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Jeffrey Strickland



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The Elements , *Synthesis and Characterization of Transition Metal Diborides* Jimmy Thörnberg, 2021-01-20 This thesis is devoted towards physical vapor deposition PVD of thin films of transition metal TM diborides focused on the material system $\text{Ti}_{1-x}\text{Al}_x\text{B}_2$ and CrB_x . The metal diborides are a large family of compounds with both metallic and ceramic properties due to its bonding nature being a mix of covalent and ionic bonds. Their characteristics include e.g. good mechanical, electrical, and thermal properties while an improved oxidation and corrosion resistance are currently sought after. Furthermore, while the ideal composition of these diborides is TM_2B_2 i.e. with a B to metal ratio of 2, the stoichiometry in the PVD deposited films typically diverges from this ratio. TiB_x is often reported to be overstoichiometric with x well above 2. One of the most known and commonly used member of the TM diboride family is TiB_x primarily used in hard coating applications such as tools for machining Al. However, the material displays a fracture toughness and oxidation resistance that ideally needs to be improved. The films presented in this thesis were deposited by high power impulse magnetron sputtering HiPIMS and direct current magnetron sputtering DCMS. Using both methods facilitates an improved control of both microstructure and composition and hence the material's properties. With HiPIMS understoichiometric TiB_x films were grown and it was shown that these films can match and even exceed the overstoichiometric counterpart deposited with DCMS in terms of mechanical properties. The hardness and fracture toughness for $\text{TiB}_{1.43}$ films were measured at 43.9 GPa and 4.201 MPa m compared to $\text{TiB}_{2.70}$ films at 37.7 GPa and 3.101 MPa m. Furthermore, the understoichiometric films significantly improve the oxidation resistance. Air annealing of $\text{TiB}_{1.43}$, $\text{TiB}_{2.20}$, and $\text{TiB}_{2.70}$ films at 400 °C showed an average oxidation rate of 2.9, 1.5, 7.1, 1.1, 0 and 20.0, 5.0 nm/h respectively, explained by the microstructural difference between over and understoichiometric material. In TiB_x films where $x > 2$ there is a B-rich phase in the grain boundaries which is suggested to enhance oxidation. The hygroscopic nature of B_2O_3 causes more rapid oxidation and evaporation thus providing an easy oxidation pathway in B-rich regions. However, understoichiometric films where $x < 2$ do not show any significant boundary phases. Instead, the B deficiency is presented as planar defects with Ti-rich stacking faults. Hence, the absence of the B-rich phase has strongly contributed to increasing the oxidation resistance. Oxidation resistance and mechanical properties were also investigated for understoichiometric $\text{Ti}_{1-x}\text{Al}_x\text{B}_2$ coatings with varying Ti/Al and B/M ratios obtained from both HiPIMS and DCMS depositions. Al alloying of the TM diboride TiB_x significantly enhances the oxidation resistance. However, incorporating too much Al is at the expense of the excellent hardness seen in the pure TiB_x going from 46.2 GPa to 22.6 GPa for $\text{Ti}_{0.9}\text{Al}_{0.1}\text{B}_{1.3}$ and $\text{Ti}_{0.3}\text{Al}_{0.7}\text{B}_{1.3}$ respectively. Hence, a reduction in the Al content is needed to retain the mechanical properties. The boundary phase in this material consists of a $\text{Ti}_{1-x}\text{Al}_x\text{B}_2$ phase rich in either Al or B depending on the x and y values. An improved oxidation resistance in $\text{Ti}_{1-x}\text{Al}_x\text{B}_2$ was seen with reduced Al and B content proposed to be due to absence of phase in the grain boundaries in line with the observations for TiB_x . The oxide scale

thickness of Ti_{0.9}Al_{0.1}B_{1.3} and Ti_{0.9}Al_{0.1}B_{1.9} after air annealing at 600 °C for 10 h was measured to be 205 nm and 320 nm respectively. Moreover the trends indicate a reduced oxidation rate as the oxide scale grows thicker. A systematical study of DCMS deposited CrB_x coatings 1.90 × 2.08 was also performed motivated by CrB_x being a material of interest for providing potential corrosion resistance. All films irrespective of the deposition conditions exhibited 001 texture with epitaxial growth observed when increasing temperature from 500 °C to 900 °C. Higher density 5.2 g cm⁻³ and smoother surfaces was seen in films grown at lower pressure 5 mTorr (0.67 Pa) compared to higher pressure 20 mTorr (2.67 Pa) and was explained by less gas scattering leading to more energetic particles impinging on the surface. CrB_x film composition show no apparent dependence on substrate temperature and has a slight dependence on deposition pressure for the samples deposited at 900 °C with reduced B content for increasing pressure. Overstoichiometric CrB_{2.08} films showed the presence of large B rich inclusions and B deficiency in CrB_{1.90} films presented as planar defects with Cr rich stacking faults similar to understoichiometric TiB_x. The thorough investigations of all the systems in this thesis are aimed towards improving the understanding of the correlation between the thin film synthesis process and the resulting composition and microstructure which in turn dictates the properties of thin films. A particular emphasis is put on control of composition.

