# Thin Film Materials Stress Defect Formation And Surface Evolution

A practical, working guide to producing high quality barrier coatings Roll-to-Roll Vacuum Deposition of Barrier Coatings is a practical guide, providing the reader with basic information to help them understand what is necessary in order to produce a good barrier coated web or to improve the quality of an existing barrier product. Keeping mathematics to a minimum, the terminology and science is introduced, and includes descriptions about barrier testing methods and the vacuum deposition process. The book looks at the whole process from the source materials through to the post deposition handling of the coated material. This holistic view of the vacuum coating process provides a description of the common sources of defects and includes the possible methods of limiting these defects. This enables readers to decide where their development efforts and money can best be used to improve the barrier performance of their own process or materials. Roll-to-Roll Vacuum Deposition of Barrier Coatings: Specifies the benefits and problems of producing vacuum deposited barrier coatings Explains why products designed by system operators might vary and how they can improve the quality and reproducibility of their products Describes the basic deposition process, limitations that may arise, and how they may be overcome Details why current barrier materials have limited performance and why it is so difficult and expensive to make improvements or to produce ultra barrier materials. This practical reference is invaluable to all readers using the roll-to-roll vacuum coating technology, including R&D scientists and engineers (process; product and process design), operators, technicians, line managers involved in producing vacuum deposited barrier coatings. It also serves the food packaging and medical packaging industries, along with any industry using Organic Light Emitting Devices (OLEDs) such as electronics, solar energy and photovoltaics (PVs), thin film battery as well as vacuum insulation panels.

This up-to-date reference is the most comprehensive summary of the field of nanoscience and its applications. It begins with fundamental properties at the nanoscale and then goes well beyond into the practical aspects of the design, synthesis, and use of nanomaterials in various industries. It emphasizes the vast strides made in the field over the past decade – the chapters focus on new, promising directions as well as emerging theoretical and experimental methods. The contents incorporate experimental data and graphs where appropriate, as well as supporting tables and figures with a tutorial approach.

The book celebrates the 65th birthday of Prof. Alexander K. Belyaev—a well-known expert in the field of Dynamics of Mechanical Systems. In addition to reflecting Prof. Belyaev's contributions, the papers gathered here address a range of current problems in Dynamics and Continuum Mechanics. All contributions were prepared by his friends and colleagues, and chiefly focus on theory and applications.

Proceeding of the 42nd International Conference on Advanced Ceramics and Composites, Ceramic Engineering and Science Proceedings Volume 39, Issue 2, 2018 Jonathan Salem, Dietmar Koch, Peter Mechnich, Mihails Kusnezoff, Narottam Bansal, Jerry LaSalvia, Palani Balaya, Zhengyi Fu, and Tatsuki Ohji, Editors Valerie Wiesner and Manabu Fukushima, Volume Editors This proceedings contains a collection of 25 papers from The American Ceramic Society's 41st International Conference on Advanced Ceramics and Composites, held in Daytona Beach, Florida, January 21-26, 2018. This issue includes papers presented in the following symposia: • Symposium 1: Mechanical Behavior and Performance of Ceramics and Composites • Symposium 2: Advanced Ceramic Coatings for Structural, Environmental, and Functional Applications • Symposium 3: 15th International Symposium on Solid Oxide Fuel Cells (SOFC) • Symposium 4: Armor Ceramics: Challenges and New Developments • Symposium 6: Advanced Materials and Technologies for Direct Thermal Energy Conversion and Rechargeable Energy Storage • Symposium 8: 12th International Symposium on Advanced Processing & Manufacturing

Transparent electrodes (TEs) are a class of materials that make it possible to bring electrical current or potentials in close proximity to optically active regions without significant loss of optical energy. However, it is a challenge to decouple the electrical and optical properties of a material, as the property of conductivity is strongly coupled to the imaginary part of the refractive index. An ideal TE has high transparency in combination with very low electrical resistivity. The main objective of the thesis was to develop TEs which can replace expensive, scarce and fragile Indium Tin Oxide (ITO), the most widely used TE material in the industry today. The thesis contains original work on ultrathin metal film (UTMF)-based TEs, which are essential elements in a wide range of optoelectronics, consumer electronics and energy devices. It presents new designs and fabrication methods and demonstrates the efficient use of UTMF-TEs in organic light emitting diodes and solar cells, achieving similar levels of efficiency to that of state-of-the-art ITO.

