

Fundamentals Of Ceramics Barsoum Solutions

One of the main, ongoing challenges for any engineering enterprise is that systems are built of materials subject to environmental degradation. Whether working with an airframe, integrated circuit, bridge, prosthetic device, or implantable drug-delivery system, understanding the chemical stability of materials remains a key element in determining their useful life.

Environmental Degradation of Advanced and Traditional Engineering Materials is a monumental work for the field, providing comprehensive coverage of the environmental impacts on the full breadth of materials used for engineering infrastructure, buildings, machines, and components. The book discusses fundamental degradation processes and presents examples of degradation under various environmental conditions. Each chapter presents the basic properties of the class of material, followed by detailed characteristics of degradation, guidelines on how to protect against corrosion, and a description of testing procedures. A complete, self-contained industrial reference guide, this valuable resource is designed for students and professionals interested in the development of deterioration-resistant technological systems constructed with metallurgical, polymeric, ceramic, and natural materials.

Supercapacitors are most interesting in the area of rechargeable battery based energy storage because they offer an unbeatable power density, quick charge/discharge rates and prolonged lifetimes in comparison to batteries. The book covers inorganic, organic and gel-polymer electrolytes, electrodes and separators used in different types of supercapacitors; with emphasis on material synthesis, characterization, fundamental electrochemical properties and most promising applications. Keywords: Supercapacitors, Rechargeable Batteries, Organic Electrolytes, Inorganic Electrolytes, Gel Polymer based Supercapacitors, Redox Electrolytes, Starch-Based Electrolytes, Flexible Supercapacitors, Pseudocapacitors, Carbon Nanoarchitectures for Supercapacitors, Photo-Supercapacitors, Bimetal Oxides/Sulfides for Electrochemical Supercapacitors.

All Refractories Are Ceramics but Not All Ceramics Are Refractories Ceramics and refractories cover a wide range of fields and applications, and their relevance can be traced as far back as 24,000 BC to the first man-made piece of earthenware, and as recently as the late 1900s when ceramics and ceramic matrix composites were developed to withstand ultra-high temperatures. Beginning with a detailed history of ceramics, An Introduction to Ceramics and Refractories examines every aspect of ceramics and refractories, and explores the connection between them. The book establishes refractories as a class of ceramics with high fusion points, introduces the fundamentals of refractories and ceramics, and also addresses several applications for each. Understand Ceramic Properties and Refractory Behavior The book details applications for natural and synthetic ceramics, as well as traditional and engineering applications. It focuses on the various thermal and thermo-mechanical properties of ceramics, classifies refractories, describes the principles of thermodynamics as applied to refractories, and highlights new developments and applications in the ceramic and refractory fields. It also presents end-of-chapter problems and a relevant case study. Divided into three sections, this text: Introduces and details the applications of ceramics and refractories Discusses the selection of materials and the two stages in selection Describes the phase equilibria in ceramic and refractory systems Outlines the three important systems: unary, binary, and ternary Considers corrosion of ceramics and refractories, failures in ceramics and refractories, and the design aspects Addresses bonding, structures of ceramics, defects in ceramics, and ceramics' microstructures Covers the production of ceramic powders starting from the raw materials Explains four forming methods Highlights three types of thermal treatments Defines mechanical properties, and thermal and thermo-mechanical properties Classifies materials and designates classes Addressing topics that include corrosion, applications, thermal properties,