I den här avhandlingen fokuserar jag på belggningar av tunna filmer dvs tunna lager av material som läggs på en yta för att ge ytan vissa specifika egenskaper. Jag genomför metodiska analyser av de filmer jag för fram för olika belggningsmetoder: high power impulse magnetron sputtering (HiPIMS) och den mer konventionella metoden directcurrent magnetron sputtering (DCMS). Dessa metoder skiljer sig främst i antal parametrar man kan variera för att kontrollera processen som styr vilket material som bildas och i HiPIMS är den metod med flest parametrar. Anledningen till att HiPIMS inte har sett ett större användningsområde till dags dato är att det är en relativt ny process jämfört med DCMS och på grund av den komplexitet som tillkommer när man utvecklar någon tillväxtparametrar för de processerna är en grundläggande förståelse av både processen och materialet nödvändigt för att få ett optimerat material med specifika önskade egenskaper.

Material i fokus i denna avhandling är TiB_x, Ti_{1-x}Al_xB_{2-y} och CrB_x även kallade övergångsmetall diborider där Ti står för titan, Al för aluminium, Cr för krom, B för bor och x, y står för variabler i sammansättningen av materialet. Dessa diborider består med sig unika egenskaper från respektive element och innehåller en blandning av kovalenta bindningar och jon bindningar. Beroende på sammansättningen av atomer så kan vi se olika mekaniska, elektriska och termiska egenskaper samt olika grad av oxidering och eroderings resistans. TiB_x är till exempel välkända för sina tillämpningar inom skrande bearbetning men har inte lika lovande egenskaper när det kommer till beständighet mot oxidering. Det här är delvis en konsekvens av att man idag kommersiellt använder sig främst av DCMS för tillväxt av dessa belggningar och denna metod typiskt genererar verstärkt kiometrisk tunna filmer av TiB_x vilket i sin tur påverkar beständigheten mot oxidering negativt. Med hjälp av HiPIMS kan man kontrollera starkt kiometrin av filmen i större grad och kan således generera understärkt kiometrisk TiB_x vilket som jag visar på har bättre mekaniska egenskaper bland annat högre hårdhet, bättre brottseghet och förbättrad beständighet mot

