Oxide Scale Behavior In High Temperature Metal Processing

The Effect of Surface-applied Reactive Elements on the High Temperature Oxidation of Chromium-containing Alloys
Joint EPRI – 123HiMAT International Conference on Advances in High-Temperature Materials
Advances and Real-Life Applications
High Performance Structural Materials
High Temperature Corrosion
High Temperature Corrosion of Advanced Materials and Protective Coatings
Aerospace Materials Handbook
Long-Term Cyclic Oxidation Behavior of Wrought Commercial Alloys at High Temperatures
Structural Intermetallics and Intermetallic Matrix Composites
Introduction to High Temperature Oxidation and Corrosion
High Temperature Coatings
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Advances in Materials Technology for Fossil Power Plants
Self-Organization During Friction
Proceedings of Chinese Materials Conference 2017
Fourth volume
High-Temperature Oxidation and Corrosion 2005
Proceedings of the International Symposium
Intermetallics Research Progress
Oxide Scale Behavior in High Temperature Metal Processing
Study of Grain Boundary Character
High Temperature Corrosion and Materials Chemistry
Wear of Materials
High Temperature Corrosion
second volume
High-Temperature Oxidation and Corrosion 2010

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The Effect of Surface-applied Reactive Elements on the High Temperature Oxidation of Chromium-containing Alloys CRC Press
Selected, peer reviewed papers from the 3rd International Symposium on High-Temperature Oxidation and Corrosion, (ISHOC), November 8-11, 2010, Zushi, Japan
Joint EPRI – 123HiMAT International Conference on Advances in High-Temperature Materials John Wiley & Sons
High Temperature Coatings, Second Edition, demonstrates how to counteract the thermal effects of rapid corrosion and degradation of exposed materials and equipment that can occur under high operating temperatures. This is the first true practical guide on the use of thermally protective coatings for high-temperature applications, including the latest developments in materials used for protective coatings. It covers the make-up and behavior of such materials under thermal stress and the methods used for applying them to specific types of substrates, as well as invaluable advice on inspection and repair of existing thermal coatings. With his long experience in the aerospace gas turbine industry, the author has compiled the very latest in coating materials and coating technologies, as well as hard-to-find guidance on maintaining and repairing thermal coatings, including appropriate inspection protocols. The book is supplemented with the latest reference information and additional support to help readers find more application- and industry-type coatings specifications and uses. Offers an overview of the underlying fundamental concepts of thermally-protective coatings, including thermodynamics, energy kinetics, crystallography and equilibrium phases Covers essential chemistry and physics of underlying substrates, including steels, nickel-iron alloys, nickel-cobalt alloys and titanium alloys Provides detailed guidance on a wide variety of coating types, including those used against high temperature corrosion and oxidative degradation and thermal barrier coatings
Advances and Real-Life Applications Butterworth-Heinemann
Whether an airplane or a space shuttle, a flying machine requires advanced materials to provide a strong, lightweight body and a powerful engine that functions at high temperature. The Aerospace Materials Handbook examines these materials, covering traditional superalloys as well as more recently developed light alloys. Capturing state-of-the-art d
High Performance Structural Materials CRC Press
The result of a fruitful, on-going collaboration between academia and industry, this book reviews recent advances in research on oxide scale behavior in high-temperature forming processes. Presenting novel, previously neglected approaches, the authors emphasize the pivotal role of reproducible experiments to elucidate the oxide scale properties and develop quantitative models with predictive accuracy. Each chapter consists of a detailed, systematic examination of different aspects of oxide scale formation with immediate impact for researchers and developers in industry. The clear and stringent style of presentation makes this monograph both coherent and easily readable.
High Temperature Corrosion Elsevier
Reviews the science and engineering of high-temperature corrosion and provides guidelines for selecting the best materials for an array of system processes High-temperature corrosion (HTC) is a widespread problem in an array of industries, including power generation, aerospace,

