Thermo Mechanical Processing Of Metallic Materials

Proceedings of the 2011 International Conference on Mechanical Materials and Manufacturing Engineering (ICMMME 2011), June 20-22, 2011, Nanchang, China. Volume is indexed by Thomson Reuters CPCI-S (WoS). The objective of ICMMME 2011, with its more than 427 papers, was to provide a forum for researchers, educators, engineers and government officials involved in the general areas of mechanical materials and manufacturing engineering; thus permitting them to disseminate their latest research results and to exchange views on the future research directions of these fields.

The objective of this work is to experimentally validate thermal andmechanical finite element models of metallic parts produced usingadditive manufacturing (AM) processes. AM offers advantages overother manufacturing processes due the fact that it can produce netand near-net shapes directly from a digital drawing file. Parts canbe produced on a layer by layer basis by melting wire or powdermetal using a laser or an electron beam. The material then cools andsolidifies to form a fully dense geometry. Unfortunately the largethermal gradients cause a buildup of residual stress often takingparts out of tolerance or causing failure by cracking ordelamination. To successfully reduce distortion and residual stressin metallic AM parts without expensive and time consuming trial anderror iterations, an experimentally validated physics based model isneeded.In this work finite element (FE) models for the laser directedenergy deposition (LDED), the Electron Beam Directed Manufacture(EBDM) process, and the Laser Powder-Bed Fusion (LPBF) process aredeveloped and validated. In situ distortion and temperaturemeasurements are taken during the LDED processing of both Ti-6Al-4Vand Inconel 625. The in situexperimental results are used in addition to post-process residualstress measurements to validate a thermo-mechanical model for eachalloy. The results show that each material builds distortiondifferently during AM processing, a previously unknown effect thatmust be accounted for in the model. The thermal boundary conditionsin the model are then modified to allow for the modeling of the EBDMprocess. The EBDM model is validated against in situ temperature anddistortion measurements as well as post-process residual stressmeasurements taken on a single bead wide Ti-6Al-4V wall build.Further model validation is provided by comparing the predictedmechanical response of a large EBDM aerospace component consistingof several thousand deposition tracks to post-process distortionmeasurements taken on the actual part. Several distortion mitigationtechniques are also investigated using an FE model. The findings areused to reduce the maximum distortion present on the largeindustrial aerospace component by 91~\%. Finally, the modeling workfor the LDED and the EBDM processes is extended to Laser Powder-BedFusion (LPBF) processing of Inconel718. The necessary boundary conditions and material properties toinclude in the models are identified by comparing the model with insitu experimental results.

