Aberration Corrected Imaging In Transmission Electron Microscopy

Aberration-Corrected Imaging in Transmission Electron MicroscopyAn Introduction Second EditionWorld Scientific Publishing Company

This special volume of Advances in Imaging and Electron Physics details the current theory, experiments, and applications of neutron and x-ray optics and microscopy for an internationa readership across varying backgrounds and disciplines. Edited by Dr. Ted Cremer, these volumes attempt to provide rapid assimilation of the presented topics that include neutron and x- scatter, refraction, diffraction, and reflection and their potential application. Contributions from leading authorities Informs and updates on all the latest developments in the field

2.6.2 Electrodes for Electrochemistry

Advances in Imaging and Electron Physics merges two long-running serials, Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. The series extended articles on the physics of electron devices, especially semiconductor devices, particle optics at high and low energies, microlithography, image science, digital image processing electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. Contains contributions from leading authorities on the subject matter Info updates on all the latest developments in the field of imaging and electron physics Provides practitioners interested in microscopy, optics, image processing, mathematical morphology, electromagnetic fields, electron, and ion emission with a valuable resource Features extended articles on the physics of electron devices, especially semiconductor devices, particle optic and low energies, microlithography, image science, and digital image processing

Springer Handbook of Microscopy

Part A

Physical Principles of Electron Microscopy

Fourier Ptychographic Imaging

Experimental Demonstration at Atomic Resolution

Advanced Computing in Electron Microscopy

The Advanced Study Institute provided an opportunity for researchers in universities, industry and National and International Laboratories, from the disciplines ofmaterials science, physics, chemistry and engineering to meet together in an assessment of the impact of electron and scanning probe microscopy on advanced material research. Since these researchers have traditionally relied upon different approaches, due to their different scientific background, to advanced materials problem solving, presentations and discussion within the Institute sessions were initially devoted to developing a set ofmutually understood basic concepts, inherently related to different techniques ofcharacterization by microscopy and spectroscopy. Particular importance was placed on Electron Energy Loss Spectroscopy (EELS), Scanning Probe Microscopy (SPM), High Resolution Transmission and Scanning Electron Microscopy (HRTEM, HRSTEM) and Environmental Scanning Electron Microscopy (ESEM). It was recognized that the electronic structure derived directly from EELS analysis as well as from atomic positions in HRTEM or High Angle Annular Dark Field STEM can be used to understand the macroscopic behaviour of materials. The emphasis, however, was upon the analysis of the electronic band structure of grain boundaries, fundamental for the understanding of macroscopic quantities such as strength, cohesion, plasticity, etc.

Modern electronic devices rely on ever-greater miniaturization of components, and semiconductor processing is approaching the domain of nanotechnology. Studies of devices in this regime can only be carried out with the most advanced forms of microscopy. Accordingly, Microscopy of Semiconducting Materials focuses on international developments in semiconductor studies carried out by all forms of microscopy. It provides an overview of the latest instrumentation, analysis techniques, and state-of-the-art advances in semiconducting materials science for solid state physicists, chemists, and material scientists.

This volume expands and updates the coverage in the authors' popular 1992 book, Electron Microdiffraction. As the title implies, the focus of the book has changed from electron microdiffraction and convergent beam electron diffraction to all forms of advanced transmission electron microscopy. Special attention is given to electron diffraction and imaging, including high-resolution TEM and STEM imaging, and the application of these methods to crystals, their defects, and nanostructures. The authoritative text summarizes and develops most of the useful knowledge which has been gained over the years from the study of the multiple electron scattering problem, the recent development of aberration correctors and their applications to materials structure characterization, as well as the authors' extensive teaching experience in these areas. Advanced Transmission Electron Microscopy: Imaging and Diffraction in Nanoscience is ideal for use as an advanced undergraduate or graduate level text in support of course materials in Materials Science, Physics or Chemistry departments.

In this book, the bases of imaging and diffraction in transmission electron microscopy (TEM) and scanning transmission electron microscopy (STEM) are explained in the style of a textbook. The book focuses on the explanation of electron microscopic imaging of TEM and STEM without including in the main text distracting information on basic knowledge of crystal diffraction, wave optics, electron lens, and scattering and diffraction theories, which are explained separately in the appendices. A comprehensive explanation is provided on the basis of Fourier transform theory, and this approach is unique in comparison with other advanced resources on high-resolution electron microscopy. With the present textbook, readers are led to understand the essence of the imaging theories of TEM and STEM without being diverted by other knowledge of electron microscopy. The up-to-date information in this book, particularly on imaging details of STEM and aberration corrections, is valuable worldwide for today's graduate students and professionals just starting their careers.