automotive, and mineral and chemical processing, to name a few. This book provides engineers, physicists, and chemists with a balanced presentation of all relevant basic science and engineering aspects of high-temperature corrosion. It covers most HTC types, including oxidation, sulfidation, nitridation, molten salts, fuel-ash corrosion, H2S/H2 corrosion, molten fluoride/HF corrosion, and carburization. It also provides corrosion data essential for making the appropriate choices of candidate materials for high-temperature service in process conditions. A form of corrosion that does not require the presence of liquids, high-temperature corrosion occurs due to the interaction at high temperatures of gases, liquids, or solids with materials. HTC is a subject is of increasing importance in many areas of science and engineering, and students, researchers, and engineers need to be aware of the nature of the processes that occur in high-temperature materials and equipment in common use today, especially in the chemical, gas, petroleum, electric power, metal manufacturing, automotive, and nuclear industries. Provides engineers and scientists with the essential data needed to make the most informed decisions on materials selection Includes up-to-date information accompanied by more than 1,000 references, 80% of which from within the past fifteen years Includes details on systems of critical engineering importance, especially the corrosion induced by low-energy radionuclides Includes practical guidelines for testing and research in HTC, along with both the European and International Standards for high-temperature corrosion engineering Offering balanced, in-depth coverage of the fundamental science behind and engineering of HTC, High Temperature Corrosion: Fundamentals and Engineering is a valuable resource for academic researchers, students, and professionals in the material sciences, solid state physics, solid state chemistry, electrochemistry, metallurgy, and mechanical, chemical, and structural engineers.

High Temperature Corrosion of Advanced Materials and Protective Coatings CRC Press
This book is a printed edition of the Special Issue "Advances in Plastic Forming of Metals" that was published in Metals

Aerospace Materials Handbook ASM International
Intermetallics is concerned with all aspects of ordered chemical compounds between two or more metals and notably with their applications. This book covers new and important research on the crystal chemistry and bonding theory of intermetallics; determination and analysis of phase diagrams; the nature of superlattices, antiphase domains and order-disorder transitions; the geometry and dynamics of dislocations and related defects in intermetallics; theory and experiments relating to flow stress, work-hardening, fatigue and creep; response of deformed intermetallics to annealing; magnetic and electrical properties of intermetallics; structure and properties of grain and interphase boundaries; the effect of deviations from stoichiometry on physical and mechanical properties; crystallisation of intermetallics from the melt or amorphous precursors.

Long-Term Cyclic Oxidation Behavior of Wrought Commercial Alloys at High Temperatures MDPI
The resistance of Alloy 22 (N06022) to localized corrosion, mainly crevice corrosion, has been extensively investigated in the last few years. The effect of influencing variables such as temperature, applied potential, chloride concentration and nitrate inhibitor concentration have been addressed previously. At this time, it was important to address the effect an oxide film or scale that forms during the high temperature annealing process or solution heat treatment (SHT) and its subsequent water quenching. Electrochemical tests such as cyclic potentiodynamic polarization (CPP) have been carried out to determine the repassivation potential for localized corrosion and to assess the mode of attack on the specimens. Tests have been carried out in parallel using mill annealed (MA) specimens free from oxide on the surface. The comparative testing was carried out in six different electrolyte solutions at temperatures ranging from 60 to 100 C. Results show that the repassivation potential of the specimens containing the black anneal oxide film on the surface was practically the same as the repassivation potential for oxide-free specimens.

Structural Intermetallics and Intermetallic Matrix Composites Oxide Scale Behavior in High Temperature Metal Processing
This text for graduate and post graduate students covers fundamentals of high temperature corrosion and related topics. Early chapters cover the thermodynamics and kinetics of oxidation and defect structure of oxides and diffusion in oxides, and later chapters cover thin and thick layer oxidation, o

Introduction to High Temperature Oxidation and Corrosion The Electrochemical Society
This book contains eight chapters with original and innovative research studies in the field of grain boundaries. The results presented in the chapters of this book are very interesting and inspiring. This book will be very valuable to all researchers who are interested in the influence of grain boundaries on the structure and different kinds of properties of engineering materials. This book is also addressed to students and professional engineers working in the industry as well as to specialists who pay attention to all aspects related to grain boundaries and their impact on the various properties of innovative materials. The chapters of this book were developed by respected and well-known researchers from different countries.

