

Edited by Rainer Waser

 WILEY-VCH

Nanotechnology

Volume 4: Information Technology II



TB 383
N186.18
v.4

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

Nanotechnology

Volume 4: Information Technology II

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E2009001034

WILEY-VCH Verlag GmbH & Co. KGaA



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Library of Congress Card No.: applied for

British Library Cataloguing-in-Publication Data

A catalogue record for this book is available from the British Library.

Bibliographic information published by the Deutsche Nationalbibliothek

Die Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the Internet at <http://dnb.d-nb.de>.

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Weinheim

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Typesetting Thomson Digital, Noida, India

Printing betz-druck GmbH, Darmstadt

Binding Litges & Dopf Buchbinderei GmbH,
Heppenheim

Printed in the Federal Republic of Germany

Printed on acid-free paper

ISBN: 978-3-527-31737-0

Nanotechnology

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Edited by Rainer Waser

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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

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.

Ltd.), Hans Lüth (FZ Jülich), Siegfried Mantl (FZ Jülich), Tobias Noll (RWTH Aachen University), Stanley Williams (Hewlett Packard Research Laboratories), and Victor Zhirnov (Semiconductor Research Corp.).

Heartfelt thanks are due to Günther Schmid, editor of the series *Nanotechnology*, who invited and motivated me, and the staff of Wiley-VCH, in particular Gudrun Walter and Steffen Pauly, who supported me in every possible way.

Last – but certainly not least – I was greatly assisted by Dagmar Leisten, who redrew most of the original figures in order to improve their graphical quality, by Thomas Pössinger for his layout work and design ideas aiming at a more consistent appearance of the book, and by Maria Garcia for all the organizational work around such a project and for her sustained support.

Aachen, January 2008

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