Book Reviews

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1 Silicon Carbide, Vol. 1: Growth, Defects, and Novel Applications

by: P.V. Kimoto, L. Ley and G. Pensl
Published 2009
by Wiley-VCH Verlag GmbH & Co.,
KGaA, Boschstrasse 12, 69469 Weinheim, Germany, 528pp
ISBN-978-3-527-40953-2

Research and development of silicon carbide (SiC) as semiconductor material has reached a critical stage. After the early commercialisation of SiC-Schottky diodes for high voltage, high power applications in 2001, there has been tremendous progress in crystal growth, defect control, and processing. First engineering models of three-terminal devices have become available; they are intended for active electrical power management in areas such as transportation and power conversion where efficiency and/or high temperature operation are of the essence. At this stage, the two volumes provide an up-to-date, comprehensive, and critical assessment of all aspects of SiC semiconductor technology with an emphasis on power electronics. The scope reaches from advanced crystal growth over defect analysis and processing to the actual device design including the systems level. In addition, salient new developments outside power electronics such as MEMS, optical sensor applications, and SiC as enabling platform for large area grapheme electronics are covered. The contributions are written by internationally renowned experts from industry as well as academia who are actively involved in SiC R&D. Hence, the two volumes provide and evaluate source of information for everybody working with SiC or generally interested in the current and future state of power electronics.

The topic covered in Volume 1, Growth, Defects, and Novel Applications, are grouped in five subsections. The first section entitled Crystal Growth starts with two articles by Akwe et al. and Epelbaum et al. in which recent methods and results for epitaxial and bulk growth of hexagonal SiC are reviewed. The connection between growth rate and extended defects in 4H-SiC epilayers is explored in the contribution by Tsuchida et al. and the section closes with a report on novel ways to grow low defect cubic 3C-SiCfor high performance vertical MOSFETs by Nagasawa and co-workers.

In the book, Volume 1, the following chapters are included:

Volume 1 Silicon Carbide: Growth, Defects, and Novel Applications

Part A Growth of SiC

- bulk growth of SiC – review on advances of SiC vapour growth for improved doping and systematic study on dislocation evolution

- bulk and epitaxial growth of micropipe-free silicon carbide on basal and rhombohedra plane seeds
- formation of extended defects in 4H-SiC epitaxial growth and development of a fast growth technique
- fabrication of high performance 3C-SiC vertical MOSFETs by reducing planar defects.

Part B Characterisation of defects and material properties

- identification of intrinsic defects in SiC: towards and understanding of defect aggregates by combining theoretical and experimental approaches
- EPR identification of intrinsic defects in SiC; electrical and topographical characterisation of aluminium implanted layers in 4H silicon carbide.
- optical properties of as-grown and process-induced stacking faults in 4H-SiC
- characterisation of defects in silicon carbide by Raman spectroscopy
- lifetime-killing defects in 4H-SiC epilayers and lifetime control by low-energy electron irradiation
- identification and carrier dynamics of the dominant lifetime limiting defect in n 4H-SiC epitaxial layers
- optical beam induced current measurements: principles and applications to SiC device characterisation
- measurements of impact ionisation coefficients of electrons and holes in 4H-SiC and their application to device simulation
- analysis of interface trap parameters from double-peak conductance spectra taken on N-implanted 3C-SiC MOS capacitors
- non-basal plane SiC surfaces: Anisotropic structures and low-dimensional electron systems.

Part C Novel applications

- comparative columnar porous etching studies on n-type 6H-SiC crytalline faces
- micro- and nanomechanical structures for silicon carbide MEMS and NEMS
- epitaxial grapheme: a new material
- density functional study of grapheme over layers on SiC.