High Temperature Coatings John Wiley & Sons
In our present era of nanoscience and nanotechnology, new materials are poised to take center stage in dramatically improving friction and wear behavior under extreme conditions. Compiled by two eminent experts, Self-Organization During Friction: Advanced Surface-Engineered Materials and Systems Design details the latest advances and developments i

High Temperature Mechanical Behaviour of Ceramic Composites Trans Tech Publications Ltd
The oxidation resistance of a high-temperature alloy is dependent upon sustaining the formation of a protective scale, which is strongly related to the alloying composition and the oxidation condition. The protective oxide scale only provides a finite period of oxidation resistance owing to its eventual breakdown, which is especially accelerated under thermal cycling conditions. This current study focuses on the long-term cyclic oxidation behavior of a number of commercial wrought alloys. The alloys studied were Fe- and Ni-based, containing different levels of minor elements, such as Si, Al, Mn, and Ti. Oxidation testing was conducted at 1000 and 1100 C in still air under both isothermal and thermal cycling conditions (1-day and 7-days). The specific aspects studied were the oxidation behavior of chromia-forming alloys that are used extensively in industry. The current study analyzed the effects of alloying elements, especially the effect of minor element Si, on cyclic oxidation resistance. The behavior of oxide scale growth, scale spallation, subsurface changes, and chromium interdiffusion in the alloy were analyzed in detail. A novel model was developed in the current study to predict the life-time during cyclic oxidation by simulating oxidation kinetics and chromium interdiffusion in the subsurface of chromia-forming alloys.

High Temperature Oxidation Behavior of Gamma-Ni+gamma'-Ni3Al Alloys and Coatings Modified with Pt and Reactive Elements Elsevier
This proceedings volume gathers selected papers presented at the Chinese Materials Conference 2017 (CMC2017), held in Yinchuan City, Ningxia, China, on July 06-12, 2017. This book covers a wide range of powder metallurgy, high performance aluminum alloys, high performance titanium & titanium alloys, superalloys, metal matrix composite, space materials science and technology, rare metals, refractory metals and their applications, advanced ceramics materials, nanostructured metals and alloys. The Chinese Materials Conference (CMC) is the most important serial conference of the Chinese Materials Research Society (C-MRS) and has been held each year since the early 1990s. The 2017 installment included 37 Symposia covering four fields: Advances in energy and environmental materials; High performance structural materials; Fundamental research on materials; and Advanced functional materials. More than 5500 participants attended the congress, and the organizers received more than 700 technical papers. Based on the recommendations of symposium organizers and after peer reviewing, 490 papers have been included in the present proceedings, which showcase the latest original research results in the field of materials, achieved by more than 300 research groups at various universities and research institutes.

Tribology in Manufacturing Technology ASTM International
A comprehensive text to the non-destructive evaluation of degradation of materials due to environment that takes an interdisciplinary approach Non-Destructive Evaluation of Corrosion and Corrosion-assisted Cracking is an important resource that covers the critical interdisciplinary topic of non-destructive evaluation of degradation of materials due to environment. The authors—noted experts in the field—offer an overview of the wide-variety of approaches to non-destructive evaluation and various types of corrosion. The text is filled with instructive case studies from a range of industries including aerospace, energy, defense, and processing. The authors review the most common non-destructive evaluation techniques that are applied in both research and industry in order to evaluate the properties and more importantly degradation of materials components or systems without causing damage. Ultrasonic, radiographic, thermographic, electromagnetic, and optical are some of the methods explored in the book. This important text: Offers a groundbreaking interdisciplinary approach to of non-destructive evaluation of corrosion and corrosion-assisted cracking Discusses techniques for non-destructive evaluation and various types of corrosion Includes information on the application of a variety of techniques as well as specific case studies Contains information targeting industries such as aerospace, energy, processing Presents information from leading researchers and technologists in both non-destructive evaluation and corrosion Written for life assessment and maintenance personnel involved in quality control, failure analysis, and R&D, Non-Destructive Evaluation of Corrosion and Corrosion-assisted Cracking is an essential interdisciplinary guide to the topic.