NiTi shape memory alloys (SMAs) have revolutionized engineering design across all industries, with major contributions in the medical, aerospace, and automotive industries. These fascinating materials possess the shape memory effect, pseudoelastic effect and biocompatibility, which make them so highly desired. Since their discovery mid-way through the 20th century a large research effort has been underway to gain fundamental understanding of the mechanisms responsible for their properties. The material properties depend on a large number of variables including the microstructure, the texture, the stress/strain state, and the temperature. An understanding of the interdependence of these variables is still being developed, with particular focus on their evolution when either multi-axial loading, or fatigue cycling are applied to the material. Furthermore, the advanced manufacturing techniques required to properly process NiTi have only recently become a reality, with further advancements being developed to continue pushing the limits of these materials. One limitation of NiTi is that standard manufactured products have only one transformation temperature. A number of techniques have been developed in an attempt to address this limitation and increase the functionality of SMAs. A highly accurate and repeatable technique was recently developed that uses a high energy density process (e.g. laser) to alter the composition of NiTi in localized regions. Laser processing enables the tailoring of different regions of a single piece of NiTi to have different transformation properties. However, there have been no in-depth studies of the evolution of the properties of these laser processed materials over multiple mechanical or thermal cycles. This lack of fundamental knowledge significantly limits both the understanding and possibilities for the application of laser processed NiTi. In addition to this limitation, the most widely used form of NiTi SMA is wires, but the major studies on laser processing have focused on sheets. Investigation of the evolution of laser processed NiTi wires over multiple mechanical or thermal cycles would not only benefit laser processing technologies, but it would also improve the general understanding of SMAs, with benefits to other areas including other local processing techniques, welding and joining, mechanical and thermomechanical fatigue. The current study investigated the evolution of the properties of laser processed NiTi when the materials were subjected to thermal cycling, mechanical cycling, and fatigue cycling. The knowledge gained was used to identify limitations in the current technology, and develop thermomechanical treatments to address these limitations. The first part of the investigation focused on a wire that had a single laser processed spot (i.e. a laser weld). Few investigations have been attempted to characterize the mechanical fatigue properties of NiTi joints, and to the author's knowledge there have been no previous investigations on the thermomechanical fatigue properties of these joints. The current work investigated the thermomechanical fatigue properties of Nd:YAG pulsed laser welded, and post-weld heat treated NiTi wires. The welded wires maintained over 86 % of the base metal ultimate tensile strength; however, they had reduced actuation stability and stroke, and had significantly reduced cycle life. Use of a post-weld heat treatment successfully increased both the actuation stability and the cycle life by an order of magnitude compared to the welded wires. The second part of the investigation focused on the development and characterization of laser processing techniques for NiTi wires. The process altered the composition of the NiTi wire with a reduction of 0.23 at.% Ni for each laser pulse after the first pulse. The first laser pulse removed 0.40 at.% Ni, which was a larger amount than the following pulses, because the wire drawn surface finish was less reflective than the laser processed surface. The coarse grained laser processed NiTi had 71 % of the base metal ultimate tensile strength, 40 % of the base metal ductility, significant reduction in the stability of the shape memory properties, and an almost complete loss of the fatigue life of the base metal. Using the fundamental knowledge gained from this investigation a thermomechanical treatment was developed to improve the properties of the laser processed NiTi. The treated laser processed NiTi had an ultimate tensile strength matching the base metal and a ductility 70 % greater than the laser processed NiTi. Significant improvement to the shape memory properties were achieved, with a return of pseudoelasticity, and an 80% greater shape memory recovery than the untreated laser processed NiTi. Furthermore the low strain (i.e. 2%) thermomechanical fatigue lives of the treated laser processed NiTi were equal to the base metal. Finally, actuators were developed with two distinct memories, with the treated actuator having 33 % lower plastic strain, and 42 % greater shape memory recovery than the untreated actuator. This technology was exploited to develop a self-biasing actuator. A shape memory alloy (SMA) actuator that is biased internally (i.e. self-biasing) would not need an external bias to achieve multiple actuation cycles. This would reduce cost, complexity and weight compared to standard one-way SMAs. The self-biasing actuators that have been developed to date have a lack of geometric and actuation stability. The current study developed a self-biasing NiTi actuator using a laser based vaporization process to alter the bulk composition of a NiTi wire. The martensitic laser processed NiTi region was the actuator, and un-processed austenitic base metal region was the internal bias. It was discovered that the laser processed region of the self-biasing actuator was unstable during high stress thermomechanical cycling due to the coarse grained microstructure. Cold-working of the half martensitic and half austenitic component resulted in similar deformation characteristics to single phase NiTi, which enabled the formation of a uniform nanocrystalline microstructure in both regions. When thermomechanically cycled 6000 times under stresses ranging from 180 to 400 MPa, it was discovered that this treated self-biasing actuator exhibited the stabilization behaviour of traditional one-way actuators. This behaviour was due to the uniform nanocrystalline microstructure, which impeded dislocation activity and ensured minimal plastic deformation.

The Magnesium Technology Symposium, the event on which this collection is based, is one of the largest yearly gatherings of magnesium specialists in the world. Papers represent all aspects of the field, ranging from primary production to applications to recycling. Moreover, papers explore everything from basic research findings to industrialization. Magnesium Technology 2015 covers a broad spectrum of current topics, including alloys and their properties; cast products and processing; wrought products and processing; forming, joining, and machining; corrosion and surface finishing; ecology; and structural applications. In addition, there is coverage of new and emerging applications.