and types of refractories, An Introduction to Ceramics and Refractories provides you with a basic knowledge of the fundamentals of refractories and ceramics, and presents a clear connection between refractory behavior and ceramic properties to the practicing engineer. Reflecting the increasing importance of ceramics, polymers, composites, and silicon in manufacturing, Fundamentals of Modern Manufacturing Second Edition provides a comprehensive treatment of these other materials and their processing, without sacrificing its solid coverage of metals and metal processing. Topics include such modern processes as rapid prototyping, microfabrication, high speed machining and nanofabrication. Additional features include: Emphasis on how material properties relate to the process variables in a given process. Emphasis on manufacturing science and quantitative engineering analysis of manufacturing processes. More than 500 quantitative problems are included as end of chapter exercises. Multiple choice quizzes in all but one chapter (approximately 500 questions). Coverage of electronics manufacturing, one of the most commercially important areas in today's technology oriented economy. Historical notes are included to introduce manufacturing from the earliest materials and processes, like woodworking, to the most recent. This is a concise, up-to-date book that covers a wide range of important ceramic materials used in modern technology. Chapters provide essential information on the nature of these key ceramic raw materials including their structure, properties, processing methods and applications in engineering and technology. Treatment is provided on materials such as alumina, aluminates, Andalusite, kyanite, and sillimanite. The chapter authors are leading experts in the field of ceramic materials. An ideal text for graduate students and practising engineers in ceramic engineering, metallurgy, and materials science and engineering. The chapters covered in this book include emerging new techniques on sintering. Major experts in this field contributed to this book and presented their research. Topics covered in this publication include Spark plasma sintering, Magnetic Pulsed compaction, Low Temperature Co-fired Ceramic technology for the preparation of 3-dimesinal circuits, Microwave sintering of thermistor ceramics, Synthesis of Bio-compatible ceramics, Sintering of Rare Earth Doped Bismuth Titanate Ceramics prepared by Soft Combustion, nanostructured ceramics, alternative solid-state reaction routes yielding densified bulk ceramics and nanopowders, Sintering of intermetallic superconductors such as MgB₂, impurity doping in luminescence phosphors synthesized using soft techniques, etc. Other advanced sintering techniques such as radiation thermal sintering for the manufacture of thin film solid oxide fuel cells are also described.

This classic review of alumina, covering every aspect of the material from mineral structure and composition to inherent properties, offers a myriad of applications. This book is a timeless reference for anyone involved in the research, application, or sale of this versatile ceramic material.

The third edition of Engineering Flow and Heat Exchange is the most practical textbook available on the design of heat transfer and equipment. This book is an excellent introduction to real-world applications for advanced undergraduates and an indispensable reference for professionals. The book includes comprehensive chapters on the different types and classifications of fluids, how to analyze fluids, and where a particular fluid fits into a broader picture. This book includes various a wide variety of problems and solutions – some whimsical and others directly from industrial applications. Numerous practical examples of heat transfer Different from other introductory books on fluids Clearly written, simple to understand, written for students to absorb material quickly Discusses non-Newtonian as well as Newtonian fluids Covers the entire field concisely Solutions manual with worked examples and solutions provided

Fundamentals of CeramicsCRC Press

Fundamentals of Ceramics presents readers with an exceptionally clear and comprehensive

introduction to ceramic science. This Second Edition updates problems and adds more worked examples, as well as adding new chapter sections on Computational Materials Science and Case Studies. The Computational Materials Science sections describe how today density functional theory and molecular dynamics calculations can shed valuable light on properties, especially ones that are not easy to measure or visualize otherwise such as surface energies, elastic constants, point defect energies, phonon modes, etc. The Case Studies sections focus more on applications, such as solid oxide fuel cells, optical fibers, alumina forming materials, ultra-strong and thin glasses, glass-ceramics, strong and tough ceramics, fiber-reinforced ceramic matrix composites, thermal barrier coatings, the space shuttle tiles, electrochemical impedance spectroscopy, two-dimensional solids, field-assisted and microwave sintering, colossal magnetoresistance, among others.

