

# Molecular Beam Epitaxy: Fundamentals and Current Status (Springer Series in Materials Science)

Herman, Marian A.

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# **Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science**

**Lifeng Chi**



## **Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science:**

*Molecular Beam Epitaxy* Marian A. Herman, Helmut Sitter, 2013-03-08 This first ever monograph on molecular beam epitaxy MBE gives a comprehensive presentation of recent developments in MBE as applied to crystallization of thin films and device structures of different semiconductor materials MBE is a high vacuum technology characterized by relatively low growth temperature ability to cease or initiate growth abruptly smoothing of grown surfaces and interfaces on an atomic scale and the unique facility for in situ analysis of the structural parameters of the growing film The excellent exploitation parameters of such MBE produced devices as quantum well lasers high electron mobility transistors and superlattice avalanche photodiodes have caused this technology to be intensively developed The main text of the book is divided into three parts The first presents and discusses the more important problems concerning MBE equipment The second discusses the physico chemical aspects of the crystallization processes of different materials mainly semiconductors and device structures The third part describes the characterization methods which link the physical properties of the grown film or structures with the technological parameters of the crystallization procedure Latest achievements in the field are emphasized such as solid source MBE including silicon MBE gas source MBE especially metalorganic MBE phase locked epitaxy and atomic layer epitaxy photoassisted molecular layer epitaxy and migration enhanced epitaxy

**Molecular Beam Epitaxy** Mohamed Henini, 2012-12-31 This multi contributor handbook discusses Molecular Beam Epitaxy MBE an epitaxial deposition technique which involves laying down layers of materials with atomic thicknesses on to substrates It summarizes MBE research and application in epitaxial growth with close discussion and a how to on processing molecular or atomic beams that occur on a surface of a heated crystalline substrate in a vacuum MBE has expanded in importance over the past thirty years in terms of unique authors papers and conferences from a pure research domain into commercial applications prototype device structures and more at the advanced research stage MBE is important because it enables new device phenomena and facilitates the production of multiple layered structures with extremely fine dimensional and compositional control The techniques can be deployed wherever precise thin film devices with enhanced and unique properties for computing optics or photonics are required This book covers the advances made by MBE both in research and mass production of electronic and optoelectronic devices It includes new semiconductor materials new device structures which are commercially available and many more which are at the advanced research stage Condenses fundamental science of MBE into a modern reference speeding up literature review Discusses new materials novel applications and new device structures grounding current commercial applications with modern understanding in industry and research Coverage of MBE as mass production epitaxial technology enhances processing efficiency and throughput for semiconductor industry and nanostructured semiconductor materials research community

**Materials Fundamentals of Molecular Beam Epitaxy** Jeffrey Y. Tsao, 2012-12-02 The technology of crystal growth has advanced enormously during the past two decades Among

these advances the development and refinement of molecular beam epitaxy MBE has been among the most important. Crystals grown by MBE are more precisely controlled than those grown by any other method and today they form the basis for the most advanced device structures in solid state physics, electronics and optoelectronics. As an example, Figure 0.1 shows a vertical cavity surface emitting laser structure grown by MBE. Provides comprehensive treatment of the basic materials and surface science principles that apply to molecular beam epitaxy. Thorough enough to benefit molecular beam epitaxy researchers. Broad enough to benefit materials surface and device researchers. References articles at the forefront of modern research as well as those of historical interest.

**Compound Semiconductors** Ferdinand Scholz, 2017-10-06 This book provides an overview of compound semiconductor materials and their technology. After presenting a theoretical background, it describes the relevant material preparation technologies for bulk and thin layer epitaxial growth. It then briefly discusses the electrical, optical and structural properties of semiconductors, complemented by a description of the most popular characterization tools. Before more complex hetero and low dimensional structures are discussed, a special chapter is devoted to GaN and related materials, owing to their huge importance in modern optoelectronic and electronic devices, on the one hand, and their particular properties compared to other compound semiconductors, on the other. In the last part of the book, the physics and functionality of optoelectronic and electronic device structures: LEDs, laser diodes, solar cells, field effect and heterojunction bipolar transistors are discussed on the basis of the specific properties of compound semiconductors presented in the preceding chapters of the book. Compound semiconductors form the backbone of all optoelectronic and electronic devices besides the classical Si electronics. Currently, the most important field is solid state lighting with highly efficient LEDs emitting visible light. Also, laser diodes of all wavelength ranges between mid infrared and near ultraviolet have been the enabler for a huge number of unprecedented applications like CDs and DVDs for entertainment and data storage, not to speak about the internet, which would be impossible without optical data communications with infrared laser diodes as key elements. This book provides a concise overview over this class of materials, including the most important technological aspects for their fabrication and characterisation, also covering the most relevant devices based on compound semiconductors. It presents therefore an excellent introduction into this subject, not only for students but also for engineers and scientists who intend to put their focus on this field of science.