Thermo-Mechanical Processing of Metallic MaterialsElsevier

Abstract: Thermo-mechanical processing of metallic glasses has been shown to change the free volume and have some effect on the mechanical properties. In order to better quantify these effects, we have studied the homogeneous flow of metallic glasses and the subsequent changes in atomic ordering, in terms of free volume and x-ray measurements, and mechanical properties via nanoindentation. The internal free volume of the specimens, as measured through changes in the specific heat by differential scanning calorimetry, has been shown to increase with increasing levels of total strain in tension and in compression. X-ray diffraction of amorphous specimens in the as-cast, annealed, and homogeneously deformed state also showed a change in the short-range atomic order of the alloy. The shape of the x-ray patterns for the as-cast and annealed states were nearly identical, while a decrease in intensity of x-rays was seen at high angles of 2[theta] in the homogeneously deformed samples. These high angles describe a change in the state of the short-range order. Nanoindentation has shown slight changes in the elastic properties and density of serrations in amorphous materials with changes in the free volume. Using available embedded atom method potentials, molecular dynamics simulations of several Cu-Zr binary, a Cu-Zr-Al ternary, and a quinternary Zr-Cu-Ni-Al-Ti alloy systems at multiple quench rates from the liquid were performed. Using an annealing/quenching technique that allows the simulation of even extremely slow quench rates, glassy structures of these alloys were produced at varying quench rates and their nearest-neighbor coordination examined. Radial distribution functions of the modeled systems show excellent agreement with experimental data, suggesting that the predicted atomic structure should have realistic features similar to real materials. The glass transition temperatures of several of these alloys were determined through a simulated dilatometry technique. Comparing the features and changes in the nearest-neighbor order and the simulated glass transitions with available experimental data, we found a novel set of criteria to predict the effect of changes in alloy composition on glass forming ability. The change in the distribution of nearest neighbors with quench rate, as compared in alloys with different experimentally determined glass forming abilities, did only provide some insights into the formation of glasses. However, the measurement of the fraction of atomic pairs that exhibited icosahedral-like short-range order was found to be directly related to the relative glass forming abilities of the alloys simulated.

A comprehensive introduction to the concepts of joining technologies for hybrid structures This book introduces the concepts of joining technology for polymer-metal hybrid structures by addressing current and new joining methods. This is achieved by using a balanced approach focusing on the scientific features (structural, physical, chemical, and metallurgical/polymer science phenomena) and engineering properties (mechanical performance, design, applications, etc.) of the currently available and new joining processes. It covers such topics as mechanical fastening, adhesive bonding, advanced joining methods, and statistical analysis in joining technology. Joining of Polymer-Metal Hybrid Structures: Principles and Applications is structured by joining principles, in adhesion-based, mechanical fastened, and direct-assembly methods. The book discusses such recent technologies as friction riveting, friction spot joining and ultrasonic joining. This is used for applications where the original base material characteristics must remain unchanged. Additional sections cover the main principles of statistical analysis in joining technology (illustrated with examples from the field of polymer-metal joining). Joining methods discussed include mechanical fastening (bolting, screwing, riveting, hinges, and fits of polymers and composites), adhesive bonding, and other advanced joining methods (friction staking, laser welding, induction welding, etc.). Provides a combined engineering and scientific approach used to describe principles, properties, and applications of polymer-metal hybrid joints Describes the current developments in design of experiments and statistical analysis in joining technology with emphasis on joining of polymer-metal hybrid structures Covers recent innovations in joining technology of polymer-metal hybrid joints including friction riveting, friction spot joining, friction staking, and ultrasonic joining Principles illustrated by pictures, 3D-schemes, charts, and drawings using examples from the field of polymer-metal joining Joining of Polymer-Metal Hybrid Structures: Principles and Applications will appeal to chemical, polymer, materials, metallurgical, composites, mechanical, process, product, and welding engineers, scientists and students, technicians, and joining process professionals.

The demands on innovative materials given by the ever-increasing requirements of contemporary industry require the use of high-performance engineering materials. The properties of materials and alloys are a result of their structures, which can primarily be affected by the preparation/production process. However, the production of materials featuring high levels of the required properties without the necessity to use costly alloying elements or time- and money-demanding heat treatment technologies typically used to enhance the mechanical properties of metallic materials (especially specific strength) still remains a challenge. The introduction of thermomechanical treatment represented a breakthrough in grain refinement, consequently leading to significant improvement of the mechanical properties of metallic materials. Contrary to conventional production technologies, the main advantage of such treatment is the possibility to precisely control structural phenomena that affect the final mechanical and utility properties. Thermomechanical treatment can only decrease the grain size to the scale of microns. However, further research devoted to pushing materials’ performance beyond the limits led to the introduction of severe plastic deformation (SPD) methods providing producers with the ability to acquire ultra-fine-grained and nanoscaled metallic materials with superior mechanical properties. SPD methods can be performed with the help of conventional forming equipment; however, many newly designed processes have also been introduced.

ICTAEM_1 treated all aspects of theoretical, applied and experimental mechanics including biomechanics, composite materials, computational mechanics, constitutive modeling of materials, dynamics, elasticity, experimental mechanics, fracture, mechanical properties of materials, micromechanics, nanomechanics, plasticity, stress analysis, structures, wave propagation. During the conference special symposia covering major areas of research activity organized by members of the Scientific Advisory Board took place. ICTAEM_1 brought together the most outstanding world leaders and gave attendees the opportunity to get acquainted with the latest developments in the area of mechanics. ICTAEM_1 is a forum of university, industry and government interaction and serves in the exchange of ideas in an area of utmost scientific and technological importance.

