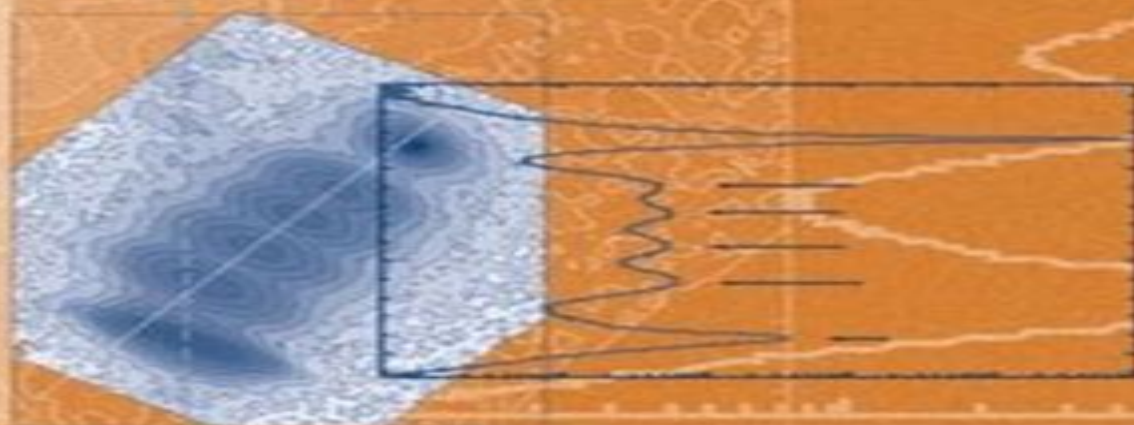


Ullrich Pietsch • Václav Holý  
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# High-Resolution X-Ray Scattering

From Thin Films to Lateral  
Nanostructures

**Second Edition**



Springer

# High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures

**Andrei Benediktovich,Ilya  
Feranchuk,Alexander Ulyanenko**



## **High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures:**

**High-Resolution X-Ray Scattering** Ullrich Pietsch, Vaclav Holy, Tilo Baumbach, 2013-03-09 During the last 20 years interest in high resolution x ray diffractometry and reflectivity has grown as a result of the development of the semiconductor industry and the increasing interest in material research of thin layers of magnetic organic and other materials For example optoelectronics requires a subsequent epitaxy of thin layers of different semiconductor materials Here the individual layer thicknesses are scaled down to a few atomic layers in order to exploit quantum effects For reasons of electronic and optical confinement these thin layers are embedded within much thicker cladding layers or stacks of multilayers of slightly different chemical composition It is evident that the interface quality of those quantum wells is quite important for the function of devices Thin metallic layers often show magnetic properties which do not appear for thick layers or in bulk material The investigation of the mutual interaction of magnetic and non magnetic layers leads to the discovery of colossal magnetoresistance for example This property is strongly related to the thickness and interface roughness of covered layers

**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 *Metrology and Diagnostic Techniques for Nanoelectronics* Zhiyong Ma, David G. Seiler, 2017-03-27 Nanoelectronics is changing the way the world communicates and is transforming our daily lives Continuing Moore's law and miniaturization of low power semiconductor chips with ever increasing functionality have been relentlessly driving R D of new devices materials and process capabilities to meet performance power and cost requirements This book covers up to date advances in research and

industry practices in nanometrology critical for continuing technology scaling and product innovation It holistically approaches the subject matter and addresses emerging and important topics in semiconductor R D and manufacturing It is a complete guide for metrology and diagnostic techniques essential for process technology electronics packaging and product development and debugging a unique approach compared to other books The authors are from academia government labs and industry and have vast experience and expertise in the topics presented The book is intended for all those involved in IC manufacturing and nanoelectronics and for those studying nanoelectronics process and assembly technologies or working in device testing characterization and diagnostic techniques     Characterization of Biological Membranes Mu-Ping

Nieh, Frederick A. Heberle, John Katsaras, 2019-07-22 The study of membranes has become of high importance in the fields of biology pharmaceutical chemistry and medicine since much of what happens in a cell or in a virus involves biological membranes The current book is an excellent introduction to the area which explains how modern analytical methods can be applied to study biological membranes and membrane proteins and the bioprocesses they are involved to