An Introduction Second Edition

Biological Low-Voltage Scanning Electron Microscopy

Selected Problems of Computational Charged Particle Optics

High-Resolution Electron Microscopy

An Introduction

Microscopy of Semiconducting Materials 2003

The book is concerned with the theory, background, and practical use of transmission electron microscopes with lens correctors that can correct the effects of spherical aberration. The book also covers a comparison with aberration correction in the TEM and applications of analytical aberration

corrected STEM in materials science and biology. This book is essential for microscopists involved in nanoscale and materials microanalysis especially those using scanning transmission electron microscopy, and related analytical techniques such as electron diffraction x-ray spectrometry (EDXS) and electron energy loss spectroscopy (EELS).

With the growing proliferation of nanotechnologies, powerful imaging technologies are being developed to operate at the sub-nanometer scale. The newest edition of a bestseller, the Handbook of Charged Particle Optics, Second Edition provides essential background information for the design and operation of high resolution focused probe instruments. The book's unique approach covers both the theoretical and practical knowledge of high resolution probe forming instruments. The second edition features new chapters on aberration correction and applications of gas phase field ionization sources. With the inclusion of additional references to past and present work in the field, this second edition offers perfectly calibrated coverage of the field's cutting-edge technologies with added insight into how they work. Written by the leading research scientists, the second edition of the Handbook of Charged Particle Optics is a complete guide to understanding, designing, and using high resolution probe instrumentation.

Advances in Imaging and Electron Physics merges two long-running serials Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. This series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing, electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. This monograph summarizes the authors' knowledge and experience acquired over many years in their work on computational charged particle optics. Its main message is that even in this era of powerful computers with a multitude of general-purpose and problem-oriented programs, asymptotic analysis based on perturbation theory remains one of the most effective tools to penetrate deeply into the essence of the problem in question.

Aberration correction in scanning/transmission electron microscopy (S/TEM) owes much to the efforts of a small dedicated group of innovators. Leading that frontier has been Prof. Harald Rose. To date his leadership and dynamic personality has spearheaded our ability to leave behind many of the limitations imposed by spherical aberration (Cs) in high resolution phase contrast imaging. Following shortly behind, has been the development of chromatic aberration correction (Cc) which augments those accomplishments. In this study we will review and summarize how the combination of Cs/Cc technology enhances our ability to conduct hyperspectral imaging and spectroscopy in today's and future computationally mediated experiments in both thin as well as realistic specimens in vacuo and during in-situ/environmental experiments.

Aberration-Corrected Imaging in Transmission Electron Microscopy

Aberration Correction for Analytical in Situ TEM - the NTEAM Concept

Aberration-corrected Imaging in Transmission Electron Microscopy

Fundamentals of Light Microscopy and Electronic Imaging

Scanning Transmission Electron Microscopy

Electron Nano-Imaging

This fully corrected second impression of the classic 2006 text on microscopy runs to more than 1,000 pages and covers up-to-the-minute developments in the field. The two-volume work brings together a slew of experts who present comprehensive reviews of all the latest instruments and new versions of the older ones, as well as their associated operational techniques. The chapters draw attention to their principal areas of application. A huge range of subjects are benefiting from these new tools, including semiconductor physics, medicine, molecular biology, the nanoworld in general, magnetism, and ferroelectricity. This fascinating book will be an indispensable guide for a wide range of scientists in university laboratories as well as engineers and scientists in industrial R&D departments.

This book, written by a pioneer in surface physics and thin film research and the inventor of Low Energy Electron Microscopy (LEEM), Spin-Polarized Low Energy Electron Microscopy (SPLEEM) and Spectroscopic Photo Emission and Low Energy Electron Microscopy (SPELEEM), covers these and other techniques for the imaging of surfaces with low energy (slow) electrons. These techniques also include Photoemission Electron Microscopy (PEEM), X-ray Photoemission Electron Microscopy (XPEEM), and their combination with microdiffraction and microspectroscopy, all of which use cathode lenses and slow electrons. Of particular interest are the fundamentals and applications of LEEM, PEEM, and XPEEM because of their widespread use. Numerous illustrations illuminate the fundamental aspects of the electron optics, the experimental setup, and particularly the application results with these instruments. Surface Microscopy with Low Energy Electrons will give the reader a unified picture of the imaging, diffraction, and spectroscopy methods that are possible using low energy electron microscopes.

