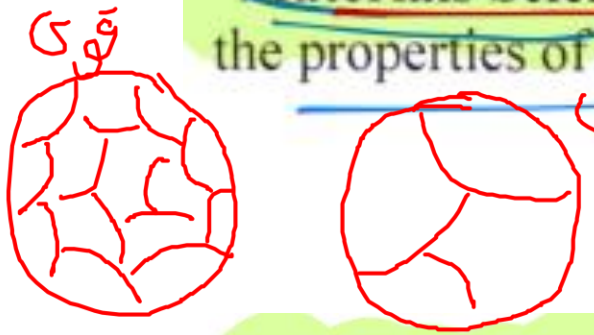
Ch1
Introduction

MATERIALS SCIENCE AND ENGINEERING

"**Materials Science**" shows how the structure can be responsible for the properties of materials (The basic knowledge of Materials).



- يهتم بالعلاقة بين تركيب المادة وخصائصها.

"**Materials Engineering**" is built on the basis of these structure–property correlations. Materials engineering involves designing or engineering the structure of a material to produce a predetermined set of properties (Applied knowledge of Materials).

- يستخدم العلاقات بين تركيب المادة وخصائصها فى تصميم وتحديد تركيب المادة المرغوب فيها للحصول على خصائص معينة.

- Virtually all-important properties of solid materials may be grouped into six different categories: **mechanical, electrical, thermal, magnetic, optical, and deteriorative.**

- **يمكن تقسيم جميع الخصائص المهمة للمواد الصلبة تقريبًا إلى ست فئات مختلفة.**

- Mechanical properties relate deformation to an applied load or force; examples include elastic modulus (stiffness), strength, and toughness.

- **ترتبط الخصائص الميكانيكية بالتشوه الناتج عن الحمل أو القوة المطبقة.**

- For electrical properties, such as electrical conductivity.

- **بالنسبة للخصائص الكهربائية، مثل التوصيلية الكهربائية.**

- The thermal behavior of solids can be represented in terms of heat capacity and thermal conductivity.

- **يمكن تمثيل السلوك الحراري للمواد الصلبة من حيث السعة الحرارية والتوصيلية الحرارية.**

- Magnetic properties demonstrate the response of a material to the application of a magnetic field.

- **تظهر الخصائص المغناطيسية استجابة المادة لتطبيق مجال مغناطيسي.**

- For optical properties, index of refraction and reflectivity are representative optical properties.

- **بالنسبة للخصائص البصرية، فإن معامل الانكسار والانعكاسية هي امثلة على الخصائص البصرية.**

- deteriorative characteristics relate to the chemical reactivity of materials.

- **ترتبط الخصائص التدهورية الخاصة بالتفاعل الكيميائي للمواد.**

Figure 1.1 The four components of the discipline of materials science and engineering and their interrelationship.

- Processing controls the structure of a material.

- The structure of a material depends on how it is processed.

