Fibers are ubiquitous. They exist in synthetic and natural forms, as polymers, metals and ceramics. This book is about the processing, microstructure and properties of materials in fibrous form, and is the first to cover the whole range of fibers. Special emphasis is given to major developments in high strength and high stiffness polymeric fibers as well as high temperature ceramic fibers.

The range of fibrous materials covered spans natural polymeric fibers such as silk, synthetic polymeric fibers such as aramid and polyethylene, metallic fibers such as steel and tungsten, and ceramic fibers such as alumina and silicon carbide. The author explains the fundamentals in a clear and concise manner and describes important advances in the production and control of microstructure in high stiffness and high strength fibers. The text contains large numbers of diagrams and micrographs to bring home to the reader the important principles and concepts.

The book will be of value to senior undergraduates, beginning graduate students and researchers in the fields of materials science and engineering, metallurgy, ceramics, textile physics and engineering, mechanical engineering and chemical engineering.

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एकं सद् विप्रा बहुधा वदंति

The truth is only one;
wise men call it by different names.
– Rigveda

In loving memory of my dear mother, Sumitra Chawla

Contents

Preface

This book is about materials in fibrous form, precisely what the title says. Perhaps the only thing that needs to be emphasized is that the materials aspects of fibers are highlighted. The main focus is on the triad of processing, microstructure, and properties of materials in a fibrous form. I have kept the mathematics to the bare minimum necessary. More emphasis is placed on physical and chemical insights. Although all kinds of fibers are touched upon, there is a distinct tilt toward synthetic, nonapparel-type fibers. This is understandable inasmuch as the second half of the twentieth century has seen tremendous research and development activity in this area of high performance fibers, mainly for use as a reinforcement in a variety of matrix materials.

The field of fibrous materials is indeed very vast. To compress all the information available in a reasonable amount of space is a daunting task. My aim in writing this text has been to provide a broad coverage of the field that would make the text suitable for anyone generally interested in fibrous materials. I have provided ample references to the original literature and review articles to direct the reader with a special interest in any particular area.

The plan of the book is as follows. After an introductory chapter, some general terms and attributes regarding fibers and products thereof are described in Chapter 2. This chapter also serves to provide a mutually comprehensible language to textile and nontextile users of fibers. There is no gainsaying the fact that many definitions, units and terms about fibers owe their origin to the textile industry. Thus, it behoves a materials scientist or engineer to take cognizance of those and be at home with them. At the same time, it is not unreasonable to expect that a textile engineer should know the stress–strain curves of fibers in

engineering units. This general chapter is followed by Chapters 3 and 4 on natural and synthetic polymeric fibers, respectively. Chapter 5 covers metallic fibers, which are quite widely used in a variety of engineering applications, although generally not so recognized. Chapter 6 describes ceramic fibers where much innovative processing work has been done during the last quarter of the twentieth century. This is followed by two chapters (7 and 8) on glass and carbon fibers; two fibers that have been commercially most successful and find widespread use as engineered materials, for example both are used as reinforcements in a variety of composites, and optical glass fiber has an enormous market in telecommunications. Chapter 9 describes some of the testing and characterization techniques used with fibers. Finally, Chapter 10 provides a statistical treatment of strength of fibrous materials. One of the major sources of confusions about fiber characteristics is due to the different units that are used, especially the textile and engineering units. An appendix giving different units and their conversion factors is provided. A book on the materials aspects of fibers, or for that matter any other entity, must have photomicrographs to illustrate the microstructural aspects pertinent to that particular material form and the processing that resulted in that material form. Never was the adage, 'A picture is worth a thousand words', truer than in the present case. I have tried to include as many micrographs as possible. The sources of these are acknowledged in the figure captions.

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