The current automotive industry faces numerous challenges, including increased global competition, more stringent environmental and safety requirements, the need for higher performance vehicles, and reducing costs. The materials used in automotive engineering play key roles in overcoming these issues. *Automotive Engineering: Lightweight, Functional, and Novel Materials* focuses on both existing materials and future developments in automotive science and technology. Divided into four sections, the book first describes the development of future vehicles, aluminum alloys for manufacturing lighter body panels, and various polymer composites for stronger module carriers. It then reviews state-of-the-art functional materials and smart technologies and projects in which application areas they will most impact future automotive designs and manufacturing. The next section considers the difficulties that must be overcome for light alloys to displace ferrous-based materials and the increasing competition from lightweight polymeric-based composites. The final section explores newer processing and manufacturing technologies, including welding and joining, titanium alloys, and durable, high-performance composites. With contributions from internationally recognized experts, this volume provides a comprehensive overview of cutting-edge automotive materials and technologies. It will help you understand the key materials and engineering concerns currently confronting this industry.

The understanding and control of transport phenomena in materials processing play an important role in the improvement of conventional processes and in the development of new techniques. Computer modeling of these phenomena can be used effectively for this purpose. Although there are several books in the literature covering the analysis of heat transfer, *Fracture Mechanics: Fundamentals and Applications, Fourth Edition* is the most useful and comprehensive guide to fracture mechanics available. It has been adopted by more than 150 universities worldwide and used by thousands of engineers and researchers. This new edition reflects the latest research, industry practices, applications, and computational analysis and modeling. It encompasses theory and applications, linear and nonlinear fracture mechanics, solid mechanics, and materials science with a unified, balanced, and in-depth approach. Numerous chapter problems have been added or revised, and additional resources are available for those teaching college courses or training sessions. Dr. Anderson's own website can be accessed at www.FractureMechanics.com.

As engineering materials and structures often contain a metal or metallic alloy bonded to a ceramic, the resultant interface must be able to sustain mechanical forces without failure. They also play an important role in oxidation or reduction of materials. The workshop on 'Bonding, Structure and Mechanical Properties of Metal/Ceramic Interfaces' was held in January 1989 within the Acta/Scripta Metallurgica conference series. It drew together an international collection of 70 scientists who discussed a wide range of issues related to metal-ceramic interfaces. The sessions were divided into 7 categories: structure and bonding, chemistry at interfaces, formation of interfaces, structure of interfaces, thermodynamics/atomistics of interface fracture, mechanics of interface cracks, and fracture resistance of bimaterial

interfaces. Within these headings attention was paid to grain boundaries, the influence of chemical processes on the behaviour of interfaces, diffusion bonding, characterization of fracture, and crack propagation by fatigue and by stress corrosion. The book presents a useful reference source for materials scientists, physicists, chemists, and mechanical engineers who are concerned with the roles and properties of interfaces.

In this comprehensive yet compact monograph, Michel W. Barsoum, one of the pioneers in the field and the leading figure in MAX phase research, summarizes and explains, from both an experimental and a theoretical viewpoint, all the features that are necessary to understand and apply these new materials. The book covers elastic, electrical, thermal, chemical and mechanical properties in different temperature regimes. By bringing together, in a unified, self-contained manner, all the information on MAX phases hitherto only found scattered in the journal literature, this one-stop resource offers researchers and developers alike an insight into these fascinating materials.

The book summarizes the current state of the know-how in the field of perovskite materials: synthesis, characterization, properties, and applications. Most chapters include a review on the actual knowledge and cutting-edge research results. Thus, this book is an essential source of reference for scientists with research fields in energy, physics, chemistry and materials. It is also a suitable reading material for graduate students.

This book summarizes recent advances in the fabrication methods, properties, and applications of various ceramic-filled polymer matrix composites. Surface-modification methods and chemical functionalization of the ceramic fillers are explored in detail, and the outstanding thermal and mechanical properties of polymer–ceramic composites, the modeling of some of their thermal and mechanical parameters, and their major potential applications are discussed along with detailed examples. Aimed at researchers, industry professionals, and advanced students working in materials science and engineering, this work offering a review of a vast number of references in the polymer–ceramic field, this work helps readers easily advance their research and understanding of the field.