Thin film mechanical behavior and stress presents a technological challenge for materials scientists, physicists and engineers. This book provides a comprehensive coverage of the major issues and topics dealing with stress, defect formation, surface evolution and allied effects in thin film materials. Physical phenomena are examined from the continuum down to the sub-microscopic length scales, with the connections between the structure of the material and its behavior described. Theoretical concepts are underpinned by discussions on experimental methodology and observations. Fundamental scientific concepts are embedded through sample calculations, a broad range of case studies with practical applications, thorough referencing, and end of chapter problems. With solutions to problems available on-line, this book will be essential for graduate courses on thin films and the classic reference for researchers in the field.

Handbook of Thin Film Deposition, Fourth Edition, is a comprehensive reference focusing on thin film technologies and applications used in the semiconductor industry and the closely related areas of thin film deposition, thin film micro properties, photovoltaic solar energy applications, materials for memory applications and methods for thin film optical processes. The book is broken up into three sections: scaling, equipment and processing, and applications. In this newly revised edition, the handbook will also explore the limits of thin film applications, most notably as they relate to applications in manufacturing, materials, design and reliability. Offers a practical survey of thin film technologies aimed at engineers and managers involved in all stages of the process: design, fabrication, quality assurance, applications and the limitations faced by those processes Covers core processes and applications in the semiconductor industry and new developments within the photovoltaic and optical thin film industries Features a new chapter discussing Gates Dielectrics

Mechanics of Microsystems Alberto Corigliano, Raffaele Ardito, Claudia Comi, Attilio Frangi, Aldo Ghisi and Stefano Mariani, Politecnico di Milano, Italy A mechanical approach to microsystems, covering fundamental concepts including MEMS design, modelling and reliability Mechanics of Microsystems takes a mechanical approach to microsystems and covers fundamental concepts including MEMS design, modelling and reliability. The book examines the mechanical behaviour of microsystems from a 'design for reliability' point of view and includes examples of applications in industry. Mechanics of Microsystems is divided into two main parts. The first part recalls basic knowledge related to the microsystems behaviour and offers an overview on microsystems and fundamental design and modelling tools from a mechanical point of view, together with many practical examples of real microsystems. The second part covers the mechanical characterization of materials at the micro-scale and considers the most important reliability issues (fracture, fatigue, stiction, damping phenomena, etc) which are fundamental to fabricate a real working device. Key features: Provides an overview of MEMS, with special focus on mechanical-based Microsystems and reliability issues. Includes examples of applications in industry. Accompanied by a website hosting supplementary material. The book provides essential reading for researchers and practitioners working with MEMS, as well as graduate students in mechanical, materials and electrical engineering.