There were, however, also two contributions from Toyota and SiC ED, a Siemens/Infineon joint venture, which provided and enticing vista for the use of SiC-based devices in the automotive sector and in general, non-military power applications. Already at that time, it was obvious that the design and application of SiC-based semiconductor devices had been progressing rapidly since the first commercially available SiC-Schottky diode in 2001. Hence, we expanded our editorial board by two experts in the field of SiC semiconductor devices, one from SiCED

(Friedrichs) and one from Kyoto University mented by another 16 papers which deal with the current state of power semiconductor devices and related problems.

2 Silicon Carbide, Vol. 2: Growth, Power Devices and Sensors

by: P.V. Kimoto, L. Ley and G. Pensl
Published 2009
by Wiley-VCH Verlag GmbH & Co.,
KGaA, Boschstrasse 12, 69469 Weinheim, Germany, 520p
ISBN-978-3-527-40997-6

In 2008, Ley and Pensl edited a special issue of physica status solidi in which we gathered 18 invited topical reviews which were meant to cover key aspects of the material and electronic properties of silicon carbide (SiC) as an emerging material for applications in semiconductor devices. The topics covered in this special issue were grouped around a nucleus of ten contributions from members of the research unit 'Silicon carbide as semiconductor material: novel aspects of crystal growth and doping' that had been funded by the Deutsche Forschungs gemeinschaft (DFG) from 2002 to 2008 and comprised researchers from physics and engineering of the University of Erlangen-Nürnberg.

Volume 2, Power Devices and Sensors, is, as the title suggests, entirely devoted to SiC-based devices. In the first two contributions, the scene is set by two high-ranking scientists from industry, Hamada from the Toyota Motor Corporation, Japan, a prime player in the emerging field of hybrid and electric vehicles, and Friedrichs from SiC ED, Germany, a company that is at the forefront of SiC device development. They present their vision for the impact of SiC-based devices by placing the development of SiC device technology in the wider context of systems, economical, and sociological developments.

The bulk of the papers in Volume 2 are gathered in the second section, Unipolar Devices. The start is made by two contributions (Reshanov et al. and Holz et al.) that deal with SiC Schottky diodes, focusing on the effect of an intermediate graphite layer and on recent improvements dedicated to increase the reliability of such components. Among the unipolar devices with grain, the junction field effect transistor (JFET) has reached the highest level of maturity metal-oxide-semiconductor field effect transistor (MOSFET). The contributions of Malhan et al., Nuedeck et al. and Veliades provide an overview over the state-of-the-art. They describe different design concepts and demonstrate successful operation of normally-off JFETs in actual circuits, some of them at temperatures of 500°C for extended periods of times.

In the book, the following chapters are included:

- present status and future prospects for electronics in electric vehicles/hybrid electric vehicles and expectations for wide-bandgap semiconductor devices
- silicon carbide power-device products – status and upcoming challenges with a special attention to traditional, non-military industrial applications
- effect of an intermediate graphite layer on the electronic properties of metal/SiC contacts

- design, process, and performance of all-epitaxial normally-off SiC JFETs
- extreme temperature 6H-SiCJFET integrated circuit technology
- alternative techniques to reduce interface traps in n-type 4H-SiCMOS capacitors
- high electron mobility achieved in n-channel 4H-SiCMOSFETs oxidised in the presence of nitrogen
- 4H-SiC MISFETs with nitrogen-containing insulators
- inversion layer electron transport in 4H-SiC metal-oxide-semiconductor field-effect transistors
- development of SiC diodes, power MOSFETs and intelligent power modules
- reliability issues of SiC power MOSFETs toward high junction temperature operation
- application of silicon carbide transistors in photovoltaic-inverters
- design and technology considerations for SiC bipolar devices: BJTs, IGBTs, and GTOs
- suppressed surface-recombination structure and surface passivation for improving current gain of 4H-SiC BJTs
- SiC avalanche photodiodes and photomultipliers for ultraviolet and solar-blind light detection.

Hence, the two volumes provide an invaluable source of information for everybody working with SiC or generally interested in the current and future state of power electronics.