Naval Postgraduate School : Monterey, California.

This book gathers a collection of papers summarizing some of the latest developments in the thermomechanical processing of steels. The replacement of conventional rolling plus post-rolling heat treatments by integrated controlled forming and cooling strategies implies important reductions in energy consumption, increases in productivity and more compact facilities in the steel industry. The metallurgical challenges that this integration implies, though, are relevant and impressive developments that have been achieved over the last 40 years. The frequency of the development of new steel grades and processing technologies devoted to thermomechanically processed products is increasing, and their implementation is being expended to higher value added products and applications. In addition to the metallurgical peculiarities and relationships between chemical composition, process and final properties, the relevance impact of advanced characterization techniques and innovative modelling strategies provides new tools to achieve the further deployment of the TMCP technologies. The contents of the book cover low carbon microalloyed grades, ferritic stainless steels and Fe–Al–Cr alloys, medium-Mn steels, and medium carbon grades. Authors of the chapters of this "Thermomechanical Processing of Steels" book represent some of the most relevant research groups from both the steel industry and academia.

Within the rapidly growing field of hot sheet metal forming and metal bulk forming the demand arises for fully three-dimensionally tailored properties at the microstructural level, nevertheless, reaching a predefined geometry with such tailored properties puts high requirements on the control mechanisms utilized in the process chain for combined heating, metal forming, and cooling processes. Therefore, the underlying control architecture needs to be freely configurable with respect to a predefined database being extendible to new geometries, microstructural distributions, and materials. The combined control of locally and temporally differential thermo-mechanical effects during the process flow needs to be based on an adaptive algorithm adjusting the process flow in real-time according to predefined parameters delivered by the aforementioned material, geometry, and microstructure property database. The interplay between measurement techniques and adaptive control processes for hot metal forming of functionally graded materials is to be investigated in order to achieve the predefined fully three-dimensional microstructure in complex geometries and optimize the process cycle time in a freely configurable control architecture being customizable to new requirements and materials, resulting in a precision manufacturing process. The emphasis within the given thesis will be on adaptive control strategies embedded within a flexible control architecture for an innovative thermo-mechanical production process embracing induction heating to predefined spatial and temporal temperature distributions, transfer, and combined metal forming as well as heat extraction processes. The flexible control architecture assures an invariant quality for the highly dynamic processes and, moreover, yields extendibility to new materials, geometries, and microstructural distributions.

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.

The CTMP technology has the potential for widespread application in all major sectors of the domestic tube and pipe industry; two of the largest sectors are seamless mechanical tubing and seamless oil country tubular goods. It has been proven for the spheroidized annealing heat cycle for through-hardened steels and has led to the development of a recipe for automotive gear steels. Potential applications also exist in the smaller sectors of seamless line pipe, pressure tubing, and stainless tubing. The technology could also apply to non-ferrous metal industries, such as titanium.

The advent of additive manufacturing (AM) processes applied to the fabrication of structural components creates the need for design methodologies supporting structural optimization approaches that take into account the specific characteristics of the process. While AM processes enable unprecedented geometrical design freedom, which can result in significant reductions of component weight, on the other hand they have implications in the fatigue and fracture strength due to residual stresses and microstructural features. This is linked to stress concentration effects and anisotropy that still warrant further research. This Special Issue of Applied Sciences brings together papers investigating the features of AM processes relevant to the mechanical behavior of AM structural components, particularly, but not exclusively, from the viewpoints of fatigue and fracture behavior. Although the focus of the issue is on AM problems related to fatigue and fracture, articles dealing with other manufacturing processes with related problems are also be included.

Flat rolling is considered to be one of the most important and most widely used metal forming processes. This book emphasizes the importance of mathematical simulation of this process in the light of the ever in- creasing need for quality improvements through automation. Mathematical models of the hot, warm and cold rolling processes are discussed, compared and critically evaluated. Engineers in the steel industry will find this book particularly useful in their everyday work.