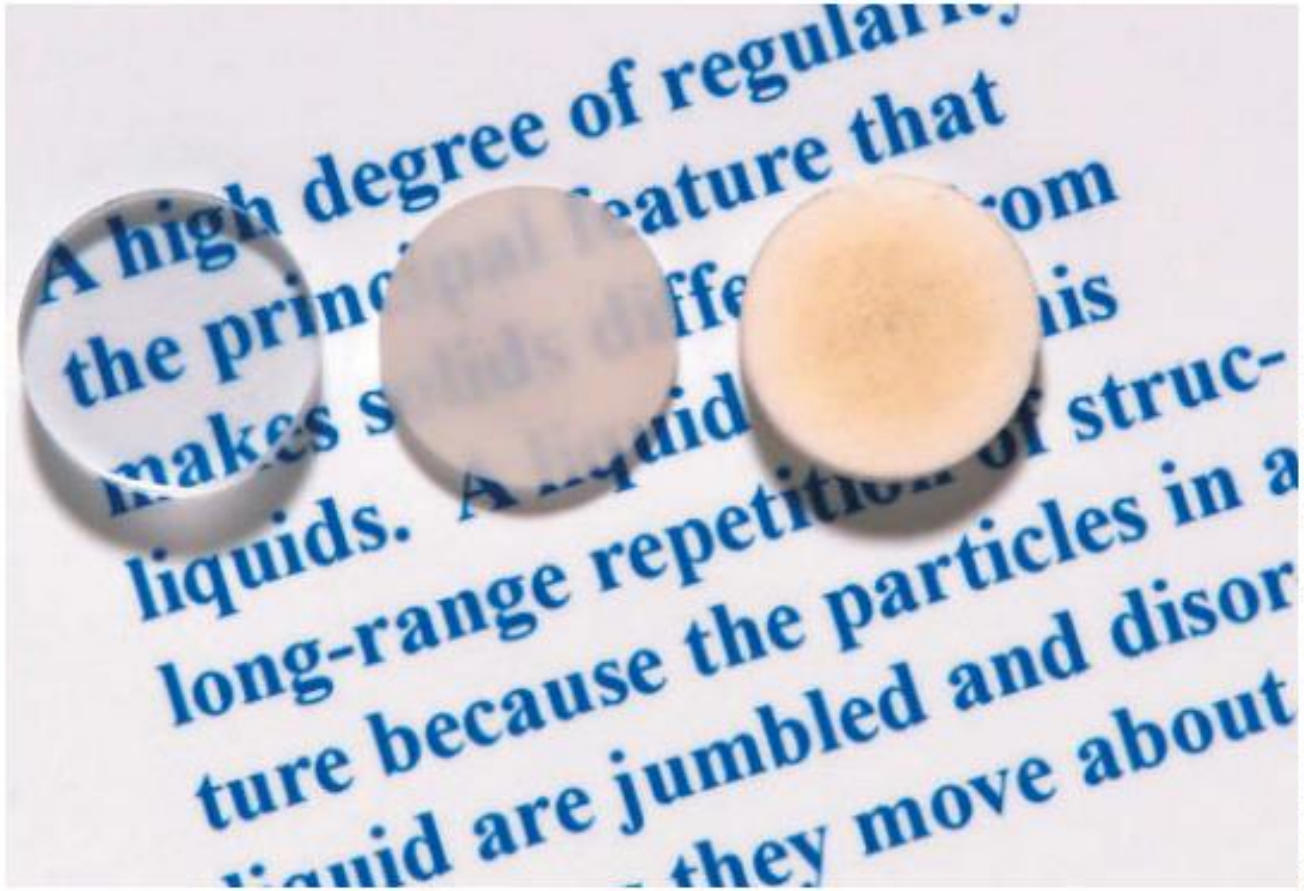
- property is a material trait in terms of the kind and magnitude of response to a specific imposed stimulus.

- A material's performance is a function of its properties.

The performance of a material depends on its properties, which in turn are a function of its structure; furthermore, structure is determined by how the material was processed.

- يعتمد أداء المادة على خصائصها، والتي بدورها تعتمد على بنيتها؛ وعلاوة على ذلك، يتم تحديد البنية من خلال العمليات التى تتم على المادة.

↳ structure
↳ properties
↳ performance
↳ processing



Specimen preparation, P. A. Lessing

Figure 1.2 Three thin disk specimens of aluminum oxide that have been placed over a printed page in order to demonstrate their differences in light-transmittance characteristics. The disk on the left is *transparent* (i.e., virtually all light that is reflected from the page passes through it), whereas the one in the center is *translucent* (meaning that some of this reflected light is transmitted through the disk). The disk on the right is *opaque*—that is, none of the light passes through it. These differences in optical properties are a consequence of differences in structure of these materials, which have resulted from the way the materials were processed.

WHY STUDY MATERIALS SCIENCE AND ENGINEERING?

- Many times, a materials problem is one of selecting the right material from the thousands available.

- في كثير من الأحيان، تكون المشكلة هي اختيار المواد المناسبة من بين الآلاف المتاحة.

Criteria for choosing the right material.

- **In-service conditions.**
- **Deterioration.**
- **Economics.**

3 basic Categories

Metals

- Metals are composed of one or more metallic elements (e.g., iron, aluminum, copper, titanium, gold, nickel).

Ceramics

- Ceramics are compounds between metallic and nonmetallic elements; they are most frequently oxides, nitrides, and carbides.

Polymers

- Polymers include the familiar plastic and rubber materials.

Composites

خليط من مادتين أو أكثر.

- A composite is composed of two (or more) individual materials.
- some naturally occurring materials are composites—for example, wood and bone.
- Another technologically important material is the carbon fiber–reinforced polymer (CFRP) composite—carbon fibers that are embedded within a polymer.