The subject of electronic and ionic materials has grown rapidly over the last 20 to 30 years. The application of these materials has had a significant impact on modern industries and on society in general. The subject is so important that no electrical engineering, materials science and engineering, applied physics or chemistry degree would be complete without it. This valuable textbook is aimed at engineering and technology undergraduates who have a background in physics or chemistry only at first year level. It provides a basic understanding of the properties and uses of a wide range of electrically and ionically conducting materials. It is not intended to be a solid state physics or chemistry book, and so the mathematics is kept to a minimum. However, it is intended to give the student an overview of a wide range of electrical materials and their uses in today's society.

This book deals with an information-driven approach to plan materials discovery and design, iterative learning. The authors present contrasting but complementary approaches, such as those based on high throughput calculations, combinatorial experiments or data driven discovery, together with machine-learning methods. Similarly, statistical methods successfully applied in other fields, such as biosciences, are presented. The content spans from materials science to information science to reflect the cross-disciplinary nature of the field. A perspective is presented that offers a paradigm (codesign loop for materials design) to involve iteratively learning from experiments and calculations to develop materials with optimum properties. Such a loop requires the elements of incorporating domain materials knowledge, a database of descriptors (the genes), a surrogate or statistical model developed to predict a given property with uncertainties, performing adaptive experimental design to guide the next experiment or calculation and aspects of high throughput calculations as well as experiments. The book is about manufacturing with the aim to halving the time to discover and design new materials.

Accelerating discovery relies on using large databases, computation, and mathematics in the material sciences in a manner similar to the way used to in the Human Genome Initiative. Novel approaches are therefore called to explore the enormous phase space presented by complex materials and processes. To achieve the desired performance gains, a predictive capability is needed to guide experiments and computations in the most fruitful directions by reducing not successful trials. Despite advances in computation and experimental techniques, generating vast arrays of data; without a clear way of linkage to models, the full value of data driven discovery cannot be realized. Hence, along with experimental, theoretical and computational materials science, we need to add a “fourth leg” to our toolkit to make the “Materials Genome” a reality, the science of Materials Informatics.

Topics in the Theory of Solid Materials provides a clear and rigorous introduction to a wide selection of topics in solid materials, overlapping traditional courses in both condensed matter physics and materials science and engineering. It introduces both the continuum properties of matter, traditionally the realm of materials science courses, and the quantum mechanical properties that are usually more emphasized in solid state physics courses, and integrates them in a manner that will be of use to students of either subject. The book spans a range of basic and more advanced topics, including stress and strain, wave propagation, thermal properties, surface waves, polarons, phonons, point defects, magnetism, and charge density waves. Topics in the Theory of Solid Materials is eminently suitable for graduates and final-year undergraduates in physics, materials science, and engineering, as well as more advanced researchers in academia and industry studying solid materials.

Almost all books available on fracture mechanics cover the majority of topics presented in this book, and often much, much more. While great as references, this makes teaching from them more difficult because the materials are not typically presented in the order that most professors cover them in their lectures and more than half the information p

This book covers the area of tribology broadly, providing important introductory chapters to fundamentals, processing, and applications of tribology. The book is designed primarily for easy and cohesive understanding for students and practicing scientists pursuing the area of tribology with focus on materials. This book helps students and practicing scientists alike understand that a comprehensive knowledge about the friction and wear properties of advanced materials is essential to further design and development of new materials. The description of the wear micromechanisms of various materials will provide a strong background to the readers as how to design and develop new tribological materials. This book also places importance on the development of new ceramic composites in the context of tribological applications. Some of the key features of the book include: Fundamentals section highlights the salient issues of ceramic processing and mechanical properties of important oxide and non-oxide ceramic systems; State of the art research findings on important ceramic composites are included and an understanding on the behavior of silicon carbide (SiC) based ceramic composites in dry sliding wear conditions is presented as a case study; Erosion wear behavior of ceramics, in which case studies on high temperature erosion behavior of SiC based composites and zirconium diboride (ZrB₂) based composites is also covered; Wear behavior of ceramic coatings is rarely discussed in any tribology related books therefore a case study explaining the abrasion wear behavior of WC-Co coating is provided. Finally an appendix chapter is included in which a collection of several types of questions including multiple choice, short answer and long answer are provided.