**Characterization of Semiconductor Heterostructures and Nanostructures** Giovanni Agostini, Carlo Lamberti, 2011-08-11 In the last couple of decades high performance electronic and optoelectronic devices based on semiconductor heterostructures have been required to obtain increasingly strict and well defined performances needing a detailed control at the atomic level of the structural composition of the buried interfaces This goal has been achieved by an improvement of the epitaxial growth techniques and by the parallel use of increasingly sophisticated characterization techniques and of refined theoretical models based on ab initio approaches This book deals with description of both characterization techniques and theoretical models needed to understand and predict the structural and electronic properties of semiconductor heterostructures and nanostructures Comprehensive collection of the most powerful characterization techniques for semiconductor heterostructures and nanostructures Most of the chapters are authored by scientists that are among the top 10 worldwide in publication ranking of the specific field Each chapter starts with a didactic introduction on the technique The second part of each chapter deals with a selection of top examples highlighting the power of the specific technique to analyze the properties of semiconductors     Integration of Functional Oxides with

Semiconductors Alexander A. Demkov, Agham B. Posadas, 2014-02-20 This book describes the basic physical principles of the oxide semiconductor epitaxy and offers a view of the current state of the field It shows how this technology enables large scale integration of oxide electronic and photonic devices and describes possible hybrid semiconductor oxide systems The book incorporates both theoretical and experimental advances to explore the heteroepitaxy of tuned functional oxides and semiconductors to identify material device and characterization challenges and to present the incredible potential in the realization of multifunctional devices and monolithic integration of materials and devices Intended for a multidisciplinary audience Integration of Functional Oxides with Semiconductors describes processing techniques that enable atomic level

control of stoichiometry and structure and reviews characterization techniques for films interfaces and device performance parameters Fundamental challenges involved in joining covalent and ionic systems chemical interactions at interfaces multi element materials that are sensitive to atomic level compositional and structural changes are discussed in the context of the latest literature Magnetic ferroelectric and piezoelectric materials and the coupling between them will also be discussed GaN SiC Si GaAs and Ge semiconductors are covered within the context of optimizing next generation device performance for monolithic device processing

*Electro-Chemo-Mechanics of Solids* Sean R. Bishop, Nicola H. Perry, Dario Marrocchelli, Brian W. Sheldon, 2017-03-18 This book brings together a collection of chapters that focus on the relationship among electrical chemical and mechanical properties and the study of adjusting one property through the control of another namely Electro Chemo Mechanics ECM The authors examine how this relationship can result in beneficial properties such as mixed ionic and electronic conductivity in oxides upon oxygen deficiency or lithium insertion electro chemo and or changes in ionic and electronic mobility observed in strained systems electro mechano They also consider how ECM interactions can be responsible for large stresses from non stoichiometry induced lattice dilation chemo mechano While many volumes are available devoted to the study of the origins and characteristics of electro chemical relationships they form the well known field of electrochemistry this volume is highly novel in its examination of the corresponding electro mechanical chemo mechanical and electro chemo mechanical relationships The book is ideal for researchers and design engineers interested in energy storage and conversion and the electrical and mechanical properties of materials

Characterization of Semiconductor Heterostructures and Nanostructures Tobias Schüllli, Vincent Favre-Nicolin, Marie-Ingrid Richard, Gilles Renaud, 2013-04-11

**X-Ray Scattering from Semiconductors and Other Materials** Paul F. Fewster, 2015 This third edition has been extended considerably to incorporate more information on instrument influences on the interpretation of X ray scattering profiles and reciprocal space maps Another significant inclusion is on the scattering from powder samples covering a new theoretical approach that explains features that conventional theory cannot The new edition includes some of the latest methodologies and theoretical treatments including the latest thinking on dynamical theory and diffuse scattering Recent advances in detectors also present new opportunities for rapid data collection and some very different approaches in data collection techniques the possibilities associated with these advances will be included This edition should be of interest to those who use X ray scattering to understand more about their samples so that they can make a better judgment of the parameter and confidence levels in their analyses and how the combination of instrument sample and detection should be considered as a whole to ensure this

*Liquid Surfaces and Interfaces* Peter S. Pershan, Mark Schlossman, 2012-08-02 The availability of synchrotron x ray sources and the subsequent developments described in this book have led to substantial progress in our understanding of molecular ordering at liquid interfaces This practical guide enables graduate students and researchers working in physics chemistry biology and materials science to understand and carry out experimental

investigations into the basic physical and chemical properties of liquid surfaces and interfaces The book examines the surfaces of bulk liquids thin wetting films and buried liquid liquid interfaces It discusses experiments on simple and complex fluids including pure water and organic liquids liquid crystals liquid metals electrified liquid liquid interfaces and interfacial monolayers of amphiphiles nanoparticles polymers and biomolecules A detailed description of the apparatus and techniques required for these experiments is provided and theoretical approaches to data analysis are described including approximate methods such as the Master formula the Born approximation Parratt s algorithm and the Distorted Wave Approximation