This 2006 book combines modern and traditional solid mechanics topics in a coherent theoretical framework.
Second edition of successful materials science text for final year undergraduate and graduate students.
The advances of microelectromechanical systems (MEMS) and devices have been instrumental in the demonstration of new devices and applications, and even in the creation of new fields of research and development: bioMEMS, actuators, microfluidic devices, RF and optical MEMS. Experience indicates a need for MEMS book covering these materials as well as the most important process steps in bulk micro-machining and modeling. We are very pleased to present this book that contains 18 chapters, written by the experts in the field of MEMS. These chapters are groups into four broad sections of BioMEMS Devices, MEMS characterization and micromachining, RF and Optical MEMS, and MEMS based Actuators. The book starts with the emerging field of bioMEMS, including MEMS coil for retinal prostheses, DNA extraction by micro/bio-fluidics devices and acoustic biosensors. MEMS characterization, micromachining, macromodels, RF and Optical MEMS switches are discussed in next sections. The book concludes with the emphasis on MEMS based actuators.
Structures that are essential for economy and security such as energy production, transportation and supply, water supply, buildings, are susceptible to failure, because of defects already present in the material, or created at fabrication, or appearing during service. Methods of assesment of the nocivity of these defects are needed, to predict the remaining service life and the eventual emergency of stopping service and repairing, if possible. To reach this objectives, this book presents the last methods derived from the classical linear, non-linear fracture mechanics concepts, including fatigue and notch fracture mechanics. Several examples of structures rehabilitations and repairing are given. This book gathers the presentation made during the Advanced Research Workshop held in Portoroz (Slovenia) in October 2008, under the auspices of NATO Science for Peace and Security Programme. It is edited by Professor Guy Pluvinage from the University Paul Verlaine – Metz (France) and Professor Aleksandar Sedmak from the University of Belgrade, Faculty of Mechanical Engineering. Both have a long and rich experience in analysis of theoretical and practical cases in safety and reliability of structures. Other contributors are all known as experts in the areas of fatigue, facture and reliability of structures.
Retaining its proven concept, the second edition of this ready reference specifically addresses the need of materials engineers for reliable, detailed information on modern material characterization methods. As such, it provides a systematic overview of the increasingly important field of characterization of engineering materials with the help of neutrons and synchrotron radiation. The first part introduces readers to the fundamentals of structure-property relationships in materials and the radiation sources suitable for materials characterization. The second part then focuses on such characterization techniques as diffraction and scattering methods, as well as direct imaging and tomography. The third part presents new and emerging methods of materials characterization in the field of 3D characterization techniques like three-dimensional X-ray diffraction microscopy. The fourth and final part is a collection of examples that demonstrate the application of the methods introduced in the first parts to problems in materials science. With thoroughly revised and updated chapters and now containing about 20% new material, this is the must-have, in-depth resource on this highly relevant topic.
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
This book constitutes the refereed proceedings of the Forth Workshop onEngineering Applications, WEA 2017, held in Cartagena, Colombia, inSeptember 2017. The 59 revised full papers presented were carefully reviewed and selectedfrom156 submissions. The papers are organized in topical sections such as computerscience; computational intelligence; simulation systems; internet of things; fuzzy sets and systems; power systems; logistics and operations management; miscellaneous applications.
Contains 32 papers from the following seven 2013 Materials Science and Technology (MS&T'13) symposia: Innovative Processing and Synthesis of Ceramics, Glasses and Composites Advances in Ceramic Matrix Composites Advanced Materials for Harsh Environments Advances in Dielectric Materials and Electronic Devices Controlled Synthesis, Processing, and Applications of Structure and Functional Nanomaterials Rustum Roy Memorial Symposium: Processing and Performance of Materials Using Microwaves, Electric and Magnetic Fields, Ultrasound, Lasers, and Mechanical Work Solution Based Processing for Ceramic Materials
Thin films are widely used in the electronic device industry. As the trend for miniaturization of electronic devices moves into the nanoscale domain, the reliability of thin films becomes an increasing concern. Building on the author's previous book, Electronic Thin Film Science by Tu, Mayer and Feldman, and based on a graduate course at UCLA given by the author, this new book focuses on reliability science and the processing of thin films. Early chapters address fundamental topics in thin film processes and reliability, including deposition, surface energy and atomic diffusion, before moving onto systematically explain irreversible processes in interconnect and packaging technologies. Describing electromigration, thermomigration and stress migration, with a closing chapter dedicated to failure analysis, the reader will come away with a complete theoretical and practical understanding of electronic thin film reliability. Kept mathematically simple, with real-world examples, this book is ideal for graduate students, researchers and practitioners.
This book reports on the recent progresses in theory, application, and characterization of magnetic materials. It covers a broad spectrum of topics on magnetic materials with different shapes

