Electron Beam Analysis Of Materials 2nd Edition

Derived from the successful three-volume Handbook of Microscopy, this book provides a broad survey of the physical fundamentals and principles of all modern techniques of electron microscopy. This reference work on the method most often used for the characterization of surfaces offers a competent comparison of the feasibilities of the latest developments in this field of research. Topics include: * Stationary Beam Methods: Transmission Electron Microscopy/ Electron Energy Loss Spectroscopy/ Convergent Electron Beam Diffraction/ Low Energy Electron Microscopy/ Electron Holographic Methods * Scanning Beam Methods: Scanning Transmission Electron Microscopy/ Scanning Auger and XPS Microscopy/ Scanning Microanalysis/ Imaging Secondary Ion Mass Spectrometry * Magnetic Microscopy: Scanning Electron Microscopy with Polarization Analysis/ Spin Polarized Low Energy Electron Microscopy Materials scientists as well as any surface scientist will find this book an invaluable source of information for the principles of electron microscopy.

To anyone who is interested in surface chemical analysis of materials on the nanometer scale, this book is prepared to give appropriate information. Based on typical application examples in materials science, a concise approach to all aspects of quantitative analysis of surfaces and thin films with AES and XPS is provided. Starting from basic principles which are step by step developed into practically useful equations, extensive guidance is given to graduate students as well as to experienced researchers. Key chapters are those on quantitative surface analysis and on quantitative depth profiling, including recent developments in topics such as surface excitation parameter and backscattering correction factor. Basic relations are derived for emission and excitation angle dependencies in the analysis of bulk material and of fractional nano-layer structures, and for both smooth and rough surfaces. It is shown how to optimize the analytical strategy, signal-to-noise ratio, certainty and detection limit. Worked examples for quantification of alloys and of layer structures in practical cases (e.g. contamination, evaporation, segregation and oxidation) are used to critically review different approaches to quantification with respect to average matrix correction factors and matrix relative sensitivity factors. State-of-the-art issues in quantitative, destructive and non-destructive depth profiling are discussed with emphasis on sputter depth profiling and on angle resolved XPS and AES. Taking into account preferential sputtering and electron backscattering corrections, an introduction to the mixing-roughness-information depth (MRI) model and its extensions is presented.

Ion Beam Analysis: Fundamentals and Applications explains the basic characteristics of ion beams as applied to the analysis of materials, as well as ion beam analysis (IBA) of art/archaeological objects. It focuses on the fundamentals and applications of ion beam methods of materials characterization. The book explains how ions interact with solids and describes what information can be gained. It starts by covering the fundamentals of ion beam analysis, including kinematics, ion stopping, Rutherford backscattering, channeling, elastic recoil detection, particle induced x-ray emission, and nuclear reaction analysis. The second part turns to applications, looking at the broad range of potential uses in thin film reactions, ion implantation, nuclear energy, biology, and art/archaeology. Examines classical collision theory Details the fundamentals of five specific ion beam analysis techniques Illustrates specific applications, including biomedicine and thin film analysis Provides examples of ion beam analysis in traditional and emerging research fields Supplying readers with the means to understand the benefits and limitations of IBA, the book offers practical information that users can immediately apply to their own work. It covers the broad range of current and emerging applications in materials science, physics, art, archaeology, and biology. It also includes a chapter on computer applications of IBA.

"Electron beam curing technology for advanced composites has emerged as a credible and attractive alternative to thermal curing for most composite products. Technical advantages, such as aerospace structures, include curing at room temperature, using low-cost tooling, and the ability to fabricate large integrated structure including structures too large to fit inside autoclaves. Studies by aerospace companies have shown potential cost savings of 10-60% by using electron beam curing. In this book, both theoretical and practical aspects of electron beam curing of composites are presented, intending to build a bridge between the academic knowledge and the industrial applications."--Publisher.

The examination of materials using electron beam techniques has developed continuously for over twenty years and there are now many different methods of extracting detailed structural and chemical information using electron beams. These techniques which include electron probe microanalysis, trans mission electron microscopy, Auger spectroscopy and scanning electron microscopy have, until recently, developed more or less independently of each other. Thus dedicated instruments designed to optimize the performance for a specific application have been available and correspondingly most of the available textbooks tend to have covered the theory and practice of an individual technique. There appears to be no doubt that dedicated instru ments taken together with the specialized textbooks will continue to be the appropriate approach for some problems. Nevertheless the underlying electron-specimen interactions are common to many techniques and in view of the fact that a range of hybrid instruments is now available it seems appropriate to provide a broad-based text for users of these electron beam facilities. The aim of the present book is therefore to provide, in a reasonably concise form, the material which will allow the practitioner of one or more of the individual techniques to appreciate and to make use of the type of information which can be obtained using other electron beam techniques.

