普通高等教育“十二五”规划教材

Professional English for Materials Science and Engineering

材料科学与工程
专业英语

材料科学与工程专业英语编委会 编

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编 委 会

《材料科学与工程专业英语》

编 委 会

前　言

材料的应用越来越广泛，并渗透到各行业，成为机械、电子、化工、建筑、能源、生物、冶金、交通运输、信息科技等行业的基础。材料科学与工程是研究材料制备、结构、性能、加工的学科，其发展从宽广到细分，又从细分到综合，对材料科学与工程学科专业结构和人才素质提出了新的要求。材料学科持续发展，学生规模不断扩大，与材料学科相关的专业英语教材出版力度需要进一步得到加强。由此，我们编写了这本《材料科学与工程专业英语》教材。

本书特色：(1)内容全面，适应多专业教学需求(可根据实际情况选择教学内容)；(2)教学内容循序渐进，体现基本知识的完整性和系统性，避免因知识点跳跃过大造成学生学习与理解困难；(3)体现材料学科建立、发展、创新的脉络，做到材料科学基础知识与材料研发应用的有机结合，增加教材可读性和吸引力；(4)精心选择教材内容，词汇量、阅读难易度适当，有利于提高教学效果。

本教材共分8部分，32个单元，每个单元由一篇课文和一篇阅读材料组成。阅读材料提供与课文相应的背景知识或是课文的续篇；根据课文与阅读材料的内容，配有相应的练习题和注释。全书包括了材料科学与工程概论、金属材料(包括合金)、陶瓷材料、纳米材料、高分子材料、复合材料和生物医学材料，以及材料与环境等内容。本教材内容丰富、新颖，知识面宽。书末附录简要介绍了专业英语的构词规则和科技英语翻译技巧等。教材中的PART 1由葛建芳、闫萍编写，PART 2由陈飞、曾冬梅、杨英歌、冯文然、秦华编写，PART 3由方必军和周丽敏编写，PART 4和附录二由李翠金编写，PART 5由黄军左和付文编写，PART 6和附录一由郭清兵编写，PART 7由韩红梅、张国福编写，PART 8由蒲侠和肖文清编写；全部内容在互相交换审阅后，由李凤红、王立岩和邹雪梅对全稿进行了认真仔细的校对。向红平同学负责全文初稿的编辑整理工作。教材编写过程中得到石油化工高等院校专业教材协作组及相关院校的大力支持和帮助，在此一并表示谢意。

本教材可作为高年级本(专)科生教材，也可供研究生、科研人员和相关领域工程技术人员参考使用。

受编者水平和能力所限，书中难免有不当甚至错误之处，恳请同行专家学者和广大读者批评指正。

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PART 1 INTRODUCTION TO MATERIALS SCIENCE & ENGINEERING

Unit 1 Materials Science and Engineering

Historical Perspective

Materials are probably more deep-seated in our culture than most of us realize. Transportation, housing, clothing, communication, recreation, and food production—virtually every segment of our everyday lives is influenced to one degree or another by materials. Historically, the development and advancement of societies have been intimately tied to the members' ability to produce and manipulate materials to fill their needs. In fact, early civilizations have been designated by the level of their materials development (Stone Age, Bronze Age, Iron Age).

deep-seated /'diːp'siːtid/ *adj.* 根深蒂固的，深层的

The earliest humans had access to only a very limited number of materials, those that occur naturally: stone, wood, clay, skins, and so on. With time they discovered techniques for producing materials that had properties superior to those of the natural ones; these new materials included pottery and various metals. Furthermore, it was discovered that the properties of a material could be altered by heat treatments and by the addition of other substances. At this point, materials utilization was totally a selection process that involved deciding from a given, rather limited set of materials

pottery /'pɔtəri/ *n.* 陶器

the one best suited for an application by virtue of its characteristics. ① It was not until relatively recent times that scientists came to understand the relationships between the structural elements of materials and their properties. This knowledge, acquired over approximately the past 100 years, has empowered them to fashion, to a large degree, the characteristics of materials. Thus, tens of thousands of different materials have evolved with rather specialized characteristics that meet the needs of our modern and complex society; these include metals, plastics, glasses, and fibers.