and morphologies such as transition metals, cylindrical and 2D ferromagnetic nanowires, core-shell nanowires, monoatomic-layered nanostructures, and nanocrystals. This book addresses diverse groups of readers with general background in physics and material science and also covers topics for the specialists in the field of magnetism. It is believed that this book will be interesting for the readers and will provide a solid foundation about the topic for the students, scientists, and engineers working in the field of material science and condensed matter physics.
Handbook of Modern Coating Technologies: Advanced Characterization Methods reviews advanced characterization methods of modern coating technologies. The topics in this volume consist of scanning vibrating electrode technique, spectroscopic ellipsometry, advances in X-ray diffraction, neutron reflectivity, micro- and nanoprobes, fluorescence technique, stress measurement methods in thin films, micropotentiometry, and localized corrosion studies.
We experience elasticity everywhere in daily life: in the straightening or curling of hairs, the irreversible deformations of car bodies after a crash, or the bouncing of elastic balls in ping-pong or soccer. The theory of elasticity is essential to the recent developments of applied and fundamental science, such as the bio-mechanics of DNA filaments and other macro-molecules, and the animation of virtual characters in computer graphics and materials science. In this book, the emphasis is on the elasticity of thin bodies (plates, shells, rods) in connection with geometry. It covers such topics as the mechanics of hairs (curled and straight), the buckling instabilities of stressed plates, including folds and conical points appearing at larger stresses, the geometric rigidity of elastic shells, and the delamination of thin compressed films. It applies general methods of classical analysis, including advanced nonlinear aspects (bifurcation theory, boundary layer analysis), to derive detailed, fully explicit solutions to specific problems. These theoretical concepts are discussed in connection with experiments. Mathematical prerequisites are vector analysis and differential equations. The book can serve as a concrete introduction to nonlinear methods in analysis.
This is the first book that can be considered a textbook on thin film science, complete with exercises at the end of each chapter. Ohring has contributed many highly regarded reference books to the AP list, including Reliability and Failure of Electronic Materials and the Engineering Science of Thin Films. The knowledge base is intended for science and engineering students in advanced undergraduate or first-year graduate level courses on thin films and scientists and engineers who are entering or require an overview of the field. Since 1992, when the book was first published, the field of thin films has expanded tremendously, especially with regard to technological applications. The second edition will bring the book up-to-date with regard to these advances. Most chapters have been greatly updated, and several new chapters have been added.
The scope of this work is to investigate and to develop advanced HIPIMS processes for deposition of oxides, utilizing industrial-scale equipment and technology. Two classes of oxide materials were studied: insulating (aluminum oxide) and conducting oxides (indium-tin oxide and aluminum-doped zinc oxide). The electrical properties of the oxides have a significant influence on the process design, as the issues and approaches for deposition of insulating materials are fairly different from conducting materials. Different types of reactive process control were also investigated, utilizing optical emission spectroscopy to control the oxygen flow and lambda probes to control the discharge power. A non-reactive process was also studied for indium-tin oxide.
Discusses the growth mechanisms of tin whiskers and the effective mitigation strategies necessary to reduce whisker growth risks This book covers key tin whisker topics, ranging from fundamental science to practical mitigation strategies. The text begins with a review of the characteristic properties of local microstructures around whisker and hillock grains to identify why these particular grains and locations become predisposed to forming whiskers and hillocks. The book discusses the basic properties of tin-based alloy finishes and the effects of various alloying elements on whisker formation, with a focus on potential mechanisms for whisker suppression or enhancement for each element. Tin whisker risk mitigation strategies for each tier of the supply chain for high reliability electronic systems are also described. Discusses whisker formation factors including surface grain geometry, crystallographic orientation-dependent surface grain boundary structure, and the localization of elastic strain/strain energy density distribution Examines how whiskers and hillocks evolve in time through real-time studies of whisker growth with the scanning electron microscope/focused ion beaming milling (SEM/FIB) Covers characterization methods of tin and tin-based alloy finishes such as transmission electron microscopy (TEM), scanning electron microscopy (SEM), and electron backscatter diffraction (EBSD) Reviews theories of mechanically-induced tin whiskers with case studies using pure tin and other lead-free finishes shown to evaluate the pressure-induced tin whiskers Mitigating Tin Whisker Risks: Theory and Practice is intended for the broader electronic packaging and manufacturing community including: manufacturing engineers, packaging development engineers, as well as engineers and researchers in high reliability industries.
Thin Films and Coatings: Toughening and Toughness Characterization captures the latest developments in the toughening of hard coatings and in the measurement of the toughness of thin films and coatings. Featuring chapters contributed by experts from Australia, China, Czech Republic, Poland, Singapore, Spain, and the United Kingdom, this first-of-its-kind book: Presents the current status of hard-yet-tough ceramic coatings Reviews various toughness evaluation methods for films and hard coatings Explores the toughness and toughening mechanisms of porous thin films and laser-treated surfaces Examines adhesions of the film/substrate interface and the characterization of coating adhesion strength Discusses nanoindentation determination of fracture toughness, resistance to cracking, and sliding contact fracture phenomena Toughening and toughness measurement (of films and coatings) are two related, yet separate, fields of great importance in today’s nanotechnology world. Thin Films and Coatings: Toughening and Toughness Characterization is a timely reference written in such a way that novices will find it a stepping stone to the field and veterans will find it a rich source of information for their research.
The International Conference on Future Manufacturing Engineering (ICFME 2014) was held in Hong Kong, December 10-11, 2014. It gathered academics, industry managers and experts, manufacturing engineers, university students all interested or proficient in the field of manufacturing engineering, including research, design and development of systems, p
This book explains biosensor development fundamentals. It also initiates awareness in engineers and scientists who would like to develop and implement novel biosensors for agriculture, biomedicine, homeland security, environmental needs, and disease identification. In addition, the book introduces and lays the basic foundation for design, fabrication, testing, and implementation of next generation biosensors through hands-on learning.
This handbook provides the most comprehensive, up-to-date and easy-to-apply information on the physics, mechanics, reliability and packaging of micro- and opto-electronic materials. It details their assemblies, structures and systems, and each chapter contains a summary of the state-of-the-art in a particular field. The book provides practical recommendations on how to apply current knowledge and

