was referred to as *microelectronics*, but this was changed to *nanoelectronics* a few years ago when the minimum feature size was reduced to below 100 nm. At about the same time, the component density has surpassed the one billion per chip mark and continues to progress at an unrestrained pace. Research areas related to nanoelectronics, however, comprise much more than simply the extension of current semiconductor technology to still smaller structures. More importantly, they cover the entire physics of nanosized objects with manifold properties that are unmatched in the macroscopic world and which might one day be exploited to store, to transmit, and to process information. In addition, they deal with technological approaches which are completely different to the *top-down* concept based on lithographical methods. The alternative *bottom-up* concept starts with the chemistry of, for example, organic molecules, nanocrystals, nanotubes, or nanowires, and strives for the self-organization of structures which can themselves act as assemblies of functional

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devices. Furthermore, nanoelectronics research investigates completely new computational concepts and architectures.

This text on *Information Technology* within the series *Nanotechnology*, is divided into two volumes and covers the concepts of potential future advances of the semiconductor technology right up to their physical limits, as well as alternative concepts which might one day augment the semiconductor technology, or even replace it in designated areas. Some readers may be familiar with the book *Nanoelectronics and Information Technology* (Wiley-VCH, 2nd edition, 2005) which I have edited. Although the topic of the present book is quite similar, the target is somewhat different. While the first volume represents an advanced text book, the present two volumes emphasize encyclopedic reviews in-line with the concept of the series. Yet, wherever possible, I have strived for a complementarity of the topics covered in the two texts.

This volume covers three parts:

Part One – *Basic Principles and Theory* – includes chapters on the mesoscopic transport of electrons, single electron effects and processes dominated by the electron spin. Furthermore, the fundamental physics of computational elements and its limits are covered.

Part Two – *Nanofabrication Methods* – starts with the prospects of various optical and non-optical lithography techniques, describes the manipulation of nanosized objects by probe methods, and closes with chemistry- and biology-based bottom-up concepts.

Part Three – *High-Density Memories* – begins with an outlook at the future potential of current memories such as Flash and DRAM, attributes magnetoresistive and ferroelectric RAM, and reports about the perspectives of resistive RAM such as phase-change RAM and electrochemical metallization RAM.

Nanotechnology Volume 4 will cover the following topics:

- *Logic Devices and Concepts* – ranges from advanced and non-conventional CMOS devices and semiconductor nanowire device, via various spin-controlled logic devices, and concepts involving carbon nanotubes, organic thin films, as well as single organic molecules, to the visionary idea of intramolecular computation.

- *Architectures and Computational Concepts* – covers biologically inspired structures, and quantum cellular automata, and finalizes by summarizing the main principles and current approaches to coherent solid-state-based quantum computation.

There are many people to whom I owe acknowledgments. First of all, I would like to express my sincere thanks to the authors of the chapters, for their dedication, their patience, and their willingness whenever I requested modifications.

Next, I must pay tribute to the following colleagues (in alphabetical order) for critically reviewing the concept of the text and for their advice on topic and author selection: George Bourianoff (Intel Corp.), Ralph Cavin (Semiconductor Research Corp.), U-In Chung (Samsung Electronics), James Hutchby (Semiconductor Research Corp.), Christoph Koch (Caltech), Phil Kuekes (Hewlett Packard Research Laboratories), Heinrich Kurz (RWTH Aachen University), Rich Liu (Macronix Intl.

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Aachen, January 2008 *Rainer Waser*

List of Contributors

Jouni Ahopelto
VTT Micro and Nanoelectronics
Micro and Nanoelectronics
P.O. Box 1000
02044 VTT
Finland

Byoung Jae Bae
Process Development Team,
Semiconductor R&D Division
Samsung Electronics Co., Ltd.
San #24, Nongseo-Dong
Giheung-Gu, Yongin-City
Gyeonggi-Do 449-711
Korea

Lothar Berger
Fraunhofer Center for Nanoelectronic Technologies
Königsbrücker Straße 180
01099 Dresden
Germany
and
Zuken Electronic Design Automation Europe GmbH
Airport Business Centre
85399 Hallbergmoos
Germany

Klaus Bergmann
Fraunhofer Institut für Lasertechnik
Steinbachstr. 15
52074 Aachen
Germany

Dirk Beyer
Vistec Electron Beam GmbH
Goeschwitzer Strasse 25
07745 Jena
Germany

Alex M. Bratkovsky
Hewlett-Packard Laboratories
1501 Page Mill Road
MS 1123
Palo Alto, CA 94304
USA