structural element 结构成分

property /'prɔpəti/*n.* 性能

The development of many technologies that make our existence so comfortable has been intimately associated with the accessibility of suitable materials. An advancement in the understanding of a material type is often the forerunner to the stepwise progression of a technology. For example, automobiles would not have been possible without the availability of inexpensive steel or some other comparable substitute. In our contemporary era, sophisticated electronic devices rely on components that are made from what are called semiconducting materials.

stepwise /'stepwaiz/*adj.* 逐步的

sophisticated /sə'fistikeitid/*adj.* 精制的，复杂的

semiconducting material 半导体材料

Materials Science and Engineering

The discipline of materials science involves investigating the relationships that exist between the structures and properties of materials. In contrast, materials engineering is, on the basis of these structure-property correlations, designing or engineering the structure of a material to produce a predetermined set of properties.

"Structure" is at this point a nebulous term that deserves some explanation. In brief, the structure of a material usually relates to the arrangement of its internal components. Subatomic structure involves electrons within the individual atoms and interactions with their nuclei. On an atomic level, structure encompasses the organization of atoms or molecules

nebulous /'nebjuləs/*adj.* 含糊的，有歧义的

subatomic /'sʌbə'tɔmik/*adj.* 亚原子的

relative to one another. The next larger structural realm, which contains large groups of atoms that are normally agglomerated together, is termed "microscopic", meaning that which is subject to direct observation using some type of microscope. Finally, structural elements that may be viewed with the naked eye are termed "macroscopic".

The notion of "property" deserves elaboration. While in service use, all materials are exposed to external stimuli that evoke some type of response. For example, a specimen subjected to forces will experience deformation; or a polished metal surface will reflect light. Property is a material trait in terms of the kind and magnitude of response to a specific imposed stimulus. Generally, definitions of properties are made independent of material shape and size.

Virtually all important properties of solid materials may be grouped into six different categories: mechanical, electrical, thermal, magnetic, optical, and deteriorative. For each there is a characteristic type of stimulus capable of provoking different responses. Mechanical properties relate deformation to an applied load or force; examples include elastic modulus and strength. For electrical properties, such as electrical conductivity and dielectric constant, the stimulus is an electric field. The thermal behavior of solids can be represented in terms of heat capacity and thermal conductivity. Magnetic properties demonstrate the response of a material to the application of a magnetic field. For optical properties, the stimulus is electromagnetic or light radiation; index of refraction and reflectivity are representative optical properties. Finally, deteriorative characteristics indicate the chemical reactivity of materials.

In addition to structure and properties, two other important components are involved in the science and engineering of materials, viz. "processing" and "performance". With regard to the relationships of these four components, the

microscopic /maikrə'skɔpik/ *adj.* 微观的

macroscopic /mækrəu'skɔpik/ *adj.* 宏观的

deformation /ˌdiːfɔː'meiʃən/*n.* 变形

deteriorative /di'tiəriəreitiv/ *n.* 破坏(老化的)

elastic modulus 弹性模量

strength /streŋθ/*n.* 强度

dielectric constant 介电常数

heat capacity 热容量

refraction /ri'frækʃən/*n.* 折射率

reflectivity /ˌriːflek'tiviti/ *n.* 反射率

processing /prəu'sesiŋ/ *n.* 加工

structure of a material will depend on how it is processed. Furthermore, a material's performance will be a function of its properties.

We now present an example of these processing-structure-properties-perfor-mance principles with Fig. 1. 1, a photograph showing three thin disk specimens placed over some printed matter. It is obvious that the optical properties (i. e., the light transmittance) of each of the three materials are different; the one on the left is transparent (i. e., virtually all of the reflected light passes through it), whereas the disks in the center and on the right are, respectively, translucent and opaque.

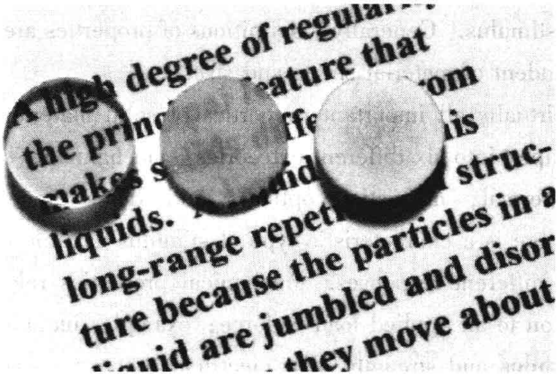


Fig. 1. 1 Photograph showing the light transmittance of three aluminum oxide specimens. From left to right: single crystal material (sapphire), which is transparent; a polycrystalline and fully dense (nonporous) material, which is translucent; and a polycrystalline material that contains approximately 5% porosity, which is opaque. (Specimen preparation, P. A. Lessing; photography by J. Telford.)

