Fundamentals Of Solidification

Solidification phenomena play an important role in many of the processes used in fields ranging from production engineering to solid-state physics. The broad range of applications of solidification models - from the large tonnages of continuously cast products, through superalloy precision castings, to high-purity single crystals - means that a book such as the present one must cater for the requirements of a very wide range of readers.

This text seeks to provide a comprehensive technical foundation and practical examples for casting process modelling technology. It highlights fundamental theory for solidification and useful applications for industrial production. It also details shape and ingot castings, semi-solid metalworking, and spray forming.

This book contains a collection of papers on the science, engineering, and technology of shape casting, with contributions from researchers worldwide. Among the topics that are addressed are the structure-property-performance relationships, modeling of casting processes, and the effect of casting defects on the mechanical properties of cast alloys.

EPD Congress is an annual collection that addresses extraction and processing metallurgy. The papers in this book are drawn from symposia held at the 2016 Annual Meeting of The Minerals, Metals & Materials Society. The 2016 edition includes papers from the following symposia: •Materials Processing Fundamentals •Advanced Characterization Techniques for Quantifying and Modeling Deformation

Pulling together information previously scattered throughout numerous research articles into one detailed resource, Physical Metallurgy of Direct Chill Casting of Aluminum Alloys connects the fundamentals of structure formation during solidification with the practically observed structure and defect patterns in billets and ingots. The author examines the formation of a structure, properties, and defects in the as-cast material in tight correlation to the physical phenomena involved in the solidification and the process parameters. The book draws on the author’s advanced research to provide a unique application of physical metallurgy to direct chill (DC) casting technology. He examines structure and defect formation— including macrosegregation and hot tearing. Each technology-centered chapter provides historical background before reviewing current developments. The author supports his conclusions with computer simulation results that have been correlated with highly progressive experimental data. He presents a logical system of structure and defect formation based on the specific features of the DC casting process. He also demonstrates that the seemingly controversial results reported in literature are, in fact, caused by the different ratio of the same mechanisms. Compiling recent results and data, the book discusses the fundamentals of solidification together with metallurgical and technological aspects of DC casting. It gives new insight and perspective into DC casting research.

“Principles of Solidification” offers comprehensive descriptions of liquid-to-solid transitions encountered in shaped casting, welding, and non-biological bulk crystal growth processes. The book logically develops through careful presentation of relevant thermodynamic and kinetic theories and models of solidification occurring in a variety of materials. Major topics encompass the liquid-state, liquid-solid transformations, chemical macro- and microsegregation, purification by fractional crystallization and zone refining, solid-liquid interfaces, polyphase freezing, and rapid solidification processing. Solid-liquid interfaces are discussed quantitatively both as sharp and diffuse entities, with supporting differential geometric descriptions. The book offers: • Detailed mathematical examples throughout to guide readers • Applications of solidification and crystal growth methodologies for preparation and purification of metals, ceramics, polymers and semiconductors • Appendices providing supporting information on special topics covered in the chapters. Readers in materials, metallurgical, chemical, and mechanical engineering will find this to be a useful source on the subjects of solidification and crystal growth. Chemists, physicists, and geologists concerned with melting/freezing phenomena will also find much of value in this book.

Ground improvement has been one of the most dynamic and rapidly evolving areas of geotechnical engineering and construction over the past 40 years. The need to develop sites with marginal soils has made ground improvement an increasingly important core component of geotechnical engineering curricula. Fundamentals of Ground Improvement Engineering addresses the most effective and latest cutting-edge techniques for ground improvement. Key ground improvement methods are introduced that provide readers with a thorough understanding of the theory, design principles, and construction approaches that underpin each method. Major topics are compaction, permeation grouting, vibratory methods, soil mixing, stabilization and solidification, cutoff walls, dewatering, consolidation, geosynthetics, jet grouting, ground freezing, compaction grouting, and earth retention. The book is ideal for undergraduate and graduate-level university students, as well as practitioners seeking fundamental background in these techniques. The numerous problems, with worked examples, photographs, schematics, charts and graphs make it an excellent reference and teaching tool.