Ralph K. Cavin
Semiconductor Research Corporation
1101 Slater Road
Durham, NC 27703
USA

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U-In Chung
Process Development Team,
Semiconductor R&D Division
Samsung Electronics Co., Ltd.
San #24, Nongseo-Dong
Giheung-Gu, Yongin-City
Gyeonggi-Do 449-711
Korea

Michael C. Gaidis
IBM T.J. Watson Research Center
1101 Kitchawan Road
Route 134
P.O. Box 218
Yorktown Heights, NY 10598
USA

Melanie Homberger
Forschungszentrum Jülich
CNI - Center of Nanoelectronic Systems
for Information Technology
Institute for Solid State Research (IFF)
52425 Jülich
Germany

Fumio Horiguchi
Toyo University
Department of Computational Science
and Engineering
2100 Kujirai
Kawagoe
Saitama 350-8585
Japan

Larissa Juschkin
RWTH Aachen
Lehrstuhl Technologie optischer
Systeme
Steinbachstr. 15
52074 Aachen
Germany

Silvia Karthäuser
RWTH Aachen University
Institute for Inorganic Chemistry (IAC)
Landoltweg 1
52074 Aachen
Germany

Michael N. Kozicki
Arizona State University
Center for Applied Nanoionics
Tempe, AZ 85287-6206
USA

Johannes Kretz
Qimonda Dresden GmbH & Co. OHG
Electron Beam Lithography
Competence Center
Koenigsbruecker Strasse 180
01099 Dresden
Germany

Andrea L. Lacaita
Politecnico di Milano
Dipartimento di Elettronice
e Informazione
Piazza L. da Vinci, 32
20133 Milan
Italy

Thomas Mikolajick
University of Technology and Mining
Institute of Electronic- and Sensor
Materials
Gustav-Zeuner-Strasse 3
09596 Freiberg
Germany

Maria Mitkova
Boise State University
Department of Electrical and Computer
Engineering
Boise, ID 83725-2075
USA

Soon Oh Park
Process Development Team,
Semiconductor R&D Division
Samsung Electronics Co., Ltd.
San #24, Nongseo-Dong
Giheung-Gu, Yongin-City
Gyeonggi-Do 449-711
Korea

Reinhart Poprawe
RWTH Aachen
Lehrstuhl für Lasertechnik
Steinbachstr. 15
52074 Aachen
Germany

Ari Requicha
University of Southern California
Computer Science Department
Laboratory for Molecular Robotics
941 Bloom Walk
Los Angeles, CA 90089-0781
USA

Thomas Schäpers
Forschungszentrum Jülich
Institut für Bio- and Nanosysteme
(IBN-1)
52425 Jülich
Germany

Anatol Schwersenz
Wuerth Electronics GmbH & Co. KG
Salzstrasse 21
74676 Niedernhall
Germany

Ulrich Simon
RWTH Aachen University
Institute for Inorganic Chemistry (IAC)
Landoltweg 1
52074 Aachen
Germany

Uri Sivan
Technion - Israel Institute of Technology
Department of Physics and the Russell
Berrie Nanotechnology Institute
Haifa 32000
Israel

Clivia M. Sotomayor Torres
University College Cork
Tyndall National Institute
Photonics Nanostructures Group
Lee Maltings
Cork
Ireland
and
Catalan Institute of Nanotechnology
Phononic and Photonic Nanostructures
Group
Campus Bellaterra - Edifici CM7
08193-Bellaterra
Barcelona
Spain

Joseph M. Thijssen
Delft University of Technology
Kavli Institute of Nanoscience
Lorentzweg 1
2628 CJ Delft
The Netherlands

Bert Voigtländer
Forschungszentrum Jülich
CNI - Center of Nanoelectronic Systems
for Information Technology
Institute for Bio- and Nanosystems
(IBN)
52425 Jülich
Germany

Dirk J. Wouters
IMEC
Memory Group, Division RDO/PT/
CMOSDR
Kapeldreef 75
3001 Leuven
Belgium

Dong Chul Yoo
Process Development Team,
Semiconductor R&D Division
Samsung Electronics Co., Ltd.
San #24, Nongseo-Dong
Giheung-Gu, Yongin-City
Gyeonggi-Do 449-711
Korea

Herre S. J. van der Zant
Delft University of Technology
Kavli Institute of Nanoscience
Lorentzweg 1
2628 CJ Delft
The Netherlands

Victor V. Zhirnov
Semiconductor Research Corporation
1101 Slater Road
Durham, NC 27703
USA

Contents

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