This book presents advances in nanoscale imaging capabilities of scanning transmission electron microscopes, along with superresolution techniques, special denoising methods, application of mathematical/statistical learning theory, and compressed sensing.

Logarithmic Image Processing: Theory and Applications, the latest volume in the series that merges two long-running serials, Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy and features cutting-edge articles on recent developments in all areas of microscopy, digital image processing, and many related subjects in electron physics. Merges two long-running serials, Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy into a single volume Contains the latest information on logarithmic image processing and its theory and applications Features cutting-edge articles on recent developments in all areas of microscopy, digital image processing, and many related subjects in electron physics

Aberration-corrected Electron Microscopy

An Introduction to TEM, SEM, and AEM

Aberration-Corrected Analytical Transmission Electron Microscopy

Physics of Image Formation
Low Voltage Electron Microscopy
Imaging and Analysis

In this paper, we demonstrate a method to achieve high efficiency phase contrast imaging in aberration corrected scanning transmission electron microscopy (STEM) with a pixelated detector. The pixelated detector is used to record the Ronchigram as a function of probe position which is then analyzed with ptychography. Ptychography has previously been used to provide super-resolution beyond the diffraction limit of the optics, alongside numerically correcting for spherical aberration. Here we rely on a hardware aberration corrector to eliminate aberrations, but use the pixelated detector data set to utilize the largest possible volume of Fourier space to create high efficiency phase contrast images. The use of ptychography to diagnose the effects of chromatic aberration is also demonstrated. In conclusion, the four dimensional dataset is used to compare different bright field detector configurations from the same scan for a sample of bilayer graphene. Our method of high efficiency ptychography produces the clearest images, while annular bright field produces almost no contrast for an in-focus aberration-corrected probe.

The three volumes in the PRINCIPLES OF ELECTRON OPTICS Series constitute the first comprehensive treatment of electron optics in over forty years. While Volumes 1 and 2 are devoted to geometrical optics, Volume 3 is concerned with wave optics and effects due to wave length. Subjects covered include: Derivation of the laws of electron propagation from SchrUdinger's equation Image formation and the notion of resolution The interaction between specimens and electrons Image processing Electron holography and interference Coherence, brightness, and the spectral function Together, these works comprise a unique and informative treatment of the subject. Volume 3, like its predecessors, will provide readers with both a textbook and an invaluable reference source.

This text is a companion volume to Transmission Electron Microscopy: A Textbook for Materials Science by Williams and Carter. The aim is to extend the discussion of certain topics that are either rapidly changing at this time or that would benefit from more detailed discussion than space allowed in the primary text. World-renowned researchers have contributed chapters in their area of expertise, and the editors have carefully prepared these chapters to provide a uniform tone and treatment for this exciting material. The book features an unparalleled collection of color figures showcasing the quality and variety of chemical data that can be obtained from today's instruments, as well as key pitfalls to avoid. As with the previous TEM text, each chapter contains two sets of questions, one for self assessment and a second more suitable for homework assignments. Throughout the book, the style follows that of Williams & Carter even when the subject matter becomes challenging—the aim is always to make the topic understandable by first-year graduate students and others who are working in the field of Materials Science Topics covered include sources, in-situ experiments, electron diffraction, Digital Micrograph, waves and holography, focal-series reconstruction and direct methods, STEM and tomography, energy-filtered TEM (EFTEM) imaging, and spectrum imaging. The range and depth of material makes this companion volume essential reading for the budding microscopist and a key reference for practicing researchers using these and related techniques.

Fundamentals of Light Microscopy and Electronic Imaging, Second Edition provides a coherent introduction to the principles and applications of the integrated optical microscope system, covering both theoretical and practical considerations. It expands and updates discussions of multi-spectral imaging, intensified digital cameras, signal colocalization, and uses of objectives, and offers guidance in the selection of microscopes and electronic cameras, as well as appropriate auxiliary optical systems and fluorescent tags. The book is divided into three sections covering optical principles in diffraction and image formation, basic modes of light microscopy, and components of modern electronic imaging systems and image processing operations. Each chapter introduces relevant theory, followed by descriptions of instrument alignment and image interpretation. This revision includes new chapters on live cell imaging, measurement of protein dynamics, deconvolution microscopy, and interference microscopy. PowerPoint slides of the figures as well as other supplementary materials for instructors are available at a companion website: www.wiley.com/go/murphy/lightmicroscopy