This book describes the rapidly expanding field of two-dimensional (2D) transition metal carbides and nitrides (MXenes). It covers fundamental knowledge on synthesis, structure, and properties of these new materials, and a description of their processing, scale-up and emerging applications. The ways in which the quickly expanding family of MXenes can outperform other novel nanomaterials in a variety of applications, spanning from energy

storage and conversion to electronics; from water science to transportation; and in defense and medical applications, are discussed in detail.

This book presents an experimentally validated probabilistic strength theory of structures made of concrete, composites, ceramics and other quasibrittle materials.

This is a textbook on the mechanical behavior of materials for mechanical and materials engineering. It emphasizes quantitative problem solving. This new edition includes treatment of the effects of texture on properties and microstructure in Chapter 7, a new chapter (12) on discontinuous and inhomogeneous deformation, and treatment of foams in Chapter 21.

A handy reference for technicians who want to understand the nature, properties and applications, of engineering ceramics. The book meets the needs of those working in the ceramics industry, as well as of technicians and engineers involved in the application of ceramic materials.

This book discusses fundamentals of nanostructured ceramics involving functional, structural and high temperature materials. It provides both solved numerical problems and unsolved problems to enable the reader to envisage the correlation between synthesis process and properties in the perspective of new material development. It serves as a concise text to answer the basics and achieve research goals for academia and industry. Key Features Deals with basic strategy on data interpretation for nanostructured ceramics Proposes to bridge the gap between the nano and bulk properties of nanostructured ceramics Discusses brief schematics and equations to understand the different properties of nano to bulk ceramics Presents mode of data acquisition and interpretation through statistical module and solved numerical Includes unsolved numericals based on properties, data acquisition and interpretation

This Text Provides A Balanced And Current Treatment Of The Full Spectrum Of Engineering Materials, Covering All The Physical Properties, Applications And Relevant Properties Associated With The Subject. It Explores All The Major Categories Of Materials While Offering Detailed Examinations Of A Wide Range Of New Materials With High-Tech Applications.

Although ceramics have been known to mankind literally for millennia, research has never ceased. Apart from the classic uses as a bulk material in pottery, construction, and decoration, the latter half of the twentieth century saw an explosive growth of application fields, such as electrical and thermal insulators, wear-resistant bearings, surface coatings, lightweight armour, or aerospace materials. In addition to plain, hard solids, modern ceramics come in many new guises such as fabrics, ultrathin films, microstructures and hybrid composites. Built on the solid foundations laid down by the 20-volume series *Materials Science and Technology*, *Ceramics Science and Technology* picks out this exciting material class and illuminates it from all sides. Materials scientists, engineers, chemists, biochemists, physicists and medical researchers alike will find this work a treasure trove for a wide range of ceramics knowledge from theory and fundamentals to practical approaches and problem solutions.

A combination of the materials science, manufacturing processes, and pioneering research and developments of SiGe and strained-Si have offered an unprecedented high level of performance enhancement at low manufacturing costs. Encompassing all of these areas, *Strained-Si Heterostructure Field Effect Devices* addresses the research needs associated with the front-end aspects of extending CMOS technology via strain engineering. The book provides the basis to compare existing technologies with the future technological directions of silicon heterostructure CMOS. After an introduction to the material, subsequent chapters focus on microelectronics, engineered substrates, MOSFETs, and hetero-FETs. Each chapter presents recent research findings, industrial devices and circuits, numerous tables and figures, important references, and, where applicable, computer simulations. Topics covered include applications of strained-Si films in SiGe-based CMOS technology, electronic properties of biaxial strained-Si films, and the developments of the gate dielectric formation on strained-

Si/SiGe heterolayers. The book also describes silicon hetero-FETs in SiGe and SiGeC material systems, MOSFET performance enhancement, and process-induced stress simulation in MOSFETs. From substrate materials and electronic properties to strained-Si/SiGe process technology and devices, the diversity of R&D activities and results presented in this book will no doubt spark further development in the field.

