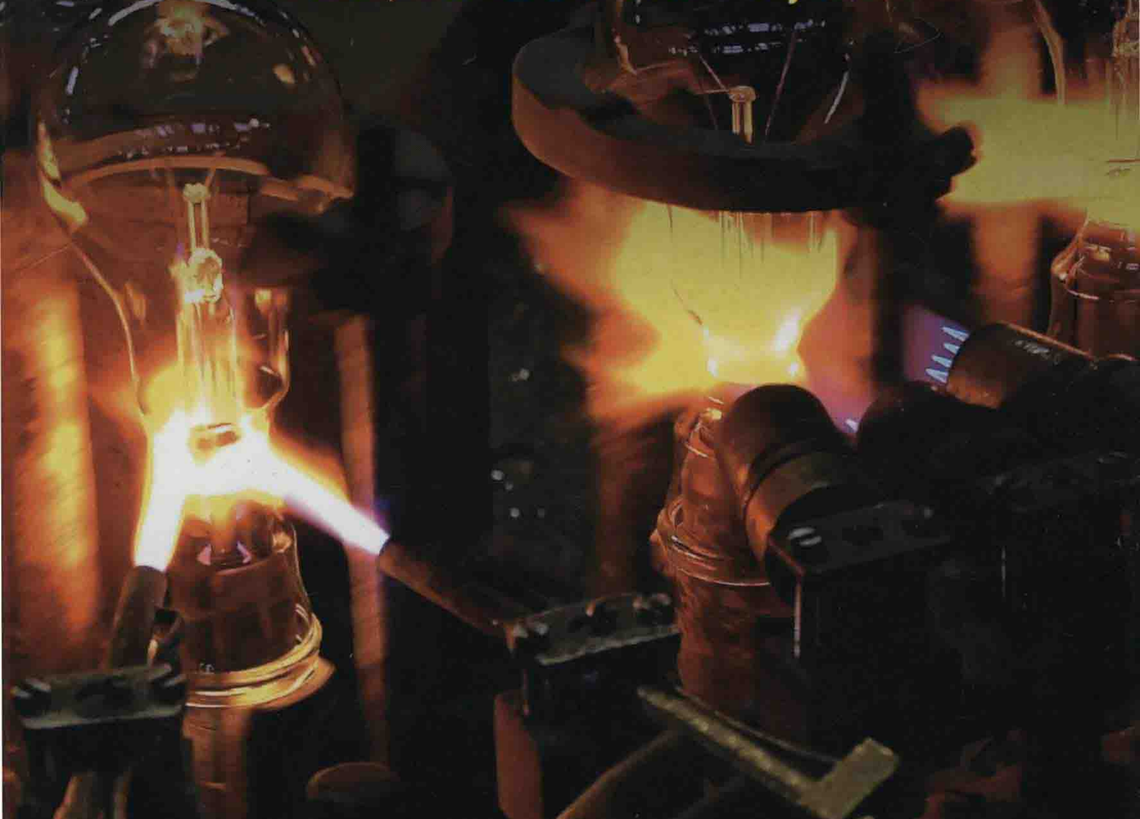
Materials Processing

A Unified Approach to Processing of Metals, Ceramics and Polymers



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with contributions from
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Dedicated to Mark and Carolyn

Preface

Materials processing is recognized as one of the four key components of the field of Materials Science and Engineering (MSE). How a material is made into its final form has great importance to a material's structure (i.e., crystal structure, phases, microstructure) and therefore to its properties and performance. For example, cold deformation processes, such as rolling, increase the dislocation density and hence the yield strength of metals. The reverse is also true: a material's structure and properties determine its ability (or inability) to be processed easily by a given method. For example, the viscosity of a typical polymer melt is too high for forming operations involving gravity-driven flow, such as melt casting, but is well suited for processes involving pressure-driven flow, such as extrusion and injection molding. Processing-structure-property interrelationships abound in all types of engineering materials. Processing also plays a significant part in determining the cost of the final item, and is central to materials selection and design. Hence, the study of materials processing builds naturally from a base understanding of structure-property relationships and is an essential component of materials selection and design.

This book introduces the fundamentals of materials processing. The area is broad both in the scientific and engineering principles and in the details involved in the practical processes. The intent here is not to cover all the details, but to explore fundamental concepts and show their application in example processes. The examples range from traditional processes, such as sand casting of metals, to newer additive processes, such as fused deposition modeling (i.e., 3D printing). The book covers processing fundamentals that apply to the three main classes of engineering materials: metals, ceramics, and polymers. The unified approach used here considers processes in categories according to their state of matter as the new shape is formed. For example, the chapter on "melt processes" explores the fundamentals aspects of melt flow and solidification and applies them to processes such as metal melt casting and polymer injection molding. This approach lends itself to exploration and application of prior knowledge.

The book is intended for undergraduates in MSE and related fields. Students who have completed an introductory materials science and engineering course, as well as calculus, physics, and chemistry courses have the background needed for this book. For example, the book could be used in a course offered in the junior or even the sophomore year directly after these prerequisites are completed, or in a course for seniors as a capstone. Graduate students and practicing engineers may also find this book useful to broaden their knowledge base and add to their understanding of fundamental concepts.

There are seven chapters in this text. The first chapter introduces the field of materials processing and provides an overview of the processing of metals, ceramics, and polymers. The second chapter deals with the preparation, formulation, and characterization of the starting materials for processing. The remaining chapters are devoted to different processing routes. These routes are grouped by the nature of the material as the final form is created: melt, solid, powder, dispersion or solution, and vapor. Important post-processing operations, such as sintering, are integrated into these chapters. Each chapter includes sections dealing with scientific and engineering fundamentals, followed by sections on the processes, including descriptions, analytical approaches to process modeling and worked examples. Each chapter ends with a bibliography, review questions, and problems.

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Lorraine F. Francis
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