Cast Iron Technology presents a critical review of the nature of cast irons. It discusses the types of cast iron and the general purpose of cast irons. It also presents the history of the iron founding industry. Some of the topics covered in the book are the description of liquid metal state; preparation of liquid metal; process of melting; description of cupola melting and electric melting methods; control of composition of liquid metal during preparation; description of primary cast iron solidification structures; and thermal analysis of metals to determine its quality. Solidification science and the fundamentals of heat treatment are also discussed. An in-depth analysis of the hot quenching techniques is provided. The graphitization potential of liquid iron is well presented. A chapter is devoted to microstructural features of cast iron. The book can provide useful information to iron smiths, welders, students, and researchers.

Solidification and Crystallization Processing in Metals and Alloys Hasse Fredriksson KTH, Royal Institute of Technology, Stockholm, Sweden Ulla Åkerlind University of

Stockholm, Sweden Solidification or crystallization occurs when atoms are transformed from the disordered liquid state to the more ordered solid state, and is fundamental to metals processing. Conceived as a companion volume to the earlier works, Materials Processing during Casting (2006) and Physics of Functional Materials (2008), this book analyzes solidification and crystallization processes in depth. Starting from the thermodynamic point of view, it gives a complete description, taking into account kinetics and mass transfer, down to the final structure. Importantly, the book shows the relationship between the theory and the experimental results. Topics covered include: Fundamentals of thermodynamics Properties of interfaces Nucleation Crystal growth - in vapours, liquids and melts Heat transport during solidification processes Solidification structures - faceted, dendritic, eutectic and peritectic Metallic glasses and amorphous alloy melts Solidification and Crystallization Processing in Metals and Alloys features many solved examples in the text, and exercises (with answers) for students. Intended for Masters and PhD students as well as researchers in Materials Science, Engineering, Chemistry and Metallurgy, it is also a valuable resource for engineers in industry.

This book describes all the metallurgical phenomena involved in the different welding processes. Practical examples of a wide variety of metals and alloys are provided, as well as an expert commentary on steel weldability and types of cracking.

As product specifications become more demanding, manufacturers require steel with ever more specific functional properties. As a result, there has been a wealth of research on how those properties emerge during steelmaking. Fundamentals of metallurgy summarises this research and its implications for manufacturers. The first part of the book reviews the effects of processing on the properties of metals with a range of chapters on such phenomena as phase transformations, types of kinetic reaction, transport and interfacial phenomena. Authors discuss how these processes and the resulting properties of metals can be modelled and predicted. Part two discusses the implications of this research for improving steelmaking and steel properties. With its distinguished editor and international team of contributors, Fundamentals of metallurgy is an invaluable reference for steelmakers and manufacturers requiring high-performance steels in such areas as automotive and aerospace engineering. It will also be useful for those dealing with non-ferrous metals and alloys, material designers for functional materials, environmentalists and above all, high technology industries designing processes towards materials with tailored properties. Summarises key research and its implications for manufacturers Essential reading for steelmakers and manufacturers Written by leading experts from both industry and academia

Paperback edition of text on fluid dynamics for graduate students and specialists alike.

Solidification is one of the oldest processes for producing complex shapes for applications ranging from art to industry, and remains as one of the most important commercial processes for many materials. Since the 1980s, numerous fundamental developments in the understanding of solidification processes and microstructure formation have come from both analytical theories and the application of computational techniques using commonly available powerful computers. This book integrates these developments in a comprehensive volume that also presents and places them in the context of more classical theories. This second edition highlights the key concepts within each chapter to help guide the reader through the most important aspects of the topics. The figures are now in color, in order to improve the visualization of phenomena and concepts. Recent important developments in the field since the first edition was published have also been added. The three-part text is aimed at graduate and professional engineers. The first part, Fundamentals and Macroscale Phenomena, presents the thermodynamics of solutions and then builds on that subject to motivate and describe equilibrium phase diagrams. Transport phenomena are discussed next, focusing on the issues of most importance to liquid-solid phase transformations, then moving on to describing in detail both analytical and numerical approaches to solving such problems. The second part, Microstructure, employs these fundamental concepts for the treatment of nucleation, dendritic growth, microsegregation, eutectic and peritectic solidification, and microstructure competition. This part concludes with a chapter describing the coupling of macro- and microscopic phenomena in microstructure development. The third and final part describes various types of Defects that may occur, with emphasis on porosity, hot tearing and macrosegregation, presented using the modeling tools and microstructure descriptions developed earlier.