This book explores systems-based, co-design, introducing a “Decision-Based, Co-Design” (DBCD) approach for the co-design of materials, products, and processes. In recent years there have been significant advances in modeling and simulation of material behavior, from the smallest atomic scale to the macro scale. However, the uncertainties associated with these approaches and models across different scales need to be addressed to enable decision-making resulting in designs that are robust, that is, relatively insensitive to uncertainties. An approach that facilitates co-design is needed across material, product design and manufacturing processes. This book describes a cloud-based platform to support decisions in the design of engineered systems (CB-PDSIDES), which feature an architecture that promotes co-design through the servitization of decision-making, knowledge capture and use templates that allow previous solutions to be reused. Placing the platform in the cloud aids mass collaboration and open innovation. A valuable reference resource reference on all areas related to the design of materials, products and processes, the book appeals to material scientists, design engineers and all those involved in the emerging interdisciplinary field of integrated computational materials engineering (ICME).

The proceedings cover the latest research in advanced materials such as design, synthesis and development of new materials, processing technology for new materials, and modeling and simulation of materials processing.

Covering thermomechanical aspects of manufacturing and materials processing, this volume provides basic fundamentals for understanding and analyzing various manufacturing processes and materials processing. It covers metal casting, metal forming, metal cutting, and the experimental tools available for solving problems of practical significance. It explores areas of future research and identifies problem areas with a view to minimizing energy losses and maximizing cost effective manufacture of industrial goods.

Severe plastic deformation (SPD) is a very attractive research field for metallic materials because it provides new possibilities for manufacturing nanostructured materials in large quantities and allows microstructural design on different hierarchical levels. The papers included in this issue address the following topics: novel SPD processes as well as recent advancements in established processing methods, microstructure evolution and grain refinement in single- and multi-phase alloys as well as composites, strategies to enhance the microstructure stability at elevated temperatures, mechanically driven phase transformations, surface nanostructuring, gradient and multilayered materials, and mechanical and physical properties of SPD-processed materials.

The volume presents advances in materials research and technology in the area of terotechnology, i.e. the technology of installation, maintenance, replacement and removal of plant machinery and equipment, reliability analysis, technical diagnostics, tribology and technical safety. Specific topics include Cavitation Erosion, Simulation of Particle Erosion, Mechanically-assisted Laser Forming, Laser Machining of Tool Steels, Titanium Carbonitride Coatings, Causes of Cracks in Thermit Welds, Diamond-Like Coatings on Titanium, Reinforcement of Concrete, Fatigue Strength of Construction Elements, Modeling of Mining Support Structures, Surface Treatments of Sintered Stainless Steel, Thermal Welding, Joints of Nickel-Based Superalloys, Robotic Laser Cleaning of Materials, Tribological Properties of Laser-processed

ESD Coatings, Laser-modified WC-Cu Electro-Spark Coatings, anti-Graffiti Coating Systems.

This Lecture Series considers process modeling which provides a new perspective to advance metal forming and thermo-mechanical processing. Working and forming processes are viewed as systems which integrate component behaviour such as workpiece flow, heat flow and friction at the workpiece-tooling interface, and microstructural evolution. These are combined to form a system process model using deformation mechanics. The Lecture Series covers extrusion, forging, rolling, and sheet forming processes. It will provide specific results for light metals, steels and superalloys and introduce finite element methods and related aspects of computer-aided process design. The Lecture Series was sponsored by the Structures and Materials Panel and organized by the Consultant and Exchange Program of AGARD.

The memorandum was adpted from a talk given by the author at a subgroup meeting of The Technical Cooperation Program (TTCP), London, April 1970. The author's primary theme is that there are sufficient data already available to permit the use of thermomechanical treatment (TMT) routinely in the manufacture of some alloy products. The use of TMT for products of low carbon steels, aluminum alloys, maraging steels, titanium alloys, nickel-base alloys and high-alloy steels is discussed briefly. Most of the memorandum deals with TMT of alloy steels. The future of TMT is forecast briefly, particularly with respect to alloy steels. An extensive bibliography includes sources in several languages, primarily English and Russian. A few sources in French, German, Czech, Serbo-Croatian, and Japanese are also cited.

In the automotive industry, the need to reduce vehicle weight has given rise to extensive research efforts to develop aluminum and magnesium alloys for structural car body parts. In aerospace, the move toward composite airframe structures urged an increased use of formable titanium alloys. In steel research, there are ongoing efforts to design novel damage-controlled forming processes for a new generation of efficient and reliable lightweight steel components. All these materials, and more, constitute today’s research mission for lightweight structures. They provide a fertile materials science research field aiming to achieve a better understanding of the interplay between industrial processing, microstructure development, and the resulting material properties. Advancements in the Processing, Characterization, and Application of Lightweight Materials provides the recent advancements in the lightweight mat materials processing, manufacturing, and characterization. This book identifies the need for modern tools and techniques for designing lightweight materials and addresses multidisciplinary approaches for applying their use. Covering topics such as numerical optimization, fatigue characterization, and process evaluation, this text is an essential resource for materials engineers, manufacturers, practitioners, engineers, academicians, chief research officers, researchers, students, and vice presidents of research in government, industry, and academia.