**Nitride Semiconductors and Devices** Hadis Morkoç, 2013-03-08 A View of the Past and a Look into the Future by a Pioneer. By Jacques I Pankove. This foreword will be a brief review of important developments in the early and recent history of gallium nitride and also a perspective on the current and future evolution of this exciting field. Gallium nitride (GaN) was synthesized more than 50 years ago by Johnson et al. 1 in 1932 and also by Juza and Hahn 2 in 1938, who passed ammonia over hot gallium. This method produced small needles and platelets. The purpose of Juza and Hahn was to investigate the crystal structure and lattice constant of GaN as part of a systematic study of many compounds. Two decades later, Grimaldi 3 in 1959 employed the same technique to produce small cry-

meiss et al of GaN for the purpose of measuring their photoluminescence spectra Another decade later Maruska and Tietjen 4 in 1969 used a chloride transport vapor technique to make a large area layer of GaN on sapphire All of the GaN made at that time was very conducting n type even when not deliberately doped The donors were believed to be nitrogen vacancies Later this model was questioned by Seifert et al 5 in 1983 and oxygen was proposed as the donor Oxygen with its 6 valence electrons on a N site N has 5 valence electrons would be a single donor

*Introduction to Mesoscopic Physics* Yoseph Imry, 1997 Mesoscopic physics refers to the physics of structures larger than a nanometer one billionth of a meter but smaller than a micrometer one millionth of a meter This book can be used as the main text in a course on mesoscopic physics or as a supplementary text in electronic devices semiconductor devices and condensed matter physics courses

**Hydrogen in Crystalline Semiconductors** Stephen J. Pearton, James W. Corbett, Michael Stavola, 2013-03-08 vgl Hardcoverausgabe

**Graphite Intercalation Compounds II** Hartmut Zabel, Stuart A. Solin, 2013-03-07 The research on graphite intercalation compounds often acts as a forerunner for research in other sciences For instance the concept of staging which is fundamental to graphite intercalation compounds is also relevant to surface science in connection with adsorbates on metal surfaces and to high temperature superconducting oxide layer materials Phonon folding and mode splitting effects are not only basic to graphite intercalation compounds but also to polytypical systems such as superconductors superlattices and metal and semiconductor superlattices Charge transfer effects play a tremendously important role in many areas and they can be most easily and fundamentally studied with intercalated graphite This list could be augmented with many more examples The important message however is that graphite intercalation compounds represent a class of materials that not only can be used for testing a variety of condensed matter concepts but also stimulates new ideas and approaches This volume is the second of a two volume set The first volume addressed the structural and dynamical aspects of graphite intercalation compounds together with the chemistry and intercalation of new compounds This second volume provides an up to date status report from expert researchers on the transport magnetic electronic and optical properties of this unique class of materials The band structure calculations of the various donor and acceptor compounds are discussed in depth and detailed reviews are provided of the experimental verification of the electronic structure in terms of their photoemission spectra and optical properties

**Nanotechnology** Lifeng Chi, 2010-08-09 This front line reference investigates nanostructured surfaces invisible to the naked eye Machinery and processes explained in a logical fashion Students and professionals will benefit from the knowledge imparted by the prominent authors

[Crystal Chemistry of High-Tc Superconducting Copper Oxides](#) Bernard Raveau, Claude Michel, Maryvonne Hervieu, Daniel Groult, 2013-03-12 The recent discovery of high temperature superconductivity in copper based oxides is an event of major importance not only with respect to the physical phenomenon itself but also because it definitely shows that solid state chemistry and especially the crystal chemistry of oxides has a crucial place in the synthesis and understanding of new materials for future applications

