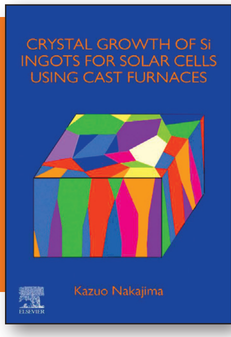


Crystal Growth of Si Ingots for Solar Cells Using Cast Furnaces

Kazuo Nakajima

Elsevier, 2020
390 pages, $133
ISBN: 9780128197486

Often, the goal of crystal growth research is to produce the highest structural perfection and lowest residual impurity concentrations possible. This is expensive, so a more practical approach, to keep the cost low, is to produce crystals that are not perfect but are good enough. This book describes the process innovations developed to grow such multicrystalline silicon ingots for fabricating economical solar cells. Although primarily for specialists interested in silicon solar-cell production, this book offers an original perspective that would be of universal interest to all researchers involved in crystal growth.

A long minority carrier lifetime is necessary for efficient crystalline solar cells. To achieve this, the silicon's dislocation density must be low, as the dislocations create recombination centers that reduce lifetimes. Dislocations arise to relieve stress in the silicon from the interactions of crystal grains as they form, temperature gradients, and the forces exerted by the crucible as the liquid silicon freezes and expands. Grain boundaries relieve stress. Consequently, judiciously introducing grains with different orientations (i.e., producing polycrystalline silicon) is beneficial, as it lowers the dislocation density, resulting in more uniform properties and lowers the material cost.

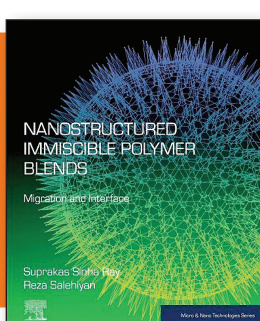
This book details the process strategies to control grain size, predominant crystal orientation, and dislocation densities in cast multicrystalline silicon ingots. It begins by describing silicon's important fundamental properties, including its solid–liquid phase behavior, types of defects commonly present (grain boundaries, twins, and dislocations), and the sources and effects of impurities. The electrical and optical properties important for solar cells are quantified.

The various casting processes and their respective advantages and disadvantages are described. In conventional casting, molten silicon is directionally solidified by imposing a temperature gradient on the melt. The resulting silicon ingot has nonuniform properties due to grain expansion as the silicon freezes. In contrast, in the dendritic cast method, an initial rapid crystallization at the bottom of the crucible produces a nucleation layer that results in greater crystal grain alignment throughout the ingot. In the high-performance cast method, small, randomly oriented crystal seeds are placed at the bottom of the crucible to initiate the growth. This results in an ingot with smaller grains, but with less stress and more uniform properties throughout. The mono-like cast method uses large silicon single crystals to initiate growth of the ingot, producing much larger and more oriented crystals. In the noncontact crucible (NOC) method, the ingot is removed from the melt before freezing occurs at the crucible walls in order to avoid the stress that this causes.

Nakajima ends the book by describing the future technologies being researched to improve the quality of cast silicon ingots. Reducing temperature gradients in the NOC method reduces dislocations and point defects, leading to higher solar-cell efficiencies. Techniques to grow square crystals instead of round ones will make it easier to completely cover an area with less loss of material.

This book provides excellent coverage of the science and technology that has gone into improving multicrystalline silicon for solar cells. The figures clearly illustrate important concepts. The references are up to date (through 2018) and extensive. Despite the many years of research that has gone into silicon solar cells, this book demonstrates that innovation is still possible to produce better quality materials.

***Reviewer: James H. Edgar**, Distinguished Professor, Kansas State University, USA.*



Nanostructured Immiscible Polymer Blends

Suprakas Sinha Ray and Reza Salehiyan

Elsevier, 2020
240 pages, $126 paperback (eBook $154)
ISBN: 9780128167076

This book covers the developments in fundamental aspects as well as applications in the area of immiscible polymer nanocomposites during the last five years. The large number of figures, images of materials, equations, and references are helpful for the reader to gain a comprehensive view of the topic. The authors depict the great potential of nanomaterials in constituting multifunctional immiscible polymer nanocomposites and the underlying mechanisms.

The introductory chapter discusses immiscible polymer blends and the factors governing their rheological behavior and compatibilization. Nanostructured materials are introduced, and developments in the area of polymer nanocomposites are briefly discussed along with the scope of the book.