oxidering kontra den verst kiometriska motsvarigheten Hur mikrostrukturen i verst kiometriska TiBx filmer ser ut r v lk nt d r
 verfl digt B ansamlas i korng r nserna och bilder en s k B rik v vnadsfas Jag har p visat hur motsvarande mikrostruktur ser ut f
 r underst kiometrisk TiBx filmer n got som fram tills nu varit ok nt I dessa faser saknas v vnadsfas i korng r nserna och ist llet
 hittas verskottet av Ti som plandefekter i de kolumn ra TiB2 strukturerna i filmen Jag visar p att avsaknaden av v vnadsfas i
 korng r nserna tydligt f rb ttrar best ndigheten mot oxidering vilket troligtvis beror p att just korng r nserna och deras inneh ll
 agerar som en katalys for oxidering P samma s tt unders ker jag hur materialsystemet Ti1 xAlxBy 2 beter sig med varierande
 Ti Al f rh llande och ven B M f rh llande bor till metall i filmer skapade med b de DCMS och HiPIMS M let med inkluderingen
 av Al r just att f rb ttra best ndighet mot oxidering och samtidigt bevara de tr v rda mekaniska egenskaperna som filmer av
 TiBx har Korng r nserna i det h r materialet best r av en v vnadsfasblandning rik p antingen Al eller B beroende p f rh llandet
 mellan x och y i Ti1 xAlxBy 2 Jag visar p att en reducering av denna v vnadsfas ven h r f rb ttrar best ndigheten mot oxidering
 Det p visas genom att reducera Al och B inneh llet i filmerna vilket minskar v vnadsfasen i korng r nserna och s ledes f rb
 ttras best ndigheten mot oxidering En systematisk unders kning av tunna filmer av CrBx belagda med DCMS har genomf rts
 d detta r ett materialsystem med potential f r best ndighet mot korrosion B de l tt ver och underst kiometriska filmer v xtes
 och fick sin mikrostruktur och lokala sammans ttning unders kt Alla filmer p visade en 001 textur med epitaxiell tillv xt n r
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 mTorr 0 67 Pa j mf rt med h gre tryck 20 mTorr 2 67 Pa Kompositionen f r CrBx filmerna p visade inte ett
 temperaturberoende men visade ett marginellt beroende p bel ggningstryck f r prover v xta vid 900 C ven observerat f r
 underst kiometriska CrB1 90 filmer r att underskottet av B presenteras som plandefekter med Cr rika plan i de kolumn ra
 CrB2 strukturerna i filmen precis som i underst kiometrisk TiBx I verst kiometriska CrB2 08 filmer s visades stora
 inneslutningar av ansamlat B Chemical Elements , Polymorphism in Pharmaceutical Solids Harry G.
 Brittain,2018-11-12 Using clear and practical examples Polymorphism of Pharmaceutical Solids Second Edition presents a
 comprehensive examination of polymorphic behavior in pharmaceutical development that is ideal for pharmaceutical
 development scientists and graduate students in pharmaceutical science This edition focuses on pharmaceutical aspects of
 polymorphism a *Physical and Analytical Electrochemistry (General)* P. Trulove,2008-04 The papers included in this issue
 of ECS Transactions were originally presented in the symposium Physical and Analytical Electrochemistry General Session
 held during the 212th meeting of The Electrochemical Society in Washington DC from October 7 to 12 2007 Molecular
 Driving Forces Ken Dill,Sarina Bromberg,2010-10-21 Molecular Driving Forces Second Edition E book is an introductory
 statistical thermodynamics text that describes the principles and forces that drive chemical and biological processes It
 demonstrates how the complex behaviors of molecules can result from a few simple physical processes and how simple
 models provide surprisingly accurate insights into the workings of the molecular world Widely adopted in its First Edition

Molecular Driving Forces is regarded by teachers and students as an accessible textbook that illuminates underlying principles and concepts The Second Edition includes two brand new chapters 1 Microscopic Dynamics introduces single molecule experiments and 2 Molecular Machines considers how nanoscale machines and engines work The Logic of Thermodynamics has been expanded to its own chapter and now covers heat work processes pathways and cycles New practical applications examples and end of chapter questions are integrated throughout the revised and updated text exploring topics in biology environmental and energy science and nanotechnology Written in a clear and reader friendly style the book provides an excellent introduction to the subject for novices while remaining a valuable resource for experts

Cathodic Arcs André Anders,2009-07-30 Cathodic arcs are among the longest studied yet least understood objects in science Plasma generating tiny spots appear on the cathode they are highly dynamic and hard to control With an approach emphasizing the fractal character of cathode spots strongly fluctuating plasma properties are described such as the presence of multiply charged ions that move with supersonic velocity Richly illustrated the book also deals with practical issues such as arc source construction macroparticle removal and the synthesis of dense well adherent coatings The book spans a bridge from plasma physics to coatings technology based on energetic condensation appealing to scientists practitioners and graduate students alike

Handbook of Chemistry and Physics David R. Lide,2000-06-01 The latest edition of the world's most popular scientific reference features tables and reference sections on everything from the Periodic Table to the bond lengths in organometallic compounds Featuring the latest facts and figures the CRC Handbook of Chemistry and Physics contains all the most frequently used data in science including the periodic table of the elements basic constants and units and geophysical data For decades physicists and chemists have turned to this handbook as their primary source for reliable data Every year material is critically evaluated new data is added and existing tables are updated The 81st edition includes eight new and forty revised or updated tables Nowhere else will you find such a useful compilation of scientific data Don't be left behind Your research deserves the best data available the CRC Handbook of Chemistry and Physics has it Tables new in the 81st edition Melting Point Index of Organic Compounds Boiling Point Index of Organic Compounds Electrical Conductivity of Water Properties of Liquid Helium Bond Length in Organometallic Compounds filling an important gap in previous editions Organic Magnets Pressure Volume Temperature Relationship for Polymer Melts Characteristics of Human Hearing Tables updated in the 81st edition Fundamental Physical Constants reflects the first change in these international recommendations in 14 years Conversion Factors The Elements the first major revision in more than five years Dissociation Constants of Organic Acids and Bases Dipole Moments of Molecules in the Gas Phase Threshold Limits for Airborne Contaminants