The numerous papers published in the field of high  $T_c$  superconductors in the last five years demonstrate that the great complexity of these materials necessitates a close collaboration between physicists and solid state chemists. This book is based to a large extent on our experience of the crystal chemistry of copper oxides which we have been studying in the laboratory for more than twelve years but it also summarizes the main results which have been obtained for these compounds in the last five years relating to their spectacular superconducting properties. We have focused on the structure, chemical bonding and nonstoichiometry of these materials bearing in mind that redox reactions are the key to the optimization of their superconducting properties owing to the importance of the mixed valence of copper and its Jahn Teller effect. We have also drawn on studies of extended defects by high resolution electron microscopy and on their creation by irradiation effects.

*Ordering at Surfaces and Interfaces* Akio Yoshimori, Teruya Shinjo, Hisatsune Watanabe, 2012-12-06 This volume contains the proceedings of the third in a series of biennial NEC Symposia on Fundamental Approaches to New Material Phases sponsored by the NEC Corporation Tokyo Japan. The symposium was held from October 7 to 11 1990 at the Hakone Kanko Hotel in Hakone. About 40 invited participants stayed together became involved in intense discussions and freely exchanged ideas both in and out of the conference room which faced Mt Fuji the beautiful lake Ashinoko and the quiet landscape in the old crater. The title of this volume *Ordering at Surfaces and Interfaces* which was also the title of the third symposium describes the aim of the symposium to discuss ordering properties and their underlying mechanisms at surfaces and interfaces. The topics treated include the reconstruction of surfaces of semiconductors and metals atomic and magnetic ordering at interfaces theoretical tools to study ordering mechanisms at surfaces and interfaces ordering in adsorbate surface systems such as alkali adsorbed silicon surfaces electric current effects on semiconductor surfaces and many related STM scanning tunneling microscopy results.

*Mechanisms of High Temperature Superconductivity* Hiroshi Kamimura, Atsushi Oshiyama, 2013-03-07 Since the discovery by Bednorz and Müller of Cu-O alloys displaying high temperature superconductivity great energy has been put into research in this field. One of the most important and interesting issues and the subject of this volume is the clarification of the microscopic origin and mechanism of high temperature superconductivity. This book discusses the latest experimental results on magnetic optical electrical thermal and mechanical properties of the Cu-O and Bi-O superconductors as well as proposed theoretical models of the mechanisms. The participants in the symposium agreed that for the high  $T_c$  Cu-O superconductors electron correlation effects are of central importance. For the Bi-O superconductors the main topic was whether the mechanism of superconductivity is the same as that of high  $T_c$  Cu-O superconductors. What was and what was not resolved at the symposium is summarized at the end of the volume.

*Dislocation Dynamics and Plasticity* Taira Suzuki, Shin Takeuchi, Hideo Yoshinaga, 2013-03-07 In the 1950s the direct observation of dislocations became possible stimulating the interest of many research workers in the dynamics of dislocations. This led to major contributions to the understanding of the plasticity of various crystalline materials. During this

time the study of metals and alloys of fcc and hcp structures developed remarkably. In particular the discovery of the so called inertial effect caused by the electron and phonon frictional forces greatly influenced the quantitative understanding of the strength of these metallic materials. Statistical studies of dislocations moving through random arrays of point obstacles played an important role in the above advances. These topics are described in Chaps 2-4. Metals and alloys with bcc structure have large Peierls forces compared to those with fcc structure. The reasons for the delay in studying substances with bcc structure were mostly difficulties connected with the purification techniques and with microscopic studies of the dislocation core. In the 1970s these difficulties were largely overcome by developments in experimental techniques and computer physics. Studies of dislocations in ionic and covalent bonding materials with large Peierls forces provided information about the core structures of dislocations and their electronic interactions with charged particles. These are the main subjects in Chaps 5-7.