3 Progress in Nanotechnology, Processing, A Progress in Ceramic Technology Series Publication

by: ACerS
Published 2010
by The American Ceramic Society, by John Wiley & Sons, Inc.
111 River Street, Hoboken, NJ 07030-5774, USA, 350p
ISBN: 978-0-470-40839-1 (cloth)

Although nanotechnology is still an emerging industry, it represents a huge potential in a variety of markets that include biomedical, electronics, and energy totalling billions of dollars. However, before these markets are realised, processing methods must be developed that can produce quality nanomaterials and structures. Whether the material is a powder, thin film, wire, or composite, an optimal processing method is needed.

Powders of various compositions can be made by a wide range of methods, including freeze casting, chemical, hydrothermal synthesis, and solution combustion, among others. Each method has its limitations and advantages. The methods to make thin films and coatings include chemical vapour deposition, spray pyrolysis, and sol gel. Wires can be

made by electro spinning or hydrothermal synthesis. Other methods are under development for making composites and other structures.

This edition of progress in ceramic technology series contains a select compilation of articles on the topic of nanomaterials processing of powders; thin films, wires and tubes, and composites that were previously published in *The American Ceramic Society Bulletin*, *Journal of the American Ceramic Society*, *International Journal of Applied Ceramic Technology*, *Ceramic Engineering and Science Proceedings (CESP)* and *Ceramic Transactions (CT)*.

The American Ceramic Society contributes to the progress of nanotechnology by providing forums for information exchange during its various meetings and by publishing articles in its various journals and proceedings.

In the book, the following chapters are included:

- synthesis methods for powders
- membranes, films, and coatings
- nanotubes, nanorods, and nanowires
- nanocomposites and nanostructures.

4 Design-Inspired Innovation

by: J. Utterback, B.A. Vedin, E. Alvarez, S. Ekman, S. Walsh Sanderson, B. Tether and R. Verganti
Published 2006, Reprinted 2007
by World Scientific Publishing Co. Pte. Ltd.
5 Toh Tuck Link, 27 Warren Street, Suite 401-402,
Hackensack, NJ 07601, Singapore 596224, 259p
ISBN-10: 981-256-694-5 (Alk. paper), ISBN-13: 978-981-256-694-2

The purpose in writing design-inspired innovation is to explore the ways in which communities of art, design, and innovation are merging and influencing each other in the world of material culture to create great new products.

In the book, the following chapters are included:

- what makes products great
- creating design classics
- integrating function and design
- managing the design process
- the work of designers
- design-inspired innovation and the design discourse
- broadening human possibilities through design
- design-vision and visualising
- interview questions for designers and design firms

- from sketch to product.

This book reports the results of a study undertaken to explore these questions, which included interviews with the founders of nearly 100 design firms in four countries – Sweden, Italy, England, and the USA – and in several industries. The sample ranged from three divisions of the largest international design firm to some of the smallest and newest firms working in their local areas. We have looked broadly at contributions to advancing innovation and design in several types of products, including consumer electronics, devices for personal mobility, and others.

Manufacturers are responding to changes in technology and market demands by trying to introduce new products into the market more rapidly. They struggle with new and converging technologies that create opportunities for developing entire new product categories and with the entry of new types of competitors. Large firms enjoy great resources in technology and science, but these resources seem to be growing more available and open to all. Smaller groups and organisations derive greater innovative capabilities from the widening variety of sophisticated design resources available, such as computer-aided design, simulation, and visualisation techniques.

5 Fundamentals of Patenting and Licensing for Scientists and Engineers

by: J.M.Y. Ma
Published 2009
by World Scientific Publishing Co. Pte. Ltd.
5 Toh Tuck Link, 27 Warren Street, Suite 401-402,
Hackensack, NJ 07601, Singapore 596224, 265p
ISBN-13: 978-981-283-420-1, ISBN-10: 981-283-420-6

Over the past decade, however, the perceived economic value of patents by technology companies, and more recently by financial markets, has undergone a dramatic transformation. Patents are now recognised not merely as a bundle of legal rights to be licensed or enforced, but as an independent commercial asset class, like real estate or corporate securities. This change in perception has spawned a variety of new value extraction models for patents based in part on the creative adaptation of existing models used with more traditional kinds of assets.