technology to design and manufacture. It further describes how to operate a viable, reliable and cost-effective electronic component or photonic device, and how to make such a device into a successful commercial product.

The acronym Laser is derived from Light Amplification by Stimulated Emission of Radiation. With the advent of the ruby laser in 1960, there has been tremendous research activity in developing novel, more versatile and more efficient laser sources or devices, as lasers applications are ubiquitous. Today, lasers are used in many areas of human endeavor and are routinely employed in a host of diverse fields: various branches of engineering, microelectronics, biomedical, medicine, dentistry, surgery, surface modification, to name just a few. In this book (containing 10 chapters) we have focused on application of lasers in adhesion and related areas. The topics covered include: • Topographical modification of polymers and metals by laser ablation to create superhydrophobic surfaces. • Non-ablative laser surface modification. • Laser surface modification to enhance adhesion. • Laser surface engineering of materials to modulate their wetting behavior • Laser surface modification in dentistry. • Laser polymer welding. • Laser based adhesion testing technique to measure thin film-substrate interface toughness. • Laser surface removal of hard thin ceramic coatings. • Laser removal of particles from surfaces. • Laser induced thin film debonding for micro-device fabrication applications.

Handbook of Silicon Based MEMS Materials and Technologies, Third Edition is a comprehensive guide to MEMS materials, technologies, and manufacturing with a particular emphasis on silicon as the most important starting material used in MEMS. The book explains the fundamentals, properties (mechanical, electrostatic, optical, etc.), materials selection, preparation, modeling, manufacturing, processing, system integration, measurement, and materials characterization techniques of MEMS structures. The third edition of this book provides an important up-to-date overview of the current and emerging technologies in MEMS making it a key reference for MEMS professionals, engineers, and researchers alike, and at the same time an essential education material for undergraduate and graduate students. Provides comprehensive overview of leading-edge MEMS manufacturing technologies through the supply chain from silicon ingot growth to device fabrication and integration with sensor/actuator controlling circuits Explains the properties, manufacturing, processing, measuring and modeling methods of MEMS structures Reviews the current and future options for hermetic encapsulation and introduces how to utilize wafer level packaging and 3D integration technologies for package cost reduction and performance improvements Geared towards practical applications presenting several modern MEMS devices including inertial sensors, microphones, pressure sensors and micromirrors

Focusing on a description of the technologies and methodologies for computer-aided conceptual design, this book covers the design, modeling and simulation of micropower generation devices. The articles are authored by internationally recognized experts in the field, who take the reader from fundamentals and design aspects to numerous power generation strategies and system engineering. The comprehensive coverage also extends to fuel processing, energy conversion, material and heat management, device operation, economics and quality control. For materials scientists, chemists, physicists, process engineers and those in power technology.

Roll-to-roll vacuum deposition is the technology that applies an even coating to a flexible material that can be held on a roll and provides a much faster and cheaper method of bulk coating than deposition onto single pieces or non-flexible surfaces, such as glass. This technology has been used in industrial-scale applications for some time, including a wide range of metalized packaging (e.g. snack packets). Its potential as a high-speed, scalable process has seen an increasing range of new products emerging that employ this cost-effective technology: solar energy products are moving from rigid panels onto flexible substrates, which are cheaper and more versatile in a similar way, electronic circuit ‘boards’ can be produced on a flexible polymer, creating a new range of ‘flexible electronics’ products flexible displays are another area of new technology in vacuum coating, with flexible display panels and light sources emerging Charles Bishop has written this book to meet the need he identified, as a trainer and consultant to the vacuum coatings industry, for a non-mathematical guide to the technologies, equipment, processes and applications of vacuum deposition. His book is aimed at a wide audience of engineers, technicians and production management. It also provides a guide to the subject for sectors in which vacuum deposition is a novel technology, such as solar energy and flexible electronics. Bishop’s non-mathematical explanation of vacuum deposition technologies will empower a wide range of technicians, production managers and engineers in related disciplines to improve performance and maximize productivity from vacuum coating systems Provides the knowledge and understanding needed to specify systems more effectively and enhance the dialogue between non-specialists and suppliers / engineers Provides those in the rapidly expanding fields of solar energy, display panels and flexible electronics with the know-how to unlock the potential of vacuum coating to transform their processes and products