Titanium alloys, due to unique physical and chemical properties (mainly high relative strength combined with very good corrosion resistance), are considered as an important structural metallic material used in hi-tech industries (e.g. aerospace, space technology). This book provides information on new manufacturing and processing methods of single- and two-phase titanium alloys. The eight chapters of this book are distributed over four sections. The first section (Introduction) indicates the main factors determining application areas of titanium and its alloys. The second section (Manufacturing, two chapters) concerns modern production methods for titanium and its alloys. The third section (Thermomechanical and surface treatment, three chapters) covers problems of thermomechanical processing and surface treatment used for single- and two-phase titanium alloys. The fourth section (Machining, two chapters) describes the recent results of high speed machining of Ti-6Al-4V alloy and the possibility of application of sustainable machining for titanium alloys.

Thermo-Mechanical Processing of Metallic Materials describes the science and technology behind modern thermo-mechanical processing (TMP), including detailed descriptions of successful examples of its application in the industry. This graduate-level introductory resource aims to fill the gap between two scientific approaches and illustrate their successful linkage by the use of suitable modern case studies. The book is divided into three key sections focusing on the basics of metallic materials processing. The first section covers the microstructural science base of the subject, including the microstructure determined mechanical properties of metals. The second section deals with the current mechanical technology of plastic forming of metals. The concluding section demonstrates the interaction of the first two disciplines in a series of case studies of successful current TMP processing and looks ahead to possible new developments in the field. This text is designed for use by graduate students coming into the field, for a graduate course textbook, and for Materials and Mechanical Engineers working in this area in the industry. * Covers both physical metallurgy and metals processing * Links basic science to real everyday applications * Written by four internationally-known experts in the field

Volume is indexed by Thomson Reuters CPCI-S (WoS). Deformation and annealing phenomena are of great technical significance to the processing and application of materials at the industrial scale. This edited collection of peer-reviewed papers was designed as a one-off vehicle for reviewing the current understanding of the basic mechanisms and processes that control deformation and annealing in various materials, together with their modelling and simulation. Another aim was to facilitate discussion of the failings of established theories, to explore new ideas, and to identify avenues where future research is required. The present papers apply these concepts to a wide range of materials and applications; from conventional steels and light alloys to nanocrystalline gold wires and geological samples.

Microstructure changes that occur during the deformation and heat treatments involved in wrought processing of metals are of central importance in achieving the desired properties or performance characteristics in the finished products. However, thorough understanding of the evolution of microstructure during thermo-mechanical processing of metallic materials is largely hampered by lack of methods for characterizing reliably their local (anisotropic) properties at the sub-micron length scales. Recently, remarkable advances in nanoindentation data analysis techniques have been made which now make it possible to obtain quantitative information about the local mechanical properties of constituent individual grains in polycrystalline metallic samples. In this work, a novel approach that combines mechanical property information obtained from spherical nanoindentation with the complementary structure information measured locally at the indentation site, using Electron Backscattered Diffraction (EBSD), is used to systematically investigate the local structure-property relationships in fcc metals. This work is focused on obtaining insights into the changes in local stored energies of polycrystalline metallic samples as a function of their crystal orientation at increasing deformation levels. Furthermore, using the same approach, the evolution of mechanical properties in the grain boundary regions in these samples is studied in order to better understand the role of such interfaces during deformation and recrystallization processes. The findings provide valuable information regarding development of stored energy gradients in polycrystalline materials during macroscopic deformation.

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.

This collection of peer-reviewed papers by results of 15th International Conference on Aluminium Alloys (ICAA15, 12-16 June, 2016 in Chongqing, China) that are cover most aspects of aluminium alloys, including casting and solidification; phase transformations; thermomechanical processing; metal plasticity and forming; strength, fracture and fatigue; advanced atomic-scale characterization; corrosion and surface properties; novel processes and alloy design; modelling and numerical simulation.

The book has been completely designed as per the syllabus of the 4th semester B.Tech. in Mechanical Engineering of APJ Abdul Kalam Technological University, Kerala.