The second edition of this textbook includes refined text in each chapter, new sections on corrosion of steel-reinforced concrete and on cathodic protection of steel reinforced bars embedded in concrete, and some new solved examples. The book introduces mathematical and engineering approximation schemes for describing the thermodynamics and kinetics of electrochemical systems, which are the essence of corrosion science, in addition to electrochemical corrosion, forms of corrosion and mechanisms of corrosion. This approach should capture the reader's attention on the complexity of corrosion. Thus, the principles of electrochemistry and electrochemical cells are subsequently characterized in simple electrolytes from a thermodynamics point of view.

Ceramic Materials: Science and Engineering is an up-to-date treatment of ceramic science, engineering, and applications in a single, comprehensive text. Building on a foundation of crystal structures, phase equilibria, defects, and the mechanical properties of ceramic materials, students are shown how these materials are processed for a wide diversity of applications in today's society. Concepts such as how and why ions move, how ceramics interact with light and magnetic fields, and how they respond to temperature changes are discussed in the context of their applications. References to the art and history of ceramics are included throughout the text, and a chapter is devoted to ceramics as gemstones. This course-tested text now includes expanded chapters on the role of ceramics in industry and their impact on the environment as well as a chapter devoted to applications of ceramic materials in clean energy technologies. Also new are expanded sets of text-specific homework problems and other resources for instructors. The revised and updated Second Edition is further enhanced with color illustrations throughout the text.

Updated and improved, this revised edition of Michel Barsoum's classic text *Fundamentals of Ceramics* presents readers with an exceptionally clear and comprehensive introduction to ceramic science. Barsoum offers introductory coverage of ceramics, their structures, and properties, with a distinct emphasis on solid state physics and chemistry. Key equations are derived from first principles to ensure a thorough understanding of the concepts involved. The book divides naturally into two parts. Chapters 1 to 9 consider bonding in ceramics and their resultant physical structures, and the electrical, thermal, and other properties that are dependent on bonding type. The second part (Chapters 11 to 16) deals with those factors that are determined by microstructure, such as fracture and fatigue, and thermal, dielectric, magnetic, and optical properties. Linking the two sections is Chapter 10, which describes sintering, grain growth, and the development of microstructure. *Fundamentals of Ceramics* is ideally suited to senior undergraduate and graduate students of materials science and engineering and related subjects.

The field of beam physics touches many areas of physics, engineering, and the sciences. In general terms, beams describe ensembles of particles with initial conditions similar enough to be treated together as a group so that the motion is a weakly nonlinear perturbation of a chosen reference particle. Particle beams are used in a variety of areas, ranging from electron microscopes, particle

spectrometers, medical radiation facilities, powerful light sources, and astrophysics to large synchrotrons and storage rings such as the LHC at CERN. An Introduction to Beam Physics is based on lectures given at Michigan State University's Department of Physics and Astronomy, the online VUBeam program, the U.S. Particle Accelerator School, the CERN Academic Training Programme, and various other venues. It is accessible to beginning graduate and upper-division undergraduate students in physics, mathematics, and engineering. The book begins with a historical overview of methods for generating and accelerating beams, highlighting important advances through the eyes of their developers using their original drawings. The book then presents concepts of linear beam optics, transfer matrices, the general equations of motion, and the main techniques used for single- and multi-pass systems. Some advanced nonlinear topics, including the computation of aberrations and a study of resonances, round out the presentation.