Advanced Material

Semiconductors

- Semiconductors have electrical properties that are intermediate between those of electrical conductors (i.e., metals and metal alloys) and insulators (i.e., ceramics and polymers).

Smart Materials

- Smart (or intelligent) materials are a group of new and state-of-the-art materials now being developed that will have a significant influence on many of our technologies.
- Components of a smart material (or system) include some type of sensor (which detects an input signal).

Nanomaterial

- They are not distinguished on the basis of their chemistry but rather their size.

Biomaterials

Biomaterials wad Biomaterials are employed in components implanted into the human body to replace diseased or damaged body parts

Figure 1.4
Bar chart of room-temperature density values for various metals, ceramics, polymers, and composite materials.

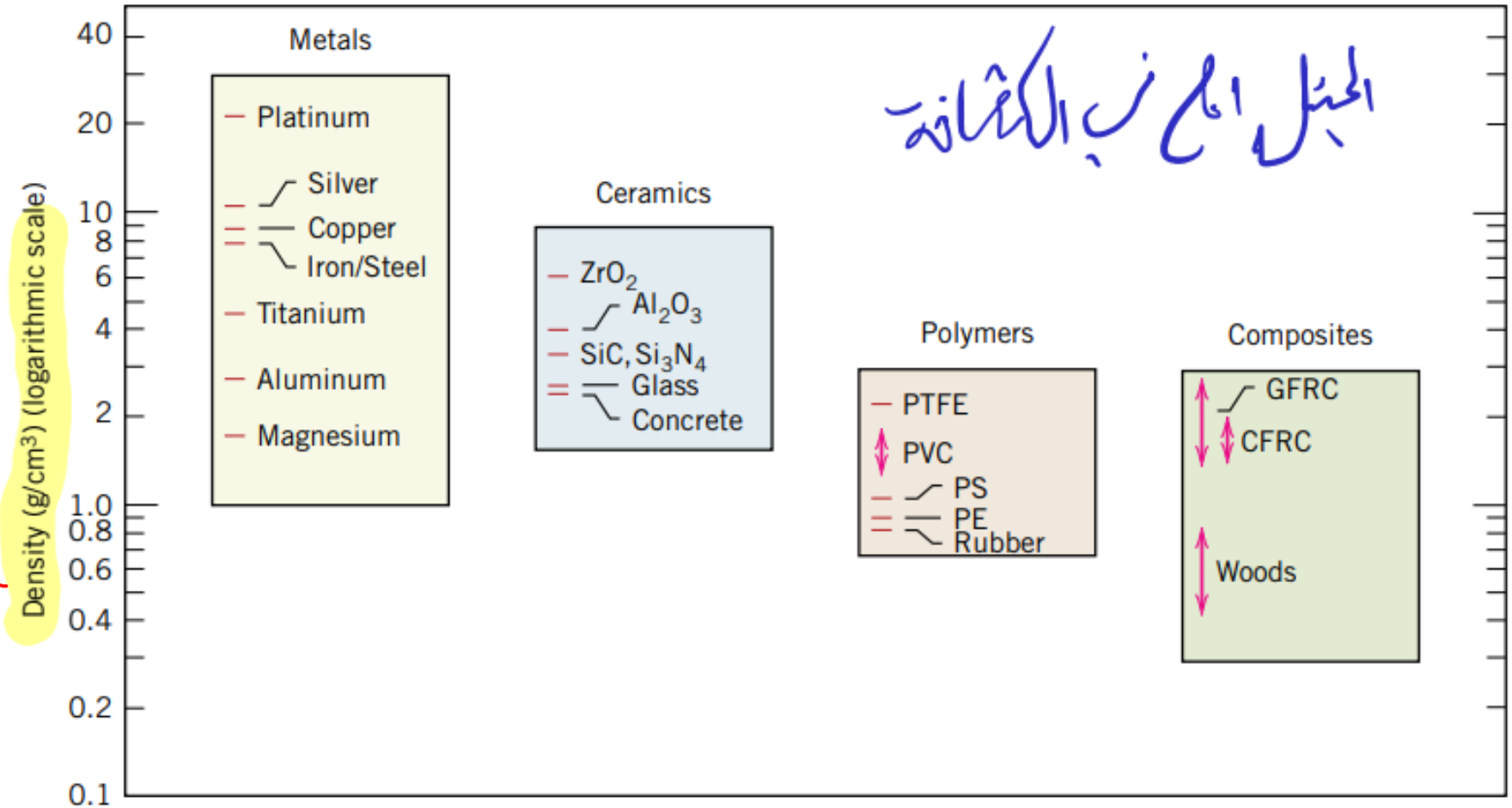


Figure 1.5
Bar chart of room-temperature stiffness (i.e., elastic modulus) values for various metals, ceramics, polymers, and composite materials.