Sulfuric Acid Digestion, Sulfuric Acid Baking, and Sulfation Roasting in Mineral and Chemical Processing, and Extractive Metallurgy François Cardarelli,2022-12-17 This monograph is primarily intended to serve as a concise review of the industrial utilization of sulfuric acid and the plethora of sulfation techniques used extensively in the mineral chemical

and metallurgical industries across the world The information has been presented in such a form that industrial chemists chemical engineers and other practicing engineers scientists professors and technologists will have access to relevant scientific and technical information supported by key data gathered from several disseminated sources along with a brief description of each major industrial processes e g phosphates titanium dioxide lithium alumina rare earths potassium and beryllium and finally several novel sulfation technologies that might be implemented in the near future This monograph will be of value also to men and women engaged in other branches of chemistry and metallurgy that want to understand these techniques outside their field of expertise Finally the monograph may be of interest to persons in the chemical and metal industries occupying nontechnical positions such as executives patent attorneys traders purchasing agents salesmen and women to whom a general knowledge of the technical aspect of their business would be helpful The following topics are covered Physical and chemical properties of sulfuric acid and oleums Corrosion resistant materials Thermochemistry of sulfation reactions Industrial sulfation processes Novel sulfation processes By products effluents and wastes Concentration and regeneration of sulfuric acid Prototype and pilot testing Health and safety Economic data Appendices Zeolites For Cleaner Technologies Jean-pierre Gilson, Michel Guisnet, 2002-09-19 This book written and edited by leading authorities from academia and industrial groups covers both preventive and curative zeolite based technologies in the field of chemical processing The opening chapter presents the state of the art in zeolite science The two subsequent chapters summarize the chemistries involved in the processes and the constraints imposed on the catalyst adsorbent Three major areas are covered oil refining petrochemicals and fine chemicals A chapter on the curative use of zeolites in pollution abatement completes this overview In the area of oil refining a general lecture sets the scene for present and future challenges It is followed by in depth case studies involving FCC hydrocracking and light naphtha isomerization Also an entire chapter is devoted to the often overlooked subject of base oils In the area of petrochemicals the processing of aromatics and olefins is described and special attention is paid to the synergy between catalysis and separation on molecular sieves **AsiaNano 2002** Teruya Ishihara, Masatsugu Shimomura, 2003 This book deals with the broad spectrum of nanoscience and nanotechnology where interdisciplinary collaboration is essential Focuses are placed on materials nanoparticles dendrimer CNT fabrication LB film SAM alternative adsorption microcontact printing photofabrication and characterization scanning probe microscopy and electron microscopy on the nanoscale Emerging applications to nanophotonics and nanobionics are discussed as well The proceedings have been selected for coverage in OCo Materials Science Citation Index OCo Index to Scientific High Density Diamond Whisker Fabrication and Suppression of Secondary Electron Emission by Whiskers D Jeon et al Preparation and Stability of the Nanochains Consisting of Copper Nanoparticles and PVA Nanofiber C Wang et al Properties of ZnO Nanotetrapods J Kang et al Fabrication of CdS Dot Array Using Polymer Honeycomb Template N Fukuda Deep UV Photopatterning of Self Assembled Monolayer and Its Application in Bioelectronic Device S Y Oh et al Resonant Light

Transmission in Metallic Photonic Crystal Slabs X Luo Electric Conductivity of Nucleic Acid Polymer Monolayer Y Hashimoto et al Nanoscale Friction and Related Tribological Phenomena at Solid Interfaces T Kawaguchi and other papers Readership Graduate students academics researchers and industrialists in nanoscience and nanotechnology **Ultrananocrystalline Diamond** Olga A. Shenderova, Dieter M. Gruen, 2006-08-10 Ultrananocrystalline Diamond Syntheses Properties and Applications is a unique practical reference handbook that brings together the basic science of nanoscale carbon structures particularly its diamond phase with detailed information on nanodiamond synthesis properties and applications Here you will learn about UNCD in its two forms as a dispersed powder made by detonation techniques and as a chemical vapor deposited film You will also learn about the superior mechanical tribological transport electrochemical and electron emission properties of UNCD for a wide range of applications including MEMS NEMS surface acoustic wave SAW devices electrochemical sensors coatings for field emission arrays photonic and RF switching biosensors and neural prostheses and more This Everything about Ultra nanocrystalline Diamond book with 16 chapters is written by leading experts worldwide It is for everyone who researches carbon nanostructures everyone who produces them everyone who characterizes them and everyone who builds devices using them *Electrocatalysis*, 2006 *Advanced Excel for Scientific Data Analysis* Robert De Levie, 2004 This guide to Excel focuses on three areas least squares Fourier transformation and digital simulation It illustrates the techniques with detailed examples many drawn from the scientific literature It also includes and describes a number of sample macros and functions to facilitate common data analysis tasks De Levie is affiliated with Bowdoin College Annotation 2004 Book News Inc Portland OR booknews com [The Changing Energy Mix](#) Paul Meier, 2020-09-21 Energy comes in many shapes and forms from wind solar power geothermal and biomass to coal natural gas and petroleum The energy we consume is constantly changing but the use of these resources whether renewable or nonrenewable has long term impacts on our planet While there has been this recent shift to renewable energy within the United States the worldwide demand for all energy types continues to increase at a rapid rate In fact it has increased by 84% over the past twenty years Despite their dwindling supply these resources are still heavily relied on today Coal still accounts for 30% of the electricity generated by the United States even though natural gas is now the primary energy used to produce electricity Likewise only 7% of electricity usage worldwide is linked to solar and wind energy In *The Changing Energy Mix* Paul F Meier compares twelve renewable and nonrenewable energy types using twelve common technical criteria These criteria span projected reserves cost to the consumer and supplier energy balances environmental issues land area required and lasting impacts While explaining the pros and cons of these resources Meier takes readers through the history of energy in the United States and world He provides insight into energy sources such as wind powered and solar powered electricity which did not exist until the mid and late 80s respectively and he explains the constantly evolving world of energy Breaking down the potential promises and struggles of transitioning to a more renewable energy based economy Meier explains the positive and negative