Molecular Beam Epitaxy Hajime Asahi, Yoshiji Horikoshi, 2019-02-01. Covers both the fundamentals and the state of the art technology used for MBE. Written by expert researchers working on the frontlines of the field, this book covers fundamentals of Molecular Beam Epitaxy, MBE technology and science as well as state of the art MBE technology for electronic and optoelectronic device applications. MBE applications to magnetic semiconductor materials are also included for future magnetic and spintronic device applications. Molecular Beam Epitaxy: Materials and Applications for Electronics and Optoelectronics is presented in five parts: Fundamentals of MBE, MBE technology for electronic devices, application of MBE for optoelectronic devices, Magnetic semiconductors and spintronic devices, and Challenge of MBE to new materials and new researches. The book offers chapters covering the history of MBE, principles of MBE and fundamental mechanism of MBE growth, migration, enhanced epitaxy and its application, quantum dot formation and selective area growth by MBE. MBE of III-nitride semiconductors for electronic devices, MBE for Tunnel FETs, applications of III-V semiconductor quantum dots in optoelectronic devices, MBE of III-V and III-nitride heterostructures for optoelectronic devices with emission wavelengths from THz to ultraviolet, MBE of III-V semiconductors for mid-infrared photodetectors and solar cells, dilute magnetic semiconductor materials and ferromagnetic semiconductor heterostructures and their application to spintronic devices, applications of bismuth-containing III-V semiconductors in devices, MBE growth and device applications of Ga<sub>2</sub>O<sub>3</sub>, Heterovalent semiconductor structures and their device applications and more. Includes chapters on the fundamentals of MBE. Covers new challenging researches in MBE and new technologies. Edited by two pioneers in the field of MBE with contributions from well-known MBE authors including three AICoMBE Award winners. Part of the Materials for Electronic and Optoelectronic Applications series. Molecular Beam Epitaxy: Materials and Applications for Electronics and Optoelectronics will appeal to graduate students, researchers in academia and industry and others interested in the area of epitaxial growth. Nanostructures & Nanomaterials Guozhong Cao, 2004. This important book focuses on the synthesis and fabrication of nanostructures and nanomaterials but also includes properties and applications of nanostructures and

nanomaterials particularly inorganic nanomaterials It provides balanced and comprehensive coverage of the fundamentals and processing techniques with regard to synthesis characterization properties and applications of nanostructures and nanomaterials Both chemical processing and lithographic techniques are presented in a systematic and coherent manner for the synthesis and fabrication of 0 D 1 D and 2 D nanostructures as well as special nanomaterials such as carbon nanotubes and ordered mesoporous oxides The book will serve as a general introduction to nanomaterials and nanotechnology for teaching and self study purposes

**Interfacial Electrochemistry** Andrzej Wieckowski, 2017-11-22 This text probes topics and reviews progress in interfacial electrochemistry It supplies chapter abstracts to give readers a concise overview of individual subjects and there are more than 1500 drawings photographs micrographs tables and equations The 118 contributors are international scholars who present theory experimentation and applications

**Handbook of Advanced Ceramics** Shigeyuki Somiya, Fritz Aldinger, Richard M. Spriggs, Kenji Uchino, Kunihito Koumoto, Masayuki Kaneno, 2003-09-17 A two volume reference set for all ceramicists both in research and working in industry The only definitive reference covering the entire field of advanced ceramics from fundamental science and processing to application Contributions from over 50 leading researchers from around the world This new Handbook will be an essential resource for ceramicists It includes contributions from leading researchers around the world and includes sections on Basic Science of Advanced Ceramic Functional Ceramics electro ceramics and optoelectro ceramics and engineering ceramics Contributions from over 50 leading researchers from around the world

**Advanced Epitaxy for Future Electronics, Optics, and Quantum Physics** Arthur C. Gossard, 2000-12-28 The future development of electronics optics and quite probably quantum physics is being driven by advances in epitaxial materials Band gap engineering wafer bonding techniques and epitaxial regrowth technology will push transistors far beyond the present speed barriers Oxide growth within epitaxial layer structures and new advances in tunnel structures will push the development of the next generation of high performance laser arrays and of efficient cascade laser designs Perfection of the growth of semiconductor nitrides will move future electronics to higher powers and to suitability for extreme environments while revolutionizing lighting and display Growth technologies to incorporate metallic particles and magnetic elements within high quality semiconductors promise ultrafast electro optical components for chemical and biological applications as well as electronically controlled magnetism for future memories and electrical magnetic hybrid devices Quantum dot materials will lead the field of signal electronics while hopefully providing a new proving and discovery ground for quantum physics This paper dicusses the current progress in these areas

