

INTRODUCTION TO COMPOSITE MATERIALS

Department of Materials Science and Engineering
Massachusetts Institute of Technology
Cambridge, MA 02139

Introduction

This module introduces basic concepts of stiffness and strength underlying the mechanics of fiber-reinforced advanced composite materials. This aspect of composite materials technology is sometimes termed “micromechanics,” because it deals with the relations between macroscopic engineering properties and the microscopic distribution of the material’s constituents, namely the volume fraction of fiber. This module will deal primarily with unidirectionally-reinforced continuous-fiber composites, and with properties measured along and transverse to the fiber direction.

Materials

The term *composite* could mean almost anything if taken at face value, since all materials are composed of dissimilar subunits if examined at close enough detail. But in modern materials engineering, the term *usually* refers to a “matrix” material that is reinforced with fibers. For instance, the term “FRP” (for Fiber Reinforced Plastic) usually indicates a thermosetting polyester matrix containing glass fibers, and this particular composite has the lion’s share of today’s commercial market. Figure 1 shows a laminate fabricated by “crossplying” unidirectionally-reinforced layers in a 0° - 90° stacking sequence.

Many composites used today are at the leading edge of materials technology, with performance and costs appropriate to ultrademanding applications such as spacecraft. But heterogeneous materials combining the best aspects of dissimilar constituents have been used by nature for millions of years. Ancient society, imitating nature, used this approach as well: the Book of Exodus speaks of using straw to reinforce mud in brickmaking, without which the bricks would have almost no strength.

As seen in Table 1¹, the fibers used in modern composites have strengths and stiffnesses far above those of traditional bulk materials. The high strengths of the glass fibers are due to processing that avoids the internal or surface flaws which normally weaken glass, and the strength and stiffness of the polymeric aramid fiber is a consequence of the nearly perfect alignment of the molecular chains with the fiber axis.

¹F.P. Gerstle, “Composites,” *Encyclopedia of Polymer Science and Engineering*, Wiley, New York, 1991. Here E is Young’s modulus, σ_b is breaking stress, ϵ_b is breaking strain, and ρ is density.

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Introduction to Materials Science Jean P Mercier, Gerald Zambelli, Wilfried Kurz, 2012-12-02 The approach of this concise but comprehensive introduction covering all major classes of materials is right for not just materials science students and professionals but also for those in engineering physics and chemistry or other related disciplines The characteristics of all main classes of materials metals polymers and ceramics are explained with reference to real world examples So each class of material is described then its properties are explained with illustrative examples from the leading edge of application This edition contains new material on nanomaterials and nanostructures and includes a study of degradation and corrosion and a presentation of the main organic composite materials Illustrative examples include carbon fibres the silicon crystal metallic glasses and diamond films Applications explored include ultra light aircraft contact lenses dental materials single crystal blades for gas turbines use of lasers in the automotive industry cables for cable cars permanent magnets and molecular electronic devices Covers latest materials including nanomaterials and nanostructures Real world case studies bring the theory to life and illustrate the latest in good design All major classes of materials are covered in this concise yet comprehensive volume

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