**Modern Diffraction Methods** E. J. Mittemeijer, U. Welzel, 2013-02-04 The role of diffraction methods for the solid state sciences has been pivotal to determining the micro structure of a material Particularly the expanding activities in materials science have led to the development of new methods for analysis by diffraction This book offers an authoritative overview of the new developments in the field of analysis of matter by in particular X ray electron and neutron diffraction It is composed of chapters written by leading experts on modern diffraction methods The focus in the various chapters of this book is on the current forefront of research on and applications for diffraction methods This unique book provides descriptions of the state of the art and at the same time identifies avenues for future research The book assumes only a basic knowledge of solid state physics and allows the application of the described methods by the readers of the book either graduate students or mature scientists

**Nanocharacterization Techniques** Osvaldo de Oliveira Jr, Ferreira LG Marystela, Fábio de Lima Leite, Alessandra Luzia Da Róz, 2017-03-18 Nanocharacterization Techniques covers the main characterization techniques used in nanomaterials and nanostructures The chapters focus on the fundamental aspects of characterization techniques and their distinctive approaches Significant advances that have taken place over recent years in refining techniques are covered and the mathematical foundations needed to use the techniques are also explained in detail This book is an important reference for materials scientists and engineers looking for a through analysis of nanocharacterization techniques in order to establish which is best for their needs Includes a detailed analysis of different nanocharacterization techniques allowing readers to explore which one is best for their particular needs Provides examples of how each characterization technique has been used giving readers a greater understanding of how each technique can be profitably used Covers the mathematical background needed to utilize each of these techniques to their best effect meaning that readers can gain a full understanding of the theoretical principles behind each technique covered Serves as an important go to reference for materials scientists and engineers

**Spin Spirals and Charge Textures in Transition-Metal-Oxide Heterostructures** Alex Frano, 2014-05-28 This thesis presents the results of resonant and non resonant x ray scattering experiments demonstrating the control of collective ordering phenomena in epitaxial nickel oxide and copper oxide based superlattices Three outstanding results are reported 1 LaNiO<sub>3</sub> LaAlO<sub>3</sub> superlattices with fewer than three consecutive NiO<sub>2</sub> layers exhibit a novel spiral spin density wave whereas superlattices with thicker nickel oxide layer stacks remain paramagnetic The

magnetic transition is thus determined by the dimensionality of the electron system The polarization plane of the spin density wave can be tuned by epitaxial strain and spatial confinement of the conduction electrons 2 Further experiments on the same system revealed an unusual structural phase transition controlled by the overall thickness of the superlattices The transition between uniform and twin domain states is confined to the nickelate layers and leaves the aluminate layers unaffected 3 Superlattices based on the high temperature superconductor YBa<sub>2</sub>Cu<sub>3</sub>O<sub>7</sub> exhibit an incommensurate charge density wave order that is stabilized by heterointerfaces These results suggest that interfaces can serve as a powerful tool to manipulate the interplay between spin order charge order and superconductivity in cuprates and other transition metal oxides

Thin Film Analysis by X-Ray Scattering Mario Birkholz, 2006-05-12 With contributions by Paul F Fewster and Christoph Genzel While X ray diffraction investigation of powders and polycrystalline matter was at the forefront of materials science in the 1960s and 70s high tech applications at the beginning of the 21st century are driven by the materials science of thin films Very much an interdisciplinary field chemists biochemists materials scientists physicists and engineers all have a common interest in thin films and their manifold uses and applications Grain size porosity density preferred orientation and other properties are important to know whether thin films fulfill their intended function depends crucially on their structure and morphology once a chemical composition has been chosen Although their backgrounds differ greatly all the involved specialists a profound understanding of how structural properties may be determined in order to perform their respective tasks in search of new and modern materials coatings and functions The author undertakes this in depth introduction to the field of thin film X ray characterization in a clear and precise manner

**X-ray Resonant Reflectometry** Marina Andreeva, 2025-07-10 Fast development of the synchrotron facilities opens a new era in X ray optics where the diffraction spectroscopic and time resolved methods are combined in one experiment Near X ray absorption edges the strong magnetic and anisotropic effects to reveal itself As a result the X ray reflectivity method has acquired new possibilities in previous times it gave the information only about the electronic density profiles in thin films but nowadays it detects the magnetic and electronic depth profiles The theoretical foundations of the method need to be developed accordingly The textbook presents the first systematic exposition of the new X ray optics including the effects of anisotropy in X rays scattering near the absorption edges or nuclear resonance Mossbauer scattering The book may be useful for students and postgraduates of physical specialties as well as for researchers of magnetic multilayers conducting experiments with synchrotron radiation