The current book contains twenty-two chapters and is divided into three sections. Section I consists of nine chapters which discuss synthesis through innovative as well as modified conventional techniques of certain advanced ceramics (e.g. target materials, high strength porous ceramics, optical and thermo-luminescent ceramics, ceramic powders and fibers) and their characterization using a combination of well known and advanced techniques. Section II is also composed of nine chapters, which are dealing with the aqueous processing of nitride ceramics, the shape and size optimization of ceramic components through design methodologies and manufacturing technologies, the sinterability and properties of ZnNb oxide ceramics, the grinding optimization, the redox behaviour of ceria based and related materials, the alloy reinforcement by ceramic particles addition, the sintering study through dihedral surface angle using AFM and the surface modification and properties induced by a laser beam in pressings of ceramic powders. Section III includes four chapters which are dealing with the deposition of ceramic powders for oxide fuel cells preparation, the perovskite type ceramics for solid fuel cells, the ceramics for laser applications and fabrication and the characterization and modeling of protonic ceramics.

Fracture Mechanics is an essential tool to evaluate whether a component is likely to fail or not. This book has been written in a simple and step-wise manner to help readers familiarise with the basic and advanced topics. Additionally it has over 185 illustrations to further reinforce and simplify the learning process. With this coverage, the book will be useful to professionals and students of engineering. With contributions from leading experts in their respective fields, Metal and Ceramic Matrix Composites provides a comprehensive overview of topics on specific materials and trends. It is a subject regularly included as a final year option in materials science courses and is also of much industrial and academic interest. The book begins with a selection of chapters describing the most common commercial applications of composite materials, including those in the aerospace, automotive, and power generation industries. Section 2 outlines

manufacturing and processing methods used in the production of composite materials ranging from basic aluminium matrix composites, through particle reinforced composites, to composites using novel matrix fibres such as titanium-silicon carbide and ceramics. Section 3 is devoted to the mechanical behaviour of different matrix materials and structure-property relations, with particular attention paid to failure and fracture mechanisms. The final section considers those new fibres and composite materials currently in development, including high strength copper composites, porous particle composites, active composites, and ceramic nanocomposites.

Since the isolation and characterization of graphene, there has been a growing interest in 2D materials owing to their unique properties compared to their 3D counterparts. Recently, a family of 2D materials of early transition metal carbides and nitrides, labelled MXenes, has been discovered (Ti_2CT_z , $\text{Ti}_3\text{C}_2\text{T}_z$, $\text{Mo}_2\text{TiC}_2\text{T}_z$, Ti_3CNT_z , $\text{Ta}_4\text{C}_3\text{T}_z$, $\text{Ti}_4\text{N}_3\text{T}_z$ among many others), where T stands for surface-terminating groups (O, OH, and F). MXenes are mostly produced by selectively etching A layers (where A stands for group A elements, mostly groups 13 and 14) from the MAX phases. The latter are a family of layered ternary carbides and/or nitrides and have a general formula of $\text{M}_{n+1}\text{AX}_n$ ($n = 1-3$), where M is a transition metal and X is carbon and/or nitrogen. The produced MXenes have a conductive carbide core and a non-conductive O-, OH- and/or F-terminated surface, which allows them to work as electrodes for energy storage applications, such as Li-ion batteries and supercapacitors. Prior to this work, MXenes were produced in the form of flakes of lateral dimension of about 1 to 2 microns; such dimensions and form are not suitable for electronic characterization and applications. I have synthesized various MXenes ($\text{Ti}_3\text{C}_2\text{T}_z$, Ti_2CT_z and Nb_2CT_z) as epitaxial thin films, a more suitable form for electronic and photonic applications. These films were produced by HF, NH_4HF_2 or $\text{LiF} + \text{HCl}$ etching of magnetron sputtered epitaxial Ti_3AlC_2 , Ti_2AlC , and Nb_2AlC thin films. For transport properties of the Ti-based MXenes, Ti_2CT_z and $\text{Ti}_3\text{C}_2\text{T}_z$, changing n from 1 to 2 resulted in an increase in conductivity but had no effect on the transport mechanism (i.e. both $\text{Ti}_3\text{C}_2\text{T}_x$ and Ti_2CT_x were metallic). In order to examine whether the electronic properties of MXenes differ when going from a few layers to a single flake, similar to graphene, the electrical characterization of a single $\text{Ti}_3\text{C}_2\text{T}_z$ flake with a lateral size of about 10 μm was performed. These measurements, the first for MXene, demonstrated its metallic nature, along with determining the nature of the charge carriers and their mobility. This indicates that $\text{Ti}_3\text{C}_2\text{T}_z$ is inherently of 2D nature independent of the number of stacked layers, unlike graphene, where the electronic properties change based on the number of stacked layers. Changing the transition metal from Ti to Nb, viz. comparing Ti_2CT_z and Nb_2CT_z thin films, the electronic properties and electronic conduction mechanism differ. Ti_2CT_z showed metallic-like behavior (resistivity increases with increasing temperature) unlike Nb_2CT_z where the conduction occurs via variable range hopping mechanism (VRH) - where resistivity