$E = \frac{\sigma}{\varepsilon}$ ← stress / ← strain

more stiff ←

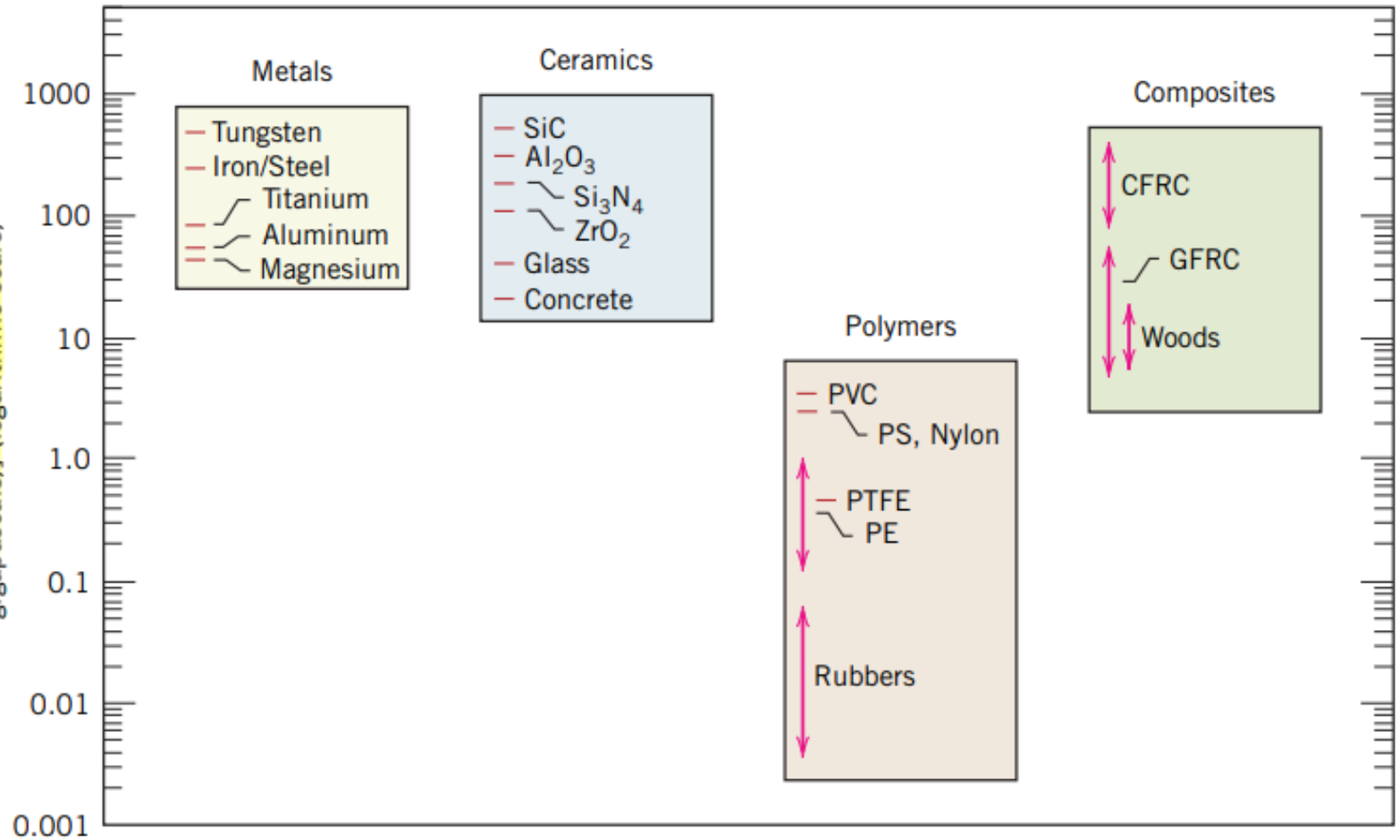
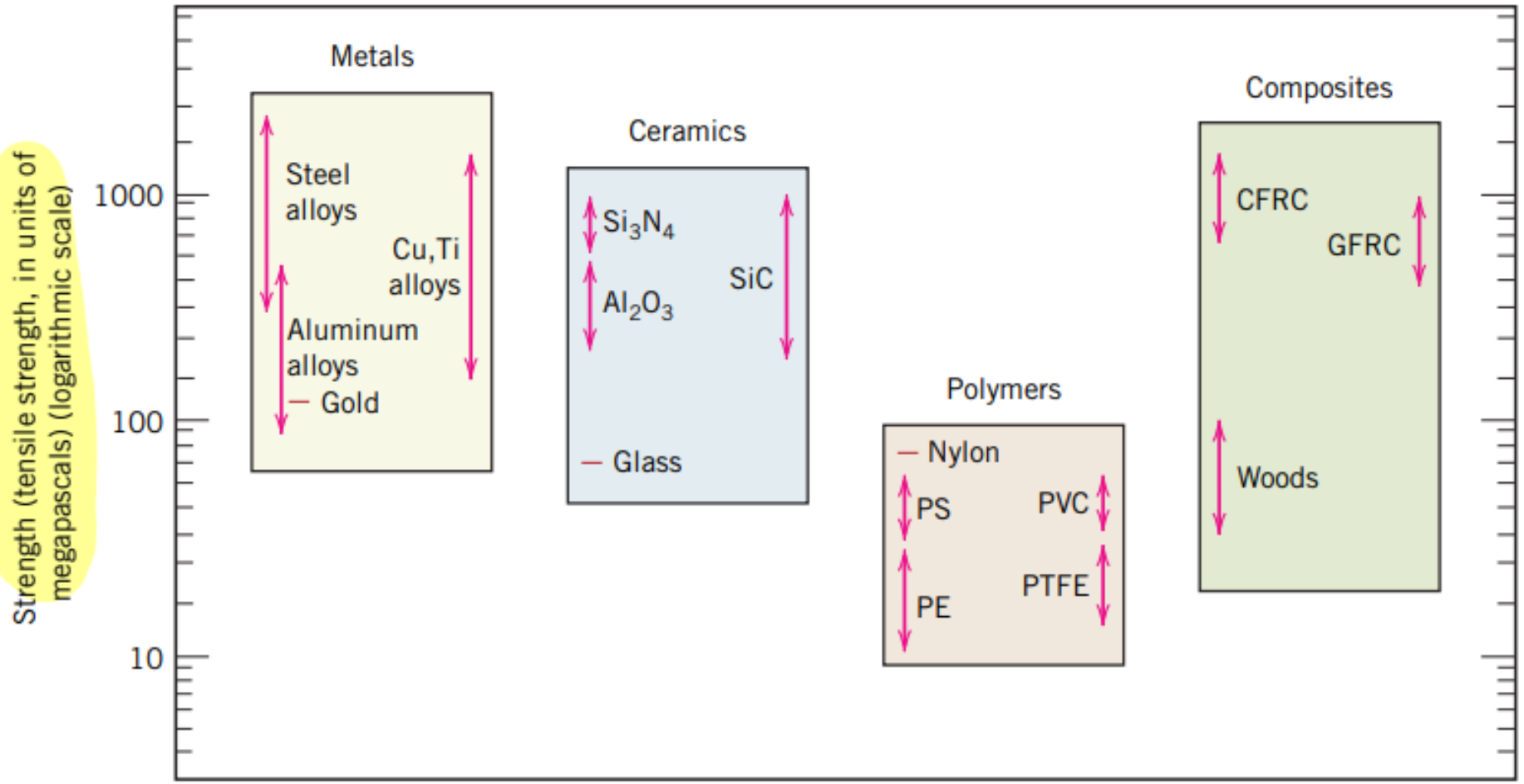
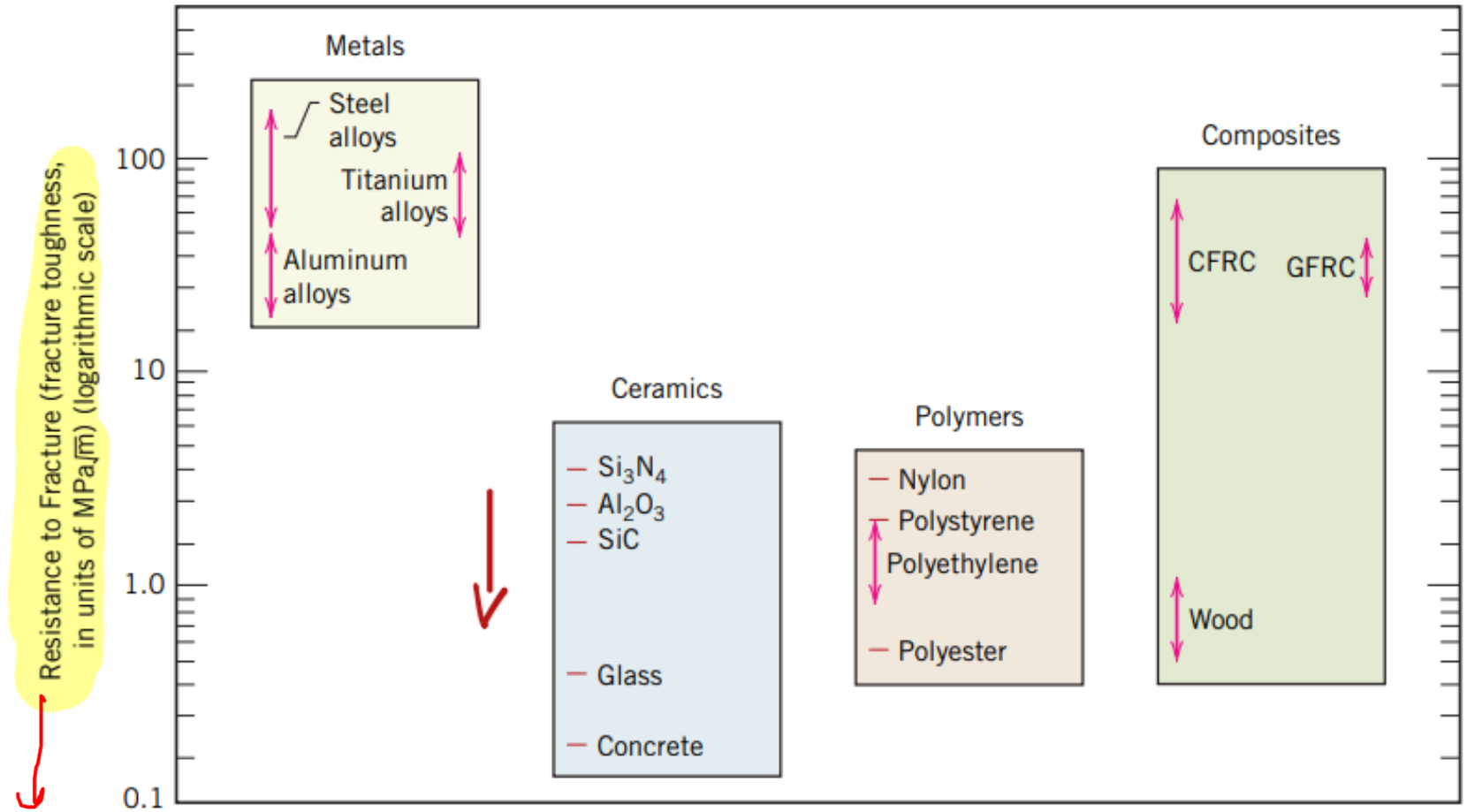


Figure 1.6
Bar chart of room-temperature strength (i.e., tensile strength) values for various metals, ceramics, polymers, and composite materials.



أقصى إجهاد تتحمله المادة

Figure 1.7 Bar chart of room-temperature resistance to fracture (i.e., fracture toughness) for various metals, ceramics, polymers, and composite materials. (Reprinted from *Engineering Materials 1: An Introduction to Properties, Applications and Design,* third edition, M. F. Ashby and D. R. H. Jones, pages 177 and 178, Copyright 2005, with permission from Elsevier.)



مقاومة الكسر

Figure 1.8
Bar chart of room-temperature electrical conductivity ranges for metals, ceramics, polymers, and semiconducting materials.