This new focus on patent value extraction requires a fresh look at the way that patents are created, acquired, managed and monetised. The market value of a patent asset depends on the quality of the patent as measured by the level of advance over the prior art represented by the underlying invention, by the scope of the patent claims, and ultimately by the current and future commercial markets that are impacted by those claims. In the past, many corporate patent development programmes stressed the number of patents obtained each year. The result of this approach is that less than 5% of the patents owned by most technology companies have significant commercial value, with the rest being of little or no value. The recent emergence of a patent marketplace, however, has resulted in a marked shift from quantity to quality. The increased attention on patent quality has also resulted from the changing legal environment which has raised the eligibility bar as regards the level of innovation that is required to satisfy the requirement that an invention must not be obvious to a person of ordinary skill in the relevant art.

The following chapters are included in the book:

Part 1 The Basics:

1 Introduction

2 Common misconceptions about patents: exclusive right, a single patent protection scheme, trade secret vs. patenting, patents vs. publications, best mode vs. protection, a first glance at attorney's draft, patent maturity date

3 what you should know about patent laws and rule: the system of patent laws and rules, types of patents, patent dates, eligibility of priority date, patentability, true inventor ship, patent ownership, accelerated examination, enablement and best mode, patent search, duty of disclosure, no new matter after the disclosure is filed, international treaty.

Part 2 Fundamentals in patenting: how to read a patent, anatomy of a patent, find your easiest entry point – a first glance, understand embodiments of a patent, understand claims, different types of claims, understand the scope of the invention, what to look for when you read a patent, published patent application; Chapter 5 innovation harvesting: knowing the art, patentability test, patenting beyond core algorithm, innovation harvesting, patent landscaping, making filing decisions; Chapter 6 preparations before filing: Lab book: to document your invention, priority date, prior art and statutory bar against your application, working with attorney, filing it yourself, trade-off solution; Chapter 7 essentials in patent filing, structural parts of a patent and their purposes, specification and claims, citing other people's works-citations, what is considered new matter, broaden and diversity your claims,

Part 3 Patent prosecution and post granting; Chapter 8 patent prosecution, prosecution history, response to office action, duty of disclosure, restriction and election requirements, overcoming rejections, when conditional allowance is received, telephone interview with the examiner, when final rejection is received, appeal, when your claims are allowed at the first office, protest, continuation-in-part (CIP) and chain of co-pending; Chapter 9 tactics for overcoming rejections: common rejections on the merits; Chapter 10 post patent granting.

Part 4 Business perspectives and beyond: Chapter 11 patent protection and beyond, patenting should be business driven, defence strategy, offence strategy, the 'carrot' licensing and the 'stick' licensing, patent issues in standards, patent issues in open source, uncovering of infringing products; Chapter 12 patent evaluation and patent maintenance, patent use, market potential, claim quality, technical strength, ease of detection and reverse engineering cost, surrounding patents, patent enforceability, about patent maintenance; Chapter 13 patent sales, licensing and common practices, outright sale or licensing, bundling and field of use, patent ownership, litigation history; Chapter 14 patent valuation, intangible assets and why valuation, representative valuation approaches, exemplary case study of patent valuation, patent auction pricing case study, patent infringement damage statistics; Chapter 15 patent search, US patent search basics, international and other foreign patent databases, patent classification, progressive patent search.

Against the backdrop of this complex commercial landscape, it is essential that engineers and scientists who are engaged in the business of innovation have a working knowledge

of the legal rules, market forces, monetisation mechanisms and IP risks that affect the value of their creations. This book will provide that knowledge.