decreases with increasing temperature. Furthermore, these studies show the synthesis of pure Mo_2CTz in the form of single flakes and freestanding films made by filtering Mo_2CTz colloidal suspensions. Electronic characterization of free-standing films made from delaminated Mo_2CTz flakes was investigated, showing that a VRH mechanism prevails at low temperatures (7 to ~ 60 K). Upon vacuum annealing, the room temperature, RT, conductivity of Mo_2CTx increased by two orders of magnitude. The conduction mechanism was concluded to be VRH most likely dominated by hopping within each flake. Other Mo-based MXenes, $\text{Mo}_2\text{TiC}_2\text{Tz}$ and $\text{Mo}_2\text{Ti}_2\text{C}_3\text{Tz}$, showed VRH mechanism at low temperature. However, at higher temperatures up to RT, the transport mechanism was not clearly understood. Therefore, a part of this thesis was dedicated to further investigating the transport properties of Mo-based MXenes. This includes Mo_2CTz , out-of-plane ordered $\text{Mo}_2\text{TiC}_2\text{Tz}$ and $\text{Mo}_2\text{Ti}_2\text{C}_3\text{Tz}$, and vacancy ordered $\text{Mo}_{1.33}\text{CTz}$. Magneto-transport of free-standing thin films of the Mo-based MXenes were studied, showing that all Mo-based MXenes have two transport regimes: a VRH mechanism at lower temperatures and a thermally activated process at higher temperatures. All Mo-based MXenes except $\text{Mo}_{1.33}\text{CTz}$ show that the electrical transport is dominated by inter-flake transfer. As for $\text{Mo}_{1.33}\text{CTz}$, the primary electrical transport mechanism is more likely to be intra-flake. The synthesis of vacancy ordered MXenes ($\text{Mo}_{1.33}\text{CTz}$ and $\text{W}_{1.33}\text{CTz}$) raised the question of possible introduction of vacancies in all MXenes. Vacancy ordered MXenes are produced by selective etching of Al and (Sc or Y) atoms from the parent 3D MAX phases, such as $(\text{Mo}_{2/3}\text{Sc}_{1/3})_2\text{AlC}$, with in-plane chemical ordering of Mo and Sc. However, not all quaternary parent MAX phases form the in-plane chemical ordering of the two M metals; thus the synthesis of the vacancy-ordered MXenes is restricted to a very limited number of MAX phases. I present a new method to obtain MXene flakes with disordered vacancies that may be generalized to all quaternary MAX phases. As proof of concept, I chose Nb-C MXene, as this 2D material has shown promise in several applications, including energy storage, photothermal cell ablation and photocatalysts for hydrogen evolution. Starting from synthesizing $(\text{Nb}_{2/3}\text{Sc}_{1/3})_2\text{AlC}$ quaternary solid solution and etching both the Sc and Al atoms resulted in $\text{Nb}_{1.33}\text{C}$ material with a large number of vacancies and vacancy clusters. This method may be applicable to other quaternary or higher MAX phases wherein one of the transition metals is more reactive than the other, and it could be of vital importance in applications such as catalysis and energy storage.

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