Logarithmic Image Processing: Theory and Applications

Principles of Electron Optics
Transmission Electron Microscopy
The Influence of Cs/Cc Correction in Analytical Imaging and Spectroscopy in Scanning and Transmission Electron Microscopy
Advanced Transmission Electron Microscopy

The basics, present status and future prospects of high-resolution scanning transmission electron microscopy (STEM) are described in the form of a textbook for advanced undergraduates and graduate students. This volume covers recent achievements in the field of STEM obtained with advanced technologies such as spherical aberration correction, monochromator, high-sensitivity electron energy loss spectroscopy and the software of image mapping. The future prospects chapter also deals with z-slice imaging and confocal STEM for 3D analysis of nanostructured materials. Contents:Introduction (N Tanaka)Historical Survey of the Development of STEM Instruments (N Tanaka)Basic Knowledge of STEM:Basics of STEM (N Tanaka and K Saitoh)Application of STEM to Nanomaterials and Biological Specimens (N Shibata, S D Findlay, Y Ikuhara and N Tanaka)Theories of STEM Imaging:Theory for HAADF-STEM and Its Image Simulation (K

Watanabe)Theory for Annular Bright Field STEM Imaging (S D Findlay, N Shibata and Y Ikuhara)Electron Energy-Loss Spectroscopy in STEM and Its Imaging (K Kimoto)Density Functional Theory for ELNES in STEM-EELS (T Mizoguchi)Advanced Methods in STEM:Aberration Correction in STEM (H Sawada)Secondary Electron Microscopy in STEM (H Inada and Y Zhu)Scanning Confocal Electron Microscopy (K Mitsuishi and M Takeguchi)Electron Tomography in STEM (N Tanaka)Electron Holography and Lorentz Electron Microscopy in STEM (N Tanaka)Recent Topics and Future Prospects in STEM (N Tanaka) Readership: Graduate students and researchers in the field of nanomaterials and nanostructures. Key Features:Most advanced; befitting beginning graduate studentsVery convenient for advanced researchers who would like to use STEM and have a comprehensive understanding of the theory of image contrast and application detailsSpans from the basic theory to the applications of STEMKeywords:STEM;Nanomaterials;HAADF-STEM;Atomic Resolution;Elemental Mapping;Dark Field Images;Nanoanalysis;Nanofabrication;NanodiffractionReviews: "This is written in a very readable style, packed with information and helpful explanations, and above all, very up to date. The book is generously illustrated, with many nice line-drawings, historic photographs, micrographs and spectra and, as a bonus, it has a name index as well as a subject index." Ultramicroscopy

Part of the Wiley-Royal Microscopical Society Series, this book discusses the rapidly developing cutting-edge field of low-voltage microscopy, a field that has only recently emerged due to the rapid developments in the electron optics design and image processing. It serves as a guide for current and new microscopists and materials scientists who are active in the field of nanotechnology, and presents applications in nanotechnology and research of surface-related phenomena, allowing researches to observe materials as never before.

This book provides a concise introduction to practical aspects of atomic-resolution imaging in aberration-corrected electron microscopy. As such, it addresses recent advances in electron optical instrumentation used for ultra-high resolution imaging in materials and nano-science. It covers two of the most popular atomic resolution imaging techniques' namely high-resolution transmission electron microscopy and scanning transmission electron microscopy. The book bridges the gap between application-oriented textbooks in conventional electron microscopy and books in physics covering dedicated topics in charged-particle optics and aberration correction. The book is structured in three parts which can be read separately. While in the first part the fundamentals of the imaging techniques and their limits in conventional electron microscopes are explained, the second part provides readers with the basic principles of electron optics and the characteristics of electron lenses. The third part, focusing on aberrations, describes the functionality of aberration correctors and provides readers with practical guidelines for the daily work with aberration-corrected electron microscopes. The book represents a detailed and easy readable guide to aberration-corrected electron microscopy.

Modeling Nanoscale Imaging in Electron Microscopy presents the recent advances that have been made using mathematical methods to resolve problems in microscopy. With improvements in hardware-based aberration software significantly expanding the nanoscale imaging capabilities of scanning transmission electron microscopes (STEM), these mathematical models can replace some labor intensive procedures used to operate and maintain STEMs. This book, the first in its field since 1998, will also cover such relevant concepts as superresolution techniques, special denoising methods, application of mathematical/statistical learning theory, and compressed sensing.