Stefanescu here attempts to describe solidification theory through the complex mathematical apparatus required for a fundamental treatment of the problem. The mathematics is however restricted to the elements essential to attain a working knowledge in the field. This is in line with the main goal of the book, which is to educate the reader in the fast moving area of computational modeling of solidification of castings. A special effort has been made to introduce the reader to the latest developments in solidification theory including, in this second edition, a new chapter on semi-solid casting.

For students ready to advance in their study of metals, Physical Metallurgy, Second Edition uses engaging historical and contemporary examples that relate to the applications of concepts in each chapter.This book combines theoretical concepts, real alloy systems, processing procedures, and examples of real-world applications. The author uses his ex

The 3rd edition of this popular textbook covers current topics in all areas of casting solidification. Partial differential equations and numerical analysis are used extensively throughout the text, with numerous calculation examples, to help the reader in achieving a working knowledge of computational solidification modeling. The features of this new edition include: • new chapters on semi-solid and metal matrix composites solidification • a significantly extended treatment of multiscale modeling of solidification and its applications to commercial alloys • a survey of new topics such as solidification of multicomponent alloys and molecular dynamic modeling • new theories, including a theory on oxide bi-films in the treatment of shrinkage problems • an in-depth treatment of the theoretical aspects of the solidification of the most important commercial alloys including steel, cast iron, aluminum-silicon eutectics, and superalloys • updated tables of material constants.

Direct-chill casting is the major production route for wrought aluminium and magnesium alloys that are later deformed (rolled, extruded, forged) to the final products. To aid in this process, this book provides comprehensive coverage on topics such as the history of process development in this field, industrial applications, including vertical and horizontal casting, melt preparation, fundamentals of solidification in DC casting, and more. The first book targeted for the industrial researcher and practitioner, it pulls together the practice and process of physics with the goal of improving process performance.

This well-written text is for non-metallurgists and anyone seeking a quick refresher on an essential tool of modern metallurgy. The basic principles, construction, interpretation, and use of alloy phase diagrams are clearly described with ample illustrations for all important liquid and solid reactions. Gas-metal reactions, important in metals processing and in-service corrosion, also are discussed. Get the basics on how phase diagrams help predict and interpret the changes in the structure of alloys.

Superalloys are unique high-temperature materials used in gas turbine engines, which display excellent resistance to mechanical and chemical degradation. This book presents the underlying

metallurgical principles which have guided their development and practical aspects of component design and fabrication from an engineering standpoint. The topics of alloy design, process development, component engineering, lifetime estimation and materials behaviour are described, with emphasis on critical components such as turbine blading and discs. The first introductory text on this class of materials, it will provide a strong grounding for those studying physical metallurgy at the advanced level, as well as practising engineers. Included at the end of each chapter are exercises designed to test the reader's understanding of the underlying principles presented. Solutions for instructors and additional resources are available at www.cambridge.org/9780521859042.

Solidification and Solid-State Transformations of Metals and Alloys describes solidification and the industrial problems presented when manufacturing structural parts by casting, or semi-products for forging, in order to obtain large, flat or specifically shaped parts. Solidification follows the nucleation and growth model, which will also be applied in solid-state transformations, such as those taking place because of changes in solubility and allotropy or changes produced by recrystallization. It also explains the heat treatments that, through controlled heating, holding and cooling, allow the metals to have specific structures and properties. It also describes the correct interpretation of phase diagrams so the reader can comprehend the behaviour of iron, aluminium, copper, lead, tin, nickel, titanium, etc. and the alloys between them or with other metallic or metalloid elements. This book can be used by graduate and undergraduate students, as well as physicists, chemists and engineers who wish to study the subject of Metallic Materials and Physical Metallurgy, specifically industrial applications where casting of metals and alloys, as well as heat treatments are relevant to the quality assurance of manufacturing processes. It will be especially useful for readers with little to no knowledge on the subject, and who are looking for a book that addresses the fundamentals of manufacturing, treatment and properties of metals and alloys. Uses theoretical formulas to obtain realistic data from industrial operations Includes detailed explanations of chemical, physical and thermodynamic phenomena to allow for a more accessible approach that will appeal to a wider audience Utilizes micrographs to illustrate and demonstrate different solidification and transformation processes