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

Presents a comprehensive survey of analytical techniques currently used in support of all stages of microelectronic materials and device processing. The diversity of topics covered has been achieved by bringing together an international field of authors contributing specialized chapters.

Since their debut in the late 1920s, particle accelerators have evolved into a backbone for the development of science and technology in modern society. Of about 30,000 accelerators at work in the world today, a majority is for applications in industry (about 20,000 systems worldwide). There are two major categories of industrial applications: materials processing and treatment, and materials analysis. Materials processing and treatment includes ion implantation (semi-conductor materials, metals, ceramics, etc.) and electron beam irradiation (sterilization of medical devices, food pasteurization, treatment of carcasses and tires, cross-linking of polymers, cutting and welding, curing of composites, etc.).

Materials analysis covers ion beam analysis (IBA), non-destructive detection using photons and neutrons, as well as accelerator mass spectrometry (AMS). All the products that are processed, treated and inspected using beams from particle accelerators are estimated to have a collective value of US$500 billion per annum worldwide. Accelerators are also applied for environment protection, such as purifying drinking water, treating waste water, disinfecting sewage sludge and removing pollutants from flue gases. Industrial accelerators continue to evolve, in terms of new applications, qualities and capabilities, and reduction of their costs. Breakthroughs are encountered whenever a new product is made, or an existing product becomes more cost effective. Their impact on our society continues to grow with the potential to address key issues in economics or the society of today. This volume contains fourteen articles, all authored by renowned scientists in their respective fields. Contents:Trends for Electron Beam Accelerator Applications in Industry (Sueo Machi)Ion Implantation for Semiconductor Doping and Materials Modification (Lawrence A Larson, Justin M Williams and Michael I Current)Ion Beam Analysis: A Century of Exploiting the Electronic and Nuclear Structure of the Atom for Materials Characterisation (Chris Jeynes, Roger P Webb and Annika Lohstroh)Neutrons and Photons in Non-Destructive Detection (J F Harmon, D P Wells and A W Hunt)Review of Cyclotrons for the Production of Radioactive Isotopes for Medical and Industrial Applications (Paul Schmor)Development of Accelerator Mass Spectrometry and Its Applications (Jiaer Chen, Zhiyu Guo, Kexin Liu and Liping Zhou)Electron Accelerators for Environment Protection (Andrzej G Chmielewski)Studying Radiation Damage in Structural Materials by Using Ion Accelerators (Peter Hosemann)Direct Current Accelerators for Industrial Applications (Ragnar Hellborg and Harry J Whitlow)Radio-Frequency Electron Accelerators for Industrial Applications (Marshall R Cleland)Accelerators for Neutron Generation and Their Applications (Guenter Mank, Guenter Bauer and Françoise Mulhauser)Prospects for Accelerator Technology (Alan Todd)CERN: From Birth to Success (Herwig Schopper)Simon van der Meer (1925–2011): A Modest Genius of Accelerator Science (Vinod C Chohan) Readership: Physicists and engineers in accelerator science and industry. Keywords:Particle Accelerators;Materials Processing and Treatment;Materials Analysis;Industrial Accelerators;LHC;EnvironmentReviews: "The book is a very helpful way to be introduced in the world of accelerators as powerful tools to carry out quite a big number of applications that play a significant role in common life." IL Nuovo Saggiatore

Ion Beam Handbook for Material Analysis emerged from the U.S.-Italy Seminar on Ion Beam Analysis of Near Surface Regions held at the Baia-Verde Hotel, Catania, June 17-20, 1974. The seminar was sponsored by the National Science Foundation and the Consiglio Nazionale delle Ricerche under the United States-Italy Cooperative Science Program. The book provides a useful collection of tables, graphs, and formulas for those involved in ion beam analysis. These tables, graphs, and formulas are divided into five chapters that cover the following topics: energy loss and energy straggling; backscattering spectrometry; channeling; applications of ion-induced nuclear reactions; and the use of ion-induced X-ray yields.

This completely revised and expanded new edition covers the full range of techniques now available for the investigation of materials structure and accurate quantitative determination of microstructural features within materials. It continues to provide the best introductory resource for understanding the interrelationship between microstructure and physical, mechanical, and chemical properties, as well as selection and application of techniques for both basic and applied studies. In particular, changes have been made to reflect developments in analysis of nanoscale and biological materials.