Advances in Imaging and Electron Physics
Three-Dimensional Aberration-Corrected Scanning Transmission Electron Microscopy for Biology
Diffraction, Imaging, and Spectrometry
Image Formation Mechanisms in Three-dimensional Aberration-corrected Scanning Transmission Electron Microscopy
Impact of Electron and Scanning Probe Microscopy on Materials Research
Scanning Transmission Electron Microscopy of Nanomaterials

Future aberration corrected transmission electron microscopes (TEM) will have a strong impact in materials science, since such microscopes yield information on chemical bonding and structure of interfaces, grain boundaries and lattice defects at an atomic level. Beyond this aberration correction offers new possibilities for in situ experiments performed under controlled temperature, magnetic field, strain etc. at atomic resolution. Such investigations are necessary for solving problems arising from electronic component miniaturization, for example. Significant progress can be expected by means of analytical aberration corrected TEM. These next generation microscopes will be equipped with an aberration corrected imaging system, a monochromator and aberration corrected energy filters. These novel elements have already been designed and partially realized [1,2,3].

Recent instrumental developments have enabled greatly improved resolution of scanning transmission electron microscopes (STEM) through aberration correction. An additional and previously unanticipated advantage of aberration correction is the greatly improved depth sensitivity that has led to the reconstruction of a three-dimensional (3D) image from a focal series. In this chapter the potential of aberration-corrected 3D STEM to provide major improvements in the imaging capabilities for biological samples will be discussed. This chapter contains a brief overview ofthe various high-resolution 3D imaging techniques, a historical perspective of the development of STEM, first estimates of the dose-limited axial and lateral resolution on biological samples and initial experiments on stained thin sections.

Advances in Imaging and Electron Physics merges two long-running serials--Advances in Electronics and Electron Physics and Advances in Optical and Electron Microscopy. This series features extended articles on the physics of electron devices (especially semiconductor devices), particle optics at high and low energies, microlithography, image science and digital image processing, electromagnetic wave propagation, electron microscopy, and the computing methods used in all these domains. Contributions from leading authorities Informs and updates on all the latest developments in the field

Scanning transmission electron microscopy has become a mainstream technique for imaging and analysis at atomic resolution and sensitivity, and the authors of this book are widely credited with bringing the field to its present popularity. Scanning Transmission Electron Microscopy(STEM): Imaging and Analysis will provide a comprehensive explanation of the theory and practice of STEM from introductory to advanced levels, covering the instrument, image formation and scattering theory, and definition and measurement of resolution for both imaging and analysis. The authors will present examples of the use of combined imaging and spectroscopy for solving materials problems in a variety of fields, including condensed matter physics, materials science, catalysis, biology, and nanoscience. Therefore this will be a comprehensive reference for those working in applied fields wishing to use the technique, for graduate students learning microscopy for the first time, and for specialists in other fields of microscopy.

Modeling Nanoscale Imaging in Electron Microscopy

Handbook of Charged Particle Optics

Science of Microscopy

Physics of Image Formation and Microanalysis

Imaging and Diffraction in Nanoscience

Efficient Phase Contrast Imaging in STEM Using a Pixelated Detector. Part 1

Major improvements in instrumentation and specimen preparation have brought SEM to the fore as a biological imaging technique. Although this imaging technique has undergone tremendous developments, it is still poorly represented in the literature, limited to journal articles and chapters in books. This comprehensive volume is dedicated to the theory and practical applications of FESEM in biological samples. It provides a comprehensive explanation of instrumentation, applications, and protocols, and is intended to teach the reader how to operate such microscopes to obtain the best quality images.

This book demonstrates the concept of Fourier ptychography, a new imaging technique that bypasses the resolution limit of the employed optics. In particular, it transforms the general challenge of high-throughput, high-resolution imaging from one that is coupled to the physical limitations of the optics to one that is solvable through computation. Demonstrated in a tutorial form and providing many MATLAB® simulation examples for the reader, it also discusses the experimental implementation and recent developments of Fourier ptychography. This book will be of interest to researchers and engineers learning simulation techniques for Fourier optics and the Fourier ptychography concept.