6 Transport in Laser Microfabrication: Fundamentals and Applications

by: C.P. Grigoropoulos
Published 2009
by Cambridge University Press
The Edinburgh Building, Cambridge CB2 8 RU, UK, 400p
ISBN 978-0-521-82172-8 (hardback)

Lasers are effective material-processing tools that offer distinct advantages, including choice of wavelength and pulse width to match the target material properties as well as one-step direct and locally confined structural modification. Understanding the evolution of the energy coupling with the target and the induced phase-change transformations is critical for improving the quality of micromachining and microprocessing. As current technology is pushed to ever smaller dimensions, lasers become a truly enabling solution, reducing thermomechanical damage and facilitating heterogeneous integration of components into functional devices. This is especially important in cases where conventional thermo-chemo-mechanical treatment processes are ineffective. Component microfabrication with basic dimensions in the few-microns range via laser irradiation has been implemented successfully in the industrial environment. Beyond this, there is an increasing need to advance the science and technology of laser processing to the nanoscale regime.

The following chapters are included in the book:

1 Fundamentals of laser energy absorption: classical electromagnetic-theory concepts, optical properties of materials.

2 Lasers and optics: laser for materials processing, some specific laser systems, basic principles of laser operation, definition of laser intensity and fluence variables, optical components, beam delivery.

3 Thermal processes in laser-materials interactions: macroscopic transport, conductive heat transfer, melting, ablative material removal.

4 Desorption at low laser energy densities: vapour kinetics, time of flight instruments, kinetic distributions of ejected particles.

5 Dynamics of laser ablation: introduction, laser-induced plasma formation, modelling of ablation-plume propagation, diagnostics of laser-ablated plumes, picosecond-laser plasmas.

6 Ultrafast-laser interactions with materials: introduction, femtosecond-laser interaction with metals, femtosecond-laser interaction with semiconductor materials, phase transformations induced by femtosecond laser irradiation, generation of highly energetic particles, ultrafast phase explosion, non-linear absorption and breakdown in dielectric materials, application in the micromachining of glass.

7 Laser processing of thin semiconductor films: modelling of energy absorption and heat transfer in pulsed-laser irradiation of thin semitransparent films,

continuous-wave (CW) laser annealing, inhomogeneous semiconductor-film-melting, nanosecond-laser-induced temperature fields in melting and resolidification of silicon thin films, nucleation in the supercooled liquid, lateral crystal growth induced by spatially modified irradiation, mass transfer and shallow doping.

8 Laser-induced surface modification: hydrodynamic stability of transient melts, capillary-driven flow, glass-surface modification.

9 Laser processing of organic materials: introduction, fundamental processor, applications.

10 Pulsed-laser interaction with liquids: rapid vaporisation of liquids on a pulsed-laser-heated surface, pulsed-laser interaction with absorbing liquids, non-linear interaction of short-pulsed lasers with dielectric liquids.

11 Laser cleaning of particulate contaminates: introduction, adhesion forces, a practical laser-cleaning system, mechanisms of laser cleaning.

12 Laser interactions with nanoparticles: size effects on optical properties, melting of nanoparticles, laser-induced production of nanoparticles.

13 Laser-assisted microprocessing: laser chemical vapour deposition, laser direct writing, laser microstereolithography.

14 Nano-structuring using pulsed laser radiation: introduction, apertureless NSOM nanomachining, apertured NSOM nanomachining, nanoscale melting and crystallisation, laser-assisted NSOM chemical processing, plasmas formed by near-field laser ablation.

The book focuses on examining the transport mechanisms involved in the laser-material interactions in the context of micro fabrication. The material was developed in the graduate course on laser processing and diagnostics. I introduced and taught in Berkeley over the years. The text aims at providing scientists, engineers, and graduate students with a comprehensive review of progress and the state-of-the-art in the field by linking fundamental phenomena with modern applications.