**Metal Oxide Defects** Vijay Kumar, Sudipta Som, Vishal Sharma, Hendrik C. Swart, 2022-11-19 Metal Oxide Defects Fundamentals Design Development and Applications provides a broad perspective on the development of advanced experimental techniques to study defects and their chemical activity and catalytic reactivity in various metal oxides This book highlights advances in characterization and analytical techniques to achieve better understanding of a wide range of defects most importantly state



of the art methodologies for controlling defects The book provides readers with pathways to apply basic principles and interpret the behavior of metal oxides After reviewing characterization and analytical techniques the book focuses on the relationship of defects to the properties and performance of metal oxides Finally there is a review of the methods to control defects and the applications of defect engineering for the design of metal oxides for applications in optoelectronics energy sensing and more This book is a key reference for materials scientists and engineers chemists and physicists Reviews advances in characterization and analytical techniques to understand the behavior of defects in metal oxide materials Introduces defect engineering applied to the design of metal oxide materials with desirable properties Discusses applications of defect engineering to enhance the performance of materials for a wide range of applications with an emphasis on optoelectronics

**Metal Oxide-Based Thin Film Structures** Nini Pryds, Vincenzo Esposito, 2017-09-07 Metal Oxide Based Thin Film Structures Formation Characterization and Application of Interface Based Phenomena bridges the gap between thin film deposition and device development by exploring the synthesis properties and applications of thin film interfaces Part I deals with theoretical and experimental aspects of epitaxial growth the structure and morphology of oxide metal interfaces deposited with different deposition techniques and new developments in growth methods Part II concerns analysis techniques for the electrical optical magnetic and structural properties of thin film interfaces In Part III the emphasis is on ionic and electronic transport at the interfaces of Metal oxide thin films Part IV discusses methods for tailoring metal oxide thin film interfaces for specific applications including microelectronics communication optical electronics catalysis and energy generation and conservation This book is an essential resource for anyone seeking to further their knowledge of metal oxide thin films and interfaces including scientists and engineers working on electronic devices and energy systems and those engaged in research into electronic materials Introduces the theoretical and experimental aspects of epitaxial growth for the benefit of readers new to the field Explores state of the art analysis techniques and their application to interface properties in order to give a fuller understanding of the relationship between macroscopic properties and atomic scale manipulation Discusses techniques for tailoring thin film interfaces for specific applications including information electronics and energy technologies making this book essential reading for materials scientists and engineers alike

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## **Table of Contents Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science**

1. Understanding the eBook Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - The Rise of Digital Reading Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Advantages of eBooks Over Traditional Books
2. Identifying Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Exploring Different Genres
  - Considering Fiction vs. Non-Fiction
  - Determining Your Reading Goals

3. Choosing the Right eBook Platform
  - Popular eBook Platforms
  - Features to Look for in an Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - User-Friendly Interface
4. Exploring eBook Recommendations from Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Personalized Recommendations
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science User Reviews and Ratings
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science and Bestseller Lists
5. Accessing Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science Free and Paid eBooks
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science Public Domain eBooks
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science eBook Subscription Services
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science Budget-Friendly Options
6. Navigating Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science eBook Formats
  - ePub, PDF, MOBI, and More
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science Compatibility with Devices
  - Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science Enhanced eBook Features
7. Enhancing Your Reading Experience
  - Adjustable Fonts and Text Sizes of Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science

- Highlighting and Note-Taking Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
- Interactive Elements Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
- 8. Staying Engaged with Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Joining Online Reading Communities
  - Participating in Virtual Book Clubs
  - Following Authors and Publishers Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
- 9. Balancing eBooks and Physical Books Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Benefits of a Digital Library
  - Creating a Diverse Reading Collection Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
- 10. Overcoming Reading Challenges
  - Dealing with Digital Eye Strain
  - Minimizing Distractions
  - Managing Screen Time
- 11. Cultivating a Reading Routine Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Setting Reading Goals Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Carving Out Dedicated Reading Time
- 12. Sourcing Reliable Information of Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Fact-Checking eBook Content of Molecular Beam Epitaxy Fundamentals And Current Status Springer Series In Materials Science
  - Distinguishing Credible Sources
- 13. Promoting Lifelong Learning
  - Utilizing eBooks for Skill Development

- Exploring Educational eBooks

#### 14. Embracing eBook Trends

- Integration of Multimedia Elements
- Interactive and Gamified eBooks

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