implications of these various sources of energy The resulting book equips readers with a unique understanding of the history availability technology implementation cost and concerns of renewable and nonrenewable energy **Light Sources 2004**

Proceedings of the 10th International Symposium on the Science and Technology of Light Sources A

Zissis, 2004-07-20 Held every three years The International Symposia on the Science and Technology of Light Sources LS provide a unique forum for the international community of engineers scientists research organizations and academia from the lighting industry In Light Sources 2004 leaders in their respective fields discuss the latest findings and exciting developments in light source research Contributors provide valuable analyses and discussions on topics such as incandescent and halogen sources fluorescent discharge sources lamp related electronic gear high intensity discharge sources diagnostics solid state sources modeling dielectric barrier sources excimer devices and nonlighting applications **The Men of**

Manhattan Jeffrey Strickland, 2011-05-16 The Men of Manhattan is a short history of the origins and development of the American atomic bomb program during World War II focusing on the men and woman who made it possible Beginning with the scientific developments of the pre war years the book details the role of scientific exploration in conducting a secret nationwide enterprise that took science from the laboratory and into combat with an entirely new type of weapon Throughout the book short biographies of the men and a women Lise Meitner Leona Woods Marshall Libby and Chien Shiung Wu are provided where most pertinent Although nuclear weapons still pose a threat to peace throughout the world splitting the atom was a watermark point in nuclear science and quantum physics Harnessed responsibly the enormous power of an atomic chain reaction can serve humanity for good e g atomic energy Nuclear medicine and x ray technology are examples of the benefits brought about by these pioneers the Men of Manhattan **Electrochemistry of Functional Supramolecular**

Systems Paola Ceroni, Alberto Credi, Margherita Venturi, 2010-01-26 With contributions from the most prominent experts around the world this resource provides an accessible summary of electrochemical techniques and the applications of electrochemical concepts to molecular level systems It describes the most important electro active functional supramolecular systems developed so far including rotaxanes and catenanes as molecular machines and as elements for information processing dendrimers as molecular batteries sensors light harvesting antennae and drug delivery systems and bio hybrid devices *The Coming of Materials Science* R.W. Cahn, 2001-03-16 The Coming of Materials Science both covers the

discipline of materials science and draws an impressionistic map of the present state of the subject The first chapter examines the emergence of the materials science concept in both academe and industry The second and third chapters delve back into the prehistory of materials science examining the growth of such concepts as atoms crystals and thermodynamics and also examine the evolution of a number of neighbouring disciplines to see what helpful parallels might emerge The book contains numerous literature references Many refer to the earliest key papers and books while others are to sources often books offering a view of the present state of a topic Early references are to the past but as the book continues it brings the

reader up to date with more recent sources The author Professor Robert Cahn FRS has striven to be critical about the history of the discipline of materials science and to draw general conclusions about scientific practice from what he has discovered about the evolution of materials science Further issues that the book highlights include What is a scientific discipline How do disciplines merge and differentiate Can a discipline also be interdisciplinary Is materials science a real discipline A large range of themes is presented in the book and readers are invited to interact with the author if they reach alternative conclusions This book is not just for reading and reference but exists to stimulate thought and provoke discussion as well

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