"Solidification Processing of Metal Matrix Composites" (MMCs) focuses primarily on microcomposites but also covers macrocomposites, nanocomposites and foams. There are four main areas detailed: fundamentals of solidification synthesis, which examines issues related to stir mixing, pressure infiltration, transfer of particles or fibers through gas-liquid and liquid-solid interfaces, and particle/fiber interactions with fluids; processing and microstructures, which focuses on microstructure formation during solidification of MMC under different conditions, such as nucleation, growth, heat transfer, microsegregation, macrosegregation and interactions between solidifying interfaces, particles and fibers; and, properties of solidification processing, covering the relationship between the microstructures and properties. Comparisons are made between properties of solidification processed composites and monolithic and composites made by solid and vapor phase processes. It also details the application of solidification processed MMCs, revealing current and future applications especially in automotive, aerospace, railroad, thermal management, electromechanical machinery and recreational equipment sectors.

Elements of Rapid Solidification: Fundamentals and Applications is the product of many years of concentrated work in the field of rapid solidification and processing. This quasi-monograph is unique in two ways. It brings together the talent of many international scientists in an effort to focus attention on all aspects of a new scientific field and it concentrates on fundamentals and practical applications. Simply stated, this book has been written by the senior students in the field of rapid solidification technology for the new generation of solid-state physicists, materials scientists, materials engineers, metallurgists and ceramicists.

Solidification is one of the oldest processes for producing useful implements and remains one of the most important modern commercial processes. This text describes the fundamentals of the technology in a coherent way, using consistent notation.

This volume details the principles underlying rapid solidification processing, material structure and properties, and their applications. This practical resource presents a manifold approach to both amorphous and crystalline rapidly solidified metallic alloys.;Written by over 30 internationally acclaimed specialists in their respective fields, Rapidly Solidified Alloys: surveys nucleation and growth studies in undercooled melts; examines various processes for the production of rapidly solidified alloys; discusses the compaction of amorphous alloys; describes surface remelting treatments for the rapid solidification of surface layers and the resultant improved workpiece properties; covers the closely related topics of structural relaxation, atomic transport and other thermally induced processes; demonstrates microstructure-property relationships in rapidly quenched crystalline alloy systems and their beneficial effects in applications; and elucidates the basic, engineeering, and applications-oriented magnetic properties of amorphous alloys.;Furnishing more than 2300 literature citations for further study of specific subjects, Rapidly Solidified Alloys is intended for materials, mechanical, product, and civil engineers; metallurgists; magneticians; physicists; physical chemists; and graduate students in these disciplines.

Fundamentals of Aluminium Metallurgy: Recent Advances updates the very successful book Fundamentals of Aluminium Metallurgy. As the technologies related to casting and forming of aluminum components are rapidly improving, with new technologies generating alternative manufacturing methods that improve competitiveness, this book is a timely resource. Sections provide an overview of recent research breakthroughs, methods and techniques of advanced manufacture, including additive manufacturing and 3D printing, a comprehensive discussion of the status of metalcasting technologies, including sand casting, permanent mold casting, pressure diecastings and investment casting, and recent information on advanced wrought alloy development, including automotive bodysheet materials, amorphous glassy materials, and more. Target readership for the book includes PhD students and academics, the casting industry, and those interested in new industrial opportunities and advanced products. Includes detailed and specific information on the processing of aluminum alloys, including additive manufacturing and advanced casting techniques Written for a broad ranging readership, from academics, to those in the industry who need to know about the latest techniques for working with aluminum Comprehensive, up-to-date coverage, with the most recent advances in the industry