Chapter 2 begins with the definition of nanomaterials based on different standards

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and their classification schemes based on the dimensionality of the crystallites and further division based on their chemical composition. Chapter 3 discusses the synthesis, structure, and properties of the three widely used nanofillers—nanoclays, carbon nanotubes, and graphene—for immiscible polymer blends. Clear and concise pictures depicting the structure and formation mechanism as well as the spectroscopic and microscopic characterization of different nanofillers are included.

Chapter 4 describes the difference between melt blending and solvent casting techniques in preparing polymer composites. The conditions for miscibility, as well as theoretical aspects of phase diagrams of the blends, are also discussed. The authors evaluate the parameters affecting the morphology of final polymer nanocomposites and discuss the theory behind morphology evolution. Chapter 5 introduces processing techniques for the preparation of immiscible polymer blends and discusses the advantages of melt blending over solution blending, as well as the measures needed to maintain the integrity of nanoparticles during the melt blending process.

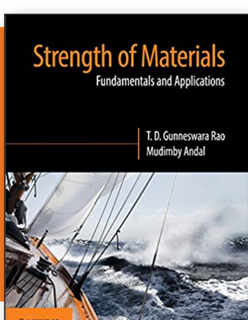
The localization or particle positioning in multiphase polymeric systems is important to tune the desired end-use application of the composite. Chapter 6 presents major migration mechanisms of particles inside an immiscible polymer blend. Chapter 7 discusses the contribution of processing conditions such as mixing sequence, mixing time, and shear force on the final localization of particles in immiscible polymer blends.

In an attempt to design a nanocomposite in line with the optimization of processing conditions, Chapter 8 discusses component-related (nanoparticle or the polymer) parameters such as the contact angle, shape, and size of the nanoparticles, and viscosity of the polymer pairs and their effect on migration.

Chapter 9 presents the migration-assisted localization of nanoparticles and the relationship between nanoparticle localization and electrical, mechanical, and rheological properties of immiscible polymer blends. Chapter 10 outlines the potential current and future applications of nanostructured immiscible polymer blend composites. Chapter 11 provides general conclusions and deep insights into future directions of immiscible polymer nanocomposites.

Overall, this book is well written and contains relevant information regarding the field of nanostructured immiscible polymer blends. Although it does not contain any problem sets, with up-to-date information and adequate bibliographical references, the book will be a valuable resource for undergraduate and graduate student researchers studying the field of polymers, as well as scientists and engineers from industry.

Reviewer: Jyothirmayee Aravind S.S.



Strength of Materials: Fundamentals and Applications

T.D. Gunneswara Rao and Mudimby Andal

Cambridge University Press, 2018
672 pages, $111.99
ISBN 9781108454285

This book is an excellent introduction to the field of mechanical properties of materials for students, engineers, researchers, and newcomers who wish to understand the fundamentals of materials design within different applications. The text introduces readers to different concepts related to the strength of materials, including stress, strain, elastic modulus, shear forces, bending stress, and bending moment. The book provides researchers with comprehensive knowledge supported by completed mathematical problems. Compelling illustrations of useful explanations of materials properties (particularly mechanical properties), as well as lists of adequate and up-to-date reference citations, are included.

The book is written from a combined perspective of mechanical engineering and materials engineering. Chapters 1 and 2 introduce the theory for stress, strain, and deformation and their relationship to the elastic constants in order to understand materials behavior. Chapters 3–5 provide an analysis of both shear-force and bending-moment diagrams, providing details regarding bending stress and flexural shear stresses of composite sections.

Chapters 6–8 discuss the various types of trusses using different methods, provide details on slope and deflections of beams with different loading conditions, and describe the analysis of the stresses induced in the cylinders. Chapters 9–11 examine the torsion of circular sections, provide information on maximum and minimal normal or shear stress, and explain the theory of open- and closed-coiled helical springs. Chapters 12 and 13 cover varying types of columns and their behaviors in-depth, with engaging sketches that illustrate estimation of stresses for combined actions. Chapters 14–17 offer readers an understanding of unsymmetrical bending and shear centers, providing details on the stresses induced in rotating discs and cylinders and stresses in bars with curvatures.

The authors provide useful discussion of solved problems to explain the mechanical properties of materials. This book would serve as an important addition to the libraries of those interested in mechanical properties of materials. It is recommended to all who are interested in the study of materials, particularly those entering the field, and is appropriate for someone with a metallurgy, materials, or mechanical engineering background.

***Reviewer: Walid M. Daoush**, Helwan University, Egypt.*

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