*Theoretical Concepts of X-Ray Nanoscale Analysis* Andrei Benediktovich, Ilya Feranchuk, Alexander Ulyanenko, 2013-09-07 This book provides a concise survey of modern theoretical concepts of X ray materials analysis The principle features of the book are basics of X ray scattering interaction between X rays and matter and new theoretical concepts of X ray scattering The various X ray techniques are considered in detail high resolution X ray diffraction X ray reflectivity grazing incidence small angle X ray scattering and X ray residual stress analysis All the theoretical methods

presented use the unified physical approach This makes the book especially useful for readers learning and performing data analysis with different techniques The theory is applicable to studies of bulk materials of all kinds including single crystals and polycrystals as well as to surface studies under grazing incidence The book appeals to researchers and graduate students alike

Handbook of Instrumentation and Techniques for Semiconductor Nanostructure Characterization Richard Haight, Frances M. Ross, James B. Hannon, 2012 As we delve more deeply into the physics and chemistry of functional materials and processes we are inexorably driven to the nanoscale And nowhere is the development of instrumentation and associated techniques more important to scientific progress than in the area of nanoscience The dramatic expansion of efforts to peer into nanoscale materials and processes has made it critical to capture and summarize the cutting edge instrumentation and techniques that have become indispensable for scientific investigation in this arena This Handbook is a key resource developed for scientists engineers and advanced graduate students in which eminent scientists present the forefront of instrumentation and techniques for the study of structural optical and electronic properties of semiconductor nanostructures

Handbook Of Instrumentation And Techniques For Semiconductor Nanostructure Characterization (In 2 Volumes) Richard A Haight, Frances M Ross, James B Hannon, 2011-11-28 These volumes provide the very latest in this critical technology and are an invaluable resource for scientists in both academia and industry concerned with the semiconductor future and all of science Foreword by Leonard C Feldman Director Institute for Advanced Materials Devices and Nanotechnology Rutgers University USA Highlights As we delve more deeply into the physics and chemistry of functional materials and processes we are inexorably driven to the nanoscale And nowhere is the development of instrumentation and associated techniques more important to scientific progress than in the area of nanoscience The dramatic expansion of efforts to peer into nanoscale materials and processes has made it critical to capture and summarize the cutting edge instrumentation and techniques that have become indispensable for scientific investigation in this arena This Handbook is a key resource developed for scientists engineers and advanced graduate students in which eminent scientists present the forefront of instrumentation and techniques for the study of structural optical and electronic properties of semiconductor nanostructures

Polymers and Electromagnetic Radiation Wolfram Schnabel, 2014-01-10 This first book to cover the interaction of polymers with radiation from the entire electromagnetic spectrum adopts a multidisciplinary approach to bridge polymer chemistry and physics photochemistry photophysics and materials science The text is equally unique in its scope devoting equal amounts of attention to the three aspects of synthesis characterization and applications The first part deals with the interaction of polymers with non ionizing radiation in the frequency range from sub terahertz via infrared radiation to visible and ultraviolet light while the second covers interaction with ionizing radiation from the extreme ultraviolet to ray photons The result is a systematic overview of how both types of radiation can be used for different polymerization approaches spectroscopy methods and lithography techniques Authored by a world renowned researcher and



teacher with over 40 years of experience in the field this is a highly practical and authoritative guide  
Semiconductor Heterostructures and Nanostructures H. Renevier, M.G. Proietti, 2013-04-11

Characterization of

This book delves into High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures. High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures is a vital topic that must be grasped by everyone, ranging from students and scholars to the general public. This book will furnish comprehensive and in-depth insights into High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures, encompassing both the fundamentals and more intricate discussions.

1. The book is structured into several chapters, namely:
  - Chapter 1: Introduction to High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures
  - Chapter 2: Essential Elements of High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures
  - Chapter 3: High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures in Everyday Life
  - Chapter 4: High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures in Specific Contexts
  - Chapter 5: Conclusion
2. In chapter 1, this book will provide an overview of High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures. The first chapter will explore what High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures is, why High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures is vital, and how to effectively learn about High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures.
3. In chapter 2, the author will delve into the foundational concepts of High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures. This chapter will elucidate the essential principles that must be understood to grasp High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures in its entirety.
4. In chapter 3, the author will examine the practical applications of High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures in daily life. The third chapter will showcase real-world examples of how High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures can be effectively utilized in everyday scenarios.
5. In chapter 4, this book will scrutinize the relevance of High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures in specific contexts. The fourth chapter will explore how High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures is applied in specialized fields, such as education, business, and technology.
6. In chapter 5, this book will draw a conclusion about High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures. The final chapter will summarize the key points that have been discussed throughout the book. This book is crafted in an easy-to-understand language and is complemented by engaging illustrations. It is highly recommended for anyone seeking to gain a comprehensive understanding of High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures.

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## **High Resolution X Ray Scattering From Thin Films And Lateral Nanostructures Introduction**

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