High Temperature Corrosion and Materials Chemistry 7 ASTM International
"The high temperature oxidation and ignition of magnesium (Mg) and its alloys have restricted their use in many applications, such as civilian aircraft and other aerospace components. Recent research activities have aimed at increasing the resistance of Mg alloys to oxidation and ignition by modifying the MgO surface scale to a more protective barrier oxide between the metal and the gas environment. Alloying is one of the techniques to alter the surface oxide structure. In this thesis, two different alloying elements, namely an alkaline earth element strontium (Sr) and a rare earth element neodymium (Nd), are studied over a range of compositions with respect to their effects on high temperature oxidation behavior and ignition temperature. Mg-Nd Alloys: In the range of 0-6 wt% Nd, the effect of Nd was composition dependent. The Ti increased from 640 °C of pure Mg to 770 oC at 0.5 wt% Nd. The beneficial effect saturated at 0.5 wt% Nd with no further significant increase in Ti as Nd increased to 6 wt% Nd (Ti is 780 °C). The oxidation behavior was investigated first on dilute Mg-Nd alloys (Nd up to 0.5 wt%) and secondly on Mg-Nd alloys richer in Nd (up to 6 wt%). Dilute Mg-Nd alloys having a near single-phase structure ([alpha]-Mg) formed a composite Nd2O3/MgO oxide scale of homogeneous morphology. The oxidation kinetics of the dilute alloys showed slower kinetics compared to pure Mg: the parabolic rate constant decreased from 8x10-7 of pure Mg to ~2x10-7 mg2 cm-4 s-1 and the linear rate decreased from 8x10-4 to 3x10-4 mg cm-2 s-1. The oxidation behavior of these alloys was largely governed by the oxidation of the [alpha]-Mg phase. Electron probe microanalysis (EPMA) indicated Nd2O3 ingrowth at the metal/oxide surface and Nd enrichment of the subsurface, which supported the formation of the Nd2O3 at the metal/oxide interface. An oxidation model was proposed wherein the formation of an initial oxide scale led a two-directional transport of the species through the oxide scale based on their diffusion coefficients. MgO formed at the oxide/gas interface via outward diffusion of Mg2+ ions through the oxide scale, while Nd2O3 created fast diffusion paths for oxygen causing inward oxide growth and slowed down MgO formation at the gas/oxide interface. The two-phase alloys also formed an MgO + Nd2O3 composite oxide structure with an Nd2O3 rich subscale but with dual-oxide morphology that mimics the two-phase structure. An Nd-depleted zone beneath the subscale was seen and attributed to the rapid Nd consumption at the metal/oxide interface through oxidation. The formation of an Nd-depleted zone lowered the protective ability of the oxide scale and adversely affected the ignition resistance. Kinetic studies showed that the parabolic oxidation kinetics controls the oxide growth on Mg-(0.5-6 wt%) Nd alloys. Mg-Sr Alloys: The oxidation and ignition of Mg-Sr alloys were investigated over the range 0-6 wt% Sr. Ti increased gradually with increased Sr from 640 °C to 860 °C (at 6 wt% Sr). The formation of a dense SrO-containing scale delayed the ignition of the alloys. The interrupted tests showed that the presence of surface active Sr at the metal/oxide interface prevented MgO formation and Mg vaporization through the cracks, which delayed the rapid temperature increase seen on the pure Mg surface and explained the continued beneficial effect of Sr on ignition resistance as Sr increased towards 6 wt% Sr. The oxidation tests at 500 °C revealed extensive SrO formation on the solid solution region on Mg-6%Sr alloy surface; since Sr has a negligible solid solubility of in Mg, this is associated with the Sr-enrichment of the surface due to the surface activity of Sr. The oxidation kinetics slowed down with Sr additions: the parabolic rate constant decreased to ~3x10-7 mg2 cm-4 s-1, and the linear rate constants decreased to 2x10-4 mg cm-2 s-1." --

Waste Production and Utilization in the Metal Extraction Industry CRC Press
Materials for high-pressure turbine blades must be able to operate in the high-temperature gases (above 1000 C) emerging from the combustion chamber. Accordingly, the development of nickel-based superalloys has been constantly motivated by the need to have improved engine efficiency, reliability and service lifetime under the harsh conditions imposed by the turbine environment. However, the melting point of nickel (1455 C) provides a natural ceiling for the temperature capability of nickel-based superalloys. Thus, surface-engineered turbine components with modified diffusion coatings and overlay coatings are used. Theses coatings are capable of forming a compact and adherent oxide scale, which greatly impedes the further transport of reactants between the high-temperature gases and the underlying metal and thus reducing attack by the