Analytical electron microscopy is one of the most powerful tools today for characterization of the advanced materials that support the nanotechnology of the twenty-first century. In this book the authors clearly explain both the basic principles and the latest developments in the field. In addition to a fundamental description of the inelastic scattering process, an explanation of the constituent hardware is provided. Standard quantitative analytical techniques employing electron energy-loss spectroscopy and energy-dispersive X-ray spectroscopy are also explained, along with elemental mapping techniques. Included are sections on convergent beam electron diffraction and electron holography utilizing the field emission gun. With generous use of illustrations and experimental data, this book is a valuable resource for anyone concerned with materials characterization, electron microscopy, materials science, crystallography, and instrumentation.

* Expert, up-to-date guidance on the appropriate techniques of local chemical analysis * Comprehensive. This volume is an ideal starting point for material research and development, bringing together a number of techniques usually only found in isolation * Recent examples of the applications of techniques are provided in all cases Helping to solve the problems of materials scientists in academia and industry, this book offers guidance on appropriate techniques of chemical analysis of materials at the local level, down to the atomic scale. Comparisons are made between various techniques in terms of the nature of the probe employed. The detection limit and the optimum spatial resolution is also considered, as well as the range of atomic number that may be identified and the precision and methods of calibration, where appropriate. The Local Chemical Analysis of Materials is amply illustrated allowing the reader to easily see typical results. It includes a comparative table of techniques to aid selection for analysis and a table of acronyms, particularly valuable in this jargon-riddled area.

Two separate experiments are described. The first was on the velocity distribution analysis of a gyrating electron beam. A retarding-potential analyzer was developed which operated at 75 kV and accepted gyrating electrons with large Larmo radii. Velocity distributions were compared with simulation results. The second experiment explored the possibility of forming a large-area electron beam from polycrystalline diamond film. Diamond, a negative electron affinity material in the crystalline 111 direction, has been observed to emit electrons into vacuum in certain configurations, but this effort was unsuccessful in obtaining emission.

This book provides the reader with a working knowledge sufficient to select microbeam techniques for the efficient, cost-effective solution of complex problems arising in today's high-tech industries. Primarily written for the industrial analyst whose field of expertise is other than microbeam analysis, it will also be of help to engineers, plant chemists and industrial research scientists who often seek the aid of the microbeam analyst in their problem solving. Research and plant managers as well as administrators may also find this book helpful since they may be called upon to select and/or approve high-priced microbeam instruments. The book is organized into two parts. Part I gives a brief description of the various techniques and critically compares their capabilities and limitations. Part II consists of selected applications which show how the various techniques or their combinations are applied to characterize materials and to guide research in a wide variety of fields. The examples and case histories will undoubtedly aid the reader in problem solving, quality assurance and research-related tasks. Newcomers to the field will find enough information in the book to enable them to begin practical work and to apply the techniques.

Our intention has been to write a book that would be useful to people with a variety of levels of interest in this subject. Clearly it should be useful to both graduate students and workers in the field. We have attempted to bring together many of the concepts used in channeling beam analysis with an indication of the origin of the ideas within fundamental channeling theory. The level of the book is appropriate to senior under-graduates and graduate students who have had a modern physics course work in related areas of materials science and wish to learn more about the "channeling" probe, its strengths, weaknesses, and areas of further potential application. To them we hope we have explained this apparent paradox of using mega-electron volt ions to probe solid state phenomena that have characteristic energies of electron volts.

We describe results from highly ion extraction experiments at the Electron Beam Ion Trap (EBIT) facility which is now operated at Lawrence Berkeley National Laboratory after transfer from Lawrence Livermore National Laboratory. Requirements on ion source performance for the application of highly charged ions (e. g. Xe{sup 44+}) in surface analysis and materials science are discussed.