This concise reference summarizes the latest results in nano-structured thin films, the first to discuss both deposition methods and electronic applications in detail. Following an introduction to this rapidly developing field, the authors present a variety of organic and inorganic materials along with new deposition techniques, and conclude with an overview of applications and considerations for their technology deployment.

WINNER 2009 CHOICE AWARD OUTSTANDING ACADEMIC TITLE! Nanotechnology is no longer a subdiscipline of chemistry, engineering, or any other field. It represents the convergence of many fields, and therefore demands a new paradigm for teaching. This textbook is for the next generation of nanotechnologists. It surveys the field’s broad landscape, exploring the physical basics such as nanorheology, nanofluidics, and nanomechanics as well as industrial concerns such as manufacturing, reliability, and safety. The authors then explore the vast range of nanomaterials and systematically outline devices and applications in various industrial sectors. This color text is an ideal companion to Introduction to Nanoscience by the same group of esteemed authors. Both titles are also available as the single volume Introduction to Nanoscience and Nanotechnology Qualifying instructors who purchase either of these volumes (or the combined set) are given online access to a wealth of instructional materials. These include detailed lecture notes, review summaries, slides, exercises, and more. The authors provide enough material for both one- and two-semester courses.

Thin films play a key role in the material science of microelectronics, and the subject matter of thin-films divides naturally into two headings: processing / structure relationship, and structure / properties relationship. The first volume of Materials Science in Microelectronics focuses on the first relationship – that between processing and the structure of the thin-film. The state of the thin film’s surface during the period that one monolayer exists - before being buried in the next layer – determines the ultimate structure of the thin film, and thus its properties. This volume takes into consideration the following potential influencing factors: crystal defects, void structure, grain structure, interface structure in epitaxial films, the structure of amorphous films, and reaction-induced structure. An ideal text or reference work for students and researchers in material science, who need to learn the basics of thin films.

This is an English translation of a Chinese textbook that has been designated a national planned university textbook, the highest award given to scientific textbooks in China. The book provides a complete overview of mechanical properties and fracture mechanics in materials science, mechanics, and physics. It details the macro- and micro-mechanical properties of metal structural materials, nonmetal structural materials, and various functional materials. It also discusses the macro and micro failure mechanism under different loadings and contains research results on thin film mechanics, smart material mechanics, and more.

Materials of micro-/nanometer dimensions have aroused remarkable interest, motivated by the diverse utility of unconventional mechanical and electronic properties distinguished from the bulk counterpart

and various industrial applications such as electronic/optic devices and MEMS/NEMS. The size of their elements is now, ultimately, approaching nanometer and atomic scales. Since the conventional theory of "fracture mechanics" is based on the continuum-body approximation, its applicability to the nanoscale components is questionable owing to the discreteness of atoms. Moreover, for describing the fracture behavior of atomic components, it is necessary to understand not only the mechanical parameters (e.g., stress and strain) but also the fracture criterion in the atomic scale. This book systematically provides recent understanding of unusual fracture behaviors in nano/atomic elements (nanofilms, nanowires, etc.) and focuses on the critical initiation and propagation of interface crack and the mechanical instability criteria of atomic structures through the introduction of state-of-the-art experimental and theoretical techniques. It covers the fundamentals and the applicability of top-down (conventional fracture mechanics to nanoscale) and bottom-up (atomistic mechanics, including quantum mechanical effects) concepts. This second edition of Fracture Nanomechanics newly includes dramatic advances in unconventional fracture mechanics in nanofilms, extraordinary fatigue mechanics and mechanisms in nanometals, and a new area of multiphysics properties in nanoelements.

This review volume explores how the current knowledge of the biological structures occuring on the surface of moth eyes, leaves, sharkskin, and the feet of reptiles can be transferred to functional technological materials.