atmosphere. Typically, these coatings contain ?-NiAl as a principal constituent phase in order to have sufficient aluminum content to form an Al2O3 scale at elevated temperatures. The drawbacks to the currently-used ?-based coatings, such as phase instabilities, associated stresses induced by such phase instabilities, and extensive coating/substrate interdiffusion, are major motivations in this study to seek next-generation coatings. The high-temperature oxidation resistance of novel Pt + Hf-modified ?-Ni + ?-Ni3Al-based alloys and coatings were investigated in this study. Both early-stage and 4-days isothermal oxidation behavior of single-phase ?-Ni and ?'-Ni3Al alloys were assessed by examining the weight changes, oxide-scale structures, and elemental concentration profiles through the scales and subsurface alloy regions. It was found that Pt promotes Al2O3 formation by suppressing the NiO growth on both ?-Ni and ?'Ni3Al single-phase alloys. This effect increases with increasing Pt content. Moreover, Pt exhibits this effect even at lower temperatures (9̃70 C) in the very early stage of oxidation. It was also inferred that Pt enhances the diffusive flux of aluminum from the substrate to the scale/alloy interface. Relatively low levels of hafnium addition to Pt-free ?'-Ni3Al increased the extent of external NiO formation due to non-protective HfO2 formation. Accordingly, this effect intensified with increasing Hf content from 0.2 to 0.5 at.%.

Proceedings of the Per Kofstad Memorial Symposium Elsevier

"ASTM Stock Number: STP1428. - "Fourth Symposium on Thermomechanical Fatigue Behavior of Materials, held in Dallas, Texas on November 7-8, 2001. The Symposium was sponsored by ASTM Committee E08 on Fatigue and Fracture and its Subcommittee E08.05 on Cyclic Deformation and Fat. - Includes bibliographical references and indexes. ASTM International; 2011.

High-temperature Oxidation of Metals World Scientific

The 14th International Conference on Wear of Materials took place in Washington, DC, USA, 30 March - 3 April 2003. These proceedings contain over two-hundred peer reviewed papers containing the best research, technical developments and engineering case studies from around the world. Biomaterials and nano-tribology receive special attention in this collection reflecting the general trends in the field. Further highlights include a focus on the new generation of instrumentation to probe wear at increasingly small scales. Approximately ninety communications and case studies, a popular format for the academic community have also been included, enabling the inclusion of the most up-to-date research. Over 200 peer-reviewed papers including hot topics such as biomaterials and nano-tribology Keeping you up-to-date with the latest research from leading experts Includes communications and case studies

High Temperature Corrosion and Materials Chemistry III ASM International

Increasingly stringent environmental regulations and industry adoption of waste minimization guidelines have thus, stimulated the need for the development of recycling and reuse options for metal related waste. This book, therefore, gives an overview of the waste generation, recycle and reuse along the mining, beneficiation, extraction, manufacturing and post-consumer value chain. This book reviews current status and future trends in the recycling and reuse of mineral and metal waste and also details the policy and legislation regarding the waste management, health and environmental impacts in the mining, beneficiation, metal extraction and manufacturing processes. This book is a useful reference for engineers and researchers in industry, policymakers and legislators in governance, and academics on the current status and future trends in the recycling and reuse of mineral and metal waste. Some of the key features of the book are as follows: Holistic approach to waste generation, recycling and reuse along the minerals and metals extraction. Detailed overview of metallurgical waste generation. Practical examples with complete flow sheets, techniques and interventions on waste management. Integrates the technical issues related to efficient resources utilization with the policy and regulatory framework. Novel approach to addressing future commodity shortages.

Advances in Plastic Forming of Metals Springer

Fills a Prominent Gap in a Significant Area of Intermetallics Presenting a comprehensive overview of structural intermetallics (the most important class of intermetallics), Structural Intermetallics and Intermetallic Matrix Composites is a reference written with the beginning student as well as the practicing professional in mind. Utilizing the author’s more than two decades of experience working on silicides and teaching a course on advanced materials, this text addresses the fundamental aspects related to structure, mechanical behavior, and the oxidation resistance of selected intermetallics and their composites. In addition to covering the structure and properties of selected intermetallics, the text places special emphasis on composite intermetallics and specifically focuses on select aluminides and silicides. It reviews existing literature on select structural silicides and aluminides, considers possible applications on the basis of the attractive properties of aluminides and silicides, and also factors in future directions of research. Fundamental aspects include thermodynamic principles, phase diagrams and crystal structures, processing methods, deformation and fracture mechanisms of ordered intermetallics, and oxidation behavior with mechanisms for protection against environmental degradation. Comprising nine chapters, this text: Explores the state-of-the-art accomplishments in this area Considers further research related to the topic Examines further innovations applying these materials An up-to-date introduction to structural intermetallics, Structural Intermetallics and Intermetallic Matrix Composites helps readers grasp the complexities of the structure of intermetallics and their effect on various physical and mechanical properties. It also highlights the recent state of development in the field.

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