The invention of the electron microscope more than 70 years ago made it possible to visualize a new world, far smaller than anything that could be seen with the traditional microscope. The biologist could study viruses and the components of cells, the materials scientist could study the structure of metals and alloys and many other substances, and especially their defects. But even the electron microscope had limits, and truly atomic structure was still too small to be observed directly. The so-called "limit of resolution" of the microscope was well understood, but attempts to use the necessary correctors were unsuccessful until the late 1990s. Such correctors now equip many microscopes in Europe, the USA and Japan and the results are extremely impressive. Moreover, microscopists feel that they are only at the beginning of a new era of subatomic microscopic imaging. In the present volume, we have brought together the principal contributors, instrument designers and microscopists to discuss this topic in depth. * First book on the subject of correctors * Well known contributors from academia and microscope manufacturers * Provides an ideal starting point for preparing funding proposals

Scanning Transmission Electron Microscopy: Advanced Characterization Methods for Materials Science Applications The information comprised in this book is focused on discussing the latest approaches in the recording of high-fidelity quantitative annular dark-field (ADF) data. It showcases the application of machine learning in electron microscopy and the latest advancements in image processing and data interpretation for materials notoriously difficult to analyze using scanning transmission electron microscopy (STEM). It also highlights strategies to record and interpret large electron diffraction datasets for the analysis of nanostructures. This book: Discusses existing approaches for experimental design in the recording of high-fidelity quantitative ADF data Presents the most common types of scintillator-photomultiplier ADF detectors, along with their strengths and weaknesses. Proposes strategies to minimize the introduction of errors from these detectors and avenues for dealing with residual errors Discusses the practice of reliable multiframe imaging, along with the benefits and new experimental opportunities it presents in electron dose or dose-rate management Focuses on supervised and unsupervised machine learning for electron microscopy Discusses open data formats, community-driven software, and data repositories Proposes methods to process information at both global and local scales, and discusses avenues to improve the storage, transfer, analysis, and interpretation of multidimensional datasets Provides the spectrum of possibilities to study materials at the resolution limit by means of new developments in instrumentation Recommends methods for quantitative structural characterization of sensitive nanomaterials using electron diffraction techniques and describes strategies to collect electron diffraction patterns for such materials This book helps academics, researchers, and industry professionals in materials science, chemistry, physics, and related fields to understand and apply computer-science–derived analysis methods to solve problems regarding data analysis and interpretation of materials properties.

Principles and Applications

Advanced Characterization Methods for Materials Science Applications

Basics of Imaging and Diffraction for TEM and STEM

A Matlab Tutorial

Direct Imaging of Light Elements in Aberration-Corrected Scanning Transmission Electron Microscopy

Wave Optics

Scanning and stationary-beam electron microscopes are indispensable tools for both research and routine evaluation in materials science, the semiconductor industry, nanotechnology and the biological, forensic, and medical sciences. This book introduces current theory and practice of electron microscopy, primarily for undergraduates who need to understand how the principles of physics apply in an area of technology that has contributed greatly to our understanding of life processes and "inner space." Physical Principles of Electron Microscopy will appeal to technologists who use electron microscopes and to graduate students, university teachers and researchers who need a concise reference on the basic principles of microscopy.

The aim of this monograph is to outline the physics of image formation, electron–specimen interactions, and image interpretation in transmission el- tron microscopy. Since the last edition, transmission electron microscopy has undergone a rapid evolution. The introduction of monochromators and - proved energy ?lters has allowed electron energy-loss spectra with an energy resolution down to about 0.1 eV to be obtained, and aberration correctors are now available that push the point-to-point resolution limit down below 0.1 nm. After the untimely death of Ludwig Reimer, Dr. Koelsch from Springer- Verlag asked me if I would be willing to prepare a new edition of the book. As it had served me as a reference for more than 20 years, I agreed without hesitation. Distinct from more specialized books on speci?c topics and from books intended for classroom teaching, the Reimer book starts with the basic principles and gives a broad survey of the state-of-the-art methods, comp- mented by a list of references to allow the reader to ?nd further details in the literature. The main objective of this revised edition was therefore to include the new developments but leave the character of the book intact. The presentation of the material follows the format of the previous e- tion as outlined in the preface to that volume, which immediately follows. A few derivations have been modi?ed to correspond more closely to modern textbooks on quantum mechanics, scattering theory, or solid state physics.