This supplement of Mikrochimica Acta contains selected papers from the Second Workshop of the European Microbeam Analysis Society (EMAS) "Modern Developments and Applications in Microbeam Analysis", on which took place in May 1991 in Dubrovnik (Yugoslavia). EMAS was founded in 1987 by members from almost all European countries, in order to stimulate research, applications and development of all forms of microbeam methods. One of the most important activities EMAS is the organisation of biannual workshops for demonstrating the current status and developing trends of microbeam methods. For this meeting, EMAS chose to highlight the following topics: electron-beam microanalysis (EPMA) of thin films and quantitative analysis of ultra-light elements, Auger electron spectroscopy (AES), electron energy loss spec trometry (EELS), high-resolution transmission electron microscopy (HRTEM), quantitative analysis of biological samples and standard-less electron-beam microanalysis. Seven introductory lectures and almost seventy poster presentations were given by speakers from twelve European and two non-European (U.S.A. and

Argentina) countries were made. One cannot assume that all fields of research in Europe were duly represented, but a definite trend is discernible. EPMA with wavelength-dispersive spectrometry (WDS) or energy-dispersive spectrometry (EDS) is the method with by far the widest range of applications, followed by TEM with EELS and then AES. There are also interesting suggestions for the further development of new appa ratus with new fields of application. Applications are heavily biased towards materials science (thin films in microelectronics and semicon ductors), ceramics and metallurgy, followed by analysis of biological and mineral samples.

Microstructural characterization is usually achieved by allowingsome form of probe to interact with a carefully prepared specimen.The most commonly used probes are visible light, X-ray radiation, ahigh-energy electron beam, or a sharp, flexible needle. These fourtypes of probe form the basis for optical microscopy, X-raydiffraction, electron microscopy, and scanning probemicroscopy. Microstructural Characterization of Materials, 2nd Editionis an introduction to the expertise involved in assessing themicrostructure of engineering materials and to the experimentalmethods used for this purpose. Similar to the first edition, this2nd edition explores the methodology of materials characterizationunder the three headings of crystal structure, microstructuralmorphology, and microanalysis. The principal methods ofcharacterization, including diffraction analysis, opticalmicroscopy, electron microscopy, and chemical microanalyticaltechniques are treated both qualitatively and quantitatively. Anadditional chapter has been added to the new edition to coversurface probe microscopy, and there are new sections on digitalimage recording and analysis, orientation imaging microscopy,focused ion-beam instruments, atom-probe microscopy, and 3-D imagereconstruction. As well as being fully updated, this second editionalso includes revised and expanded examples and exercises, with asolutions manual available athttp://develop.wiley.co.uk/microstructural2e/ Microstructural Characterization of Materials, 2nd Editionwill appeal to senior undergraduate and graduate students ofmaterial science, materials engineering, and materials chemistry,as well as to qualified engineers and more advanced researchers,who will find the book a useful and comprehensive generalreference source.

Electron microscopy has revolutionized our understanding the extraordinary intellectual demands required of the mi of materials by completing the processing-structure-prop croscopist in order to do the job properly: crystallography, erties links down to atomistic levels. It now is even possible diffraction, image contrast, inelastic scattering events, and to tailor the microstructure (and meso structure) of materials spectroscopy. Remember, these used to be fields in them to achieve specific sets of properties; the extraordinary abili selves. Today, one has to understand the fundamentals ties of modem transmission electron microscopy-TEM of all of these areas before one can hope to tackle signifi instruments to provide almost all of the structural, phase, cant problems in materials science. TEM is a technique of and crystallographic data allow us to accomplish this feat. characterizing materials down to the atomic limits. It must Therefore, it is obvious that any curriculum in modem mate be used with care and attention, in many cases involving rials education must include suitable courses in electron mi teams of experts from different venues. The fundamentals croscopy. It is also essential that suitable texts be available are, of course, based in physics, so aspiring materials sci for the preparation of the students and researchers who must entists would be well advised to have prior exposure to, for carry out electron microscopy properly and quantitatively.

Pioneered by the pharmaceutical industry and adapted for the purposes of materials science and engineering, the combinatorial method is now widely considered a watershed in the accelerated discovery, development, and optimization of new materials. Combinatorial Materials Synthesis reveals the gears behind combinatorial materials chemistry and thin-film technology, and discusses the prime techniques involved in synthesis and property determination for experimentation with a variety of materials. Funneling historic innovations into one source, the book explores core approaches to synthesis and rapid characterization techniques for work with combinatorial materials libraries.

Synchroton radiation (SR) is utilized in most scientific fields. This book will therefore be useful not only for researchers engaged in analytical chemistry, and those studying the basic fields such as physics, chemistry, biology, as well as earth science, medicine, and life science but also for those engaged in research for elucidating structure of material and its function in the application fields including applied physics, semiconductor engineering, and metal engineering. The book has a highly interdisciplinary character. The outstanding characteristics of SR have also contributed to the rapid development of new fields and applications in analytical chemistry. Features of this book: • Explains the basics of SR • Facilities and instrumentation are covered to facilitate the planning of experiments using SR. • Aspects for the future development of SR are included together with an introduction to the latest techniques which are expected to find increasing use in the coming years. This book should stimulate students specializing in analytical chemistry and materials science to have an interest in SR. In addition, it will provide scientists who are beginning analytical chemistry research using SR with instructive and illustrative descriptions. The book can also be used as an explanatory text for advanced research on the application of SR.