The aim of this book is to outline the physics of image formation, electron specimen interactions and image interpretation in transmission electron mic roscopy. The book evolved from lectures delivered at the University of Munster and is a revised version of the first part of my earlier book Elek tronenmikroskopische Untersuchungs- und Priiparationsmethoden, omitting the part which describes specimen-preparation methods. In the introductory chapter, the different types of electron microscope are compared, the various electron-specimen interactions and their applications are summarized and the most important aspects of high-resolution, analytical and high-voltage electron microscopy are discussed. The optics of electron lenses is discussed in Chapter 2 in order to bring out electron-lens properties that are important for an understanding of the function of an electron microscope. In Chapter 3, the wave optics of elec trons and the phase shifts by electrostatic and magnetic fields are introduced; Fresnel electron diffraction is treated using Huygens' principle. The recogni tion that the Fraunhofer-diffraction pattern is the Fourier transform of the wave amplitude behind a specimen is important because the influence of the imaging process on the contrast transfer of spatial frequencies can be described by introducing phase shifts and envelopes in the Fourier plane. In Chapter 4, the elements of an electron-optical column are described: the electron gun, the condenser and the imaging system. A thorough understanding of electron-specimen interactions is essential to explain image contrast.

This book features reviews by leading experts on the methods and applications of modern forms of microscopy. The recent awards of Nobel Prizes awarded for super-resolution optical microscopy and cryo-electron microscopy have demonstrated the rich scientific opportunities for research in novel microscopies. Earlier Nobel Prizes for electron microscopy (the instrument itself and applications to biology), scanning probe microscopy and holography are a reminder of the central role of microscopy in modern science, from the study of nanostructures in materials science, physics and chemistry to structural biology. Separate chapters are devoted to confocal, fluorescent and related novel optical microscopies, coherent diffractive imaging, scanning probe microscopy, transmission electron microscopy in all its modes from aberration corrected and analytical to in-situ and time-resolved, low energy electron microscopy, photoelectron microscopy, cryo-electron microscopy in biology, and also ion microscopy. In addition to serving as an essential reference for researchers and teachers in the fields such as materials science, condensed matter physics, solid-state chemistry, structural biology and the molecular sciences generally, the Springer Handbook of Microscopy is a unified, coherent and pedagogically attractive text for advanced students who need an authoritative yet accessible guide to the science and practice of microscopy.

Basics of Imaging and Analysis

Surface Microscopy with Low Energy Electrons

Liquid Cell Electron Microscopy

This updated and revised edition of a classic work provides a summary of methods for numerical computation of high resolution conventional and scanning transmission electron microscope images. At the limits of resolution, image artifacts due to the instrument and the specimen interaction can complicate image interpretation. Image calculations can help the user to interpret and understand high resolution information in recorded electron micrographs. The book contains expanded sections on aberration correction, including a detailed discussion of higher order (multipole) aberrations and their effect on high resolution imaging, new imaging modes such as ABF (annular bright field), and the latest developments in parallel processing using GPUs (graphic processing units), as well as updated references. Beginning and experienced users at the advanced undergraduate or graduate level will find the book to be a unique and essential guide to the theory and methods of computation in electron microscopy.

This book describes how to see atoms using electron microscopes. This new edition includes updated sections on applications and new uses of atomic-resolution transmission electron microscopy. Several new chapters and sources of software for image interpretation and electron-optical design have also been added.

Aberration-Corrected Imaging in Transmission Electron Microscopy provides an introduction to aberration-corrected atomic-resolution electron microscopy imaging in materials and physical sciences. It covers both the broad beam transmission mode (TEM; transmission electron microscopy) and the scanning transmission mode (STEM; scanning transmission electron microscopy). The book is structured in three parts. The first part introduces the basics of conventional atomic-resolution electron microscopy imaging in TEM and STEM modes. This part also describes limits of conventional electron microscopes and possible artefacts which are caused by the intrinsic lens aberrations that are unavoidable in such instruments. The second part introduces fundamental electron optical concepts and thus provides a brief introduction to electron optics. Based on the first and second parts of the book, the third part focuses on aberration correction; it describes the various aberrations in electron microscopy and introduces the concepts of spherical aberration correctors and advanced aberration correctors, including correctors for chromatic aberration. This part also provides guidelines on how to optimize the imaging conditions for atomic-resolution STEM and TEM imaging. This second edition has been completely revised and updated in order to incorporate the very recent technological and scientific achievements that have been realized since the first edition appeared in 2010.