Ion beam of various energies is a standard research tool in many areas of science, from basic physics to diverse areas in space science and technology, device fabrications, materials science, environment science, and medical sciences. It is an advance and versatile tool to frequently discover applications across a broad range of disciplines and fields. Moreover, scientists are continuously improving the ion beam sources and accelerators to explore ion beam at the forefront of scientific endeavours. This book provides a glance view on MeV ion beam applications, focused ion beam generation and its applications as well as practical applications of ion implantation.

The use of ion beams for materials analysis involves many different ion-atom interaction processes which previously have largely been considered in separate reviews and texts. A list of books and conference proceedings is given in Table 2. This book is divided into three parts, the first which treats all ion beam techniques and their applications in such diverse fields as materials science, thin film and semiconductor technology, surface science, geology, biology, medicine, environmental science, archaeology and so on.

This book brings a broad review of recent global developments in theory, instrumentation, and practical applications of electron microscopy. It was created by 13 contributions from experts in different fields of electron microscopy and technology from over 20 research institutes worldwide.

Abstract: Electron beam (E-beam) vacuum deposition is extensively used for the production of multi-layered optical coatings. High precision optical coating designs for advanced applications entail complex layer structures that have tight error tolerances. The ability to achieve those designs while consistently producing large volumes is limited by the current E-beam process control capability. In particular, subliming materials pose significant challenges to obtain high yields for precision optical coatings. The focus of this dissertation is to investigate the critical issue required to develop enhanced E-beam processing capability for subliming materials. The primary material analyzed is fused silica (SiO_2) due to its importance in optical coating manufacturing and challenges in E-beam processing. This work, however, is applicable to other subliming material such as alumina (Al_2O_3). Deposition rate control and electron beam sweep pattern design are identified as two critical aspects that can be optimized to significantly reduce process variations that lead to coating performance errors. A dynamic model of E-beam silica deposition is developed that captures both the complex process physics and critical equipment characteristics and used to obtain a better understanding of the fundamental sublimation dynamics and to develop improved sweep designs. Experimental characterization of commercial scale systems is performed to reveal major electron gun nonlinearities, important process disturbances, and controller tuning requirements that need to be considered for improving process capability. Model predictions are validated with experimental measurements of steady-state deposition rates, evaporation spot intensity distributions, and dynamic rate responses under the heating of both stationary beam and different sweep patterns. The model is used to understand the influence of sweep design parameters, electron beam focus nonlinearities, and the crucible attributes on the resulting source surface temperature and evaporation distributions. The nonlinear temperature dependences of the source surface thermal and deposition rate dynamics are obtained. The relation of sweep pattern design to the resulting deposition rate dynamics and melt surface uniformity are discussed. Improved deposition rate control strategies are experimentally evaluated and significant process and coating performance improvement is demonstrated.

The various forms of microscopy and related microanalytical techniques are making unique contributions to semiconductor research and development that underpin many important areas of microelectronics technology. Microscopy of Semiconducting Materials 1987 highlights the progress that is being made in semiconductor microscopy, primarily in electron probe methods as well as in light optical and ion scattering techniques. The book covers the state of the art, with sections on high resolution microscopy, epitaxial layers, quantum wells and superlattices, bulk gallium arsenide and other compounds, properties of dislocations, device silicon and dielectric structures, silicides and contacts, device testing, x-ray techniques, microanalysis, and advanced scanning microscopy techniques. Contributed by numerous international experts, this volume will be an indispensable guide to recent developments in semiconductor microscopy for all those who work in the field of semiconducting materials and research development.

Problems after each chapter.

Quantitative Microbeam Analysis provides a comprehensive introduction to the field of quantitative microbeam analysis (MQA). MQA is a technique used to analyze subatomic quantities of materials blasted from a surface by a laser or particle beam, providing information on the structure and composition of the material. Contributed to by international experts, the book is unique in the breadth of microbeam analytical techniques covered. For each technique, it develops the theoretical background, discusses practical details relating to choice of equipment, and describes the current advances. The book highlights developments relating to Auger electron spectroscopy in scanning electron microscopes and transmission electron microscopes and advances in surface analytical imaging and accelerated ion beam-surface interactions.

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