transmittance /trænz'mitəns/ *n.* 透射性
sapphire /sæfaiə/ *n.* 蓝宝石
transparent /træns'pɛərənt/ *adj.* 透明的
polycrystalline /ˌpɔli'kristəlain/ *n.* 多晶体
translucent /trænz'ljuːsnt/ *adj.* 半透明的
opaque /əu'peik/ *adj.* 不透明的
single crystal 单晶体

All of these specimens are of the same material, aluminum oxide, but the leftmost one is what we call a single crystal—that is, it is highly perfect—which gives rise to its transparency. The center one is composed of numerous and very small single crystals that are all connected; the boundaries between these small crystals scatter a portion of the light reflected from the printed page, which makes this material optically translucent. ② And finally, the specimen on the right is composed not only of many small, interconnected crystals, but also of a large number of very small pores or void spaces. These pores also effectively scatter the reflected light and render this material opaque.

Thus, the structures of these three specimens are different in terms of crystal boundaries and pores, which affect the optical transmittance properties. Furthermore, each material was produced using a different processing technique. And, of course, if optical transmittance is an important parameter relative to the ultimate in-service application, the performance of each material will be different.

Why Study Materials Science and Engineering?

Why do we study materials? Many an applied scientist or engineer, whether mechanical, civil, chemical, or electrical, will at one time or another be exposed to a design problem involving materials. Examples might include a transmission gear, the superstructure for a building, an oil refinery component, or an integrated circuit chip. Of course, materials scientists and engineers are specialists who are totally involved in the investigation and design of materials.

transmission gear 传动齿轮

Many times, a materials problem is one of selecting the right material from the many thousands that are available. There are several criteria on which the final decision is normally based. First of all, the in-service conditions must be characterized, for these will dictate the properties required of the material. On only rare occasions does a material possess the maximum or ideal combination of properties.

dictate /dik'teit/*v.* 决定

Thus, it may be necessary to trade off one characteristic for another. The classic example involves strength and ductility; normally, a material having a high strength will have only a limited ductility. In such cases a reasonable compromise between two or more properties may be necessary.

trade off 权衡；折中

ductility /dʌk'tiliti/*n.* 延展性

A second selection consideration is any deterioration of material properties that may occur during service operation. For example, significant reductions in mechanical strength may result from exposure to elevated temperatures or corrosive environments.

overriding /ˌəuvəˈraidiŋ/ *adj.* 最主要的

Finally, probably the overriding consideration is that of economics: What will the finished product cost? A material may be found that has the ideal set of properties but is prohibitively expensive. Here again, some compromise is inevitable.

judicious /dʒuːˈdiʃəs/ *adj.* 明智的

The cost of a finished piece also includes any expense incurred during fabrication to produce the desired shape. The more familiar an engineer or scientist is with the various characteristics and structure-property relationships, as well as processing techniques of materials, the more proficient and confident he or she will be to make judicious materials choices based on these criteria. ③

Reference: William D. Callister, Materials science and engineering: an introduction, Press: John Wiley & Sons, Inc., 2007: 2－5

Notes

1. At this point, materials utilization was totally a selection process that involved deciding from a given, rather limited set of materials the one best suited for an application by virtue of its characteristics.

由此看来，材料的使用完全就是一个选择过程，且此过程又是根据材料的性质从许多的而不是有限的材料中选择一种最适于某种用途的材料。

2. The center one is composed of numerous and very small single crystals that are all connected; the boundaries between these small crystals scatter a portion of the light reflected from the printed page, which makes this material optically translucent.

中心由无数相连的微小单晶体所组成；这些微小晶体之间的界面散射了一部分从纸面折射来的光，从而致使材料变为光学透明。

3. The more familiar an engineer or scientist is with the various characteristics and structure-property relationships, as well as processing techniques of materials, the more

proficient and confident he or she will be to make judicious materials choices based on these criteria.

工程师或科学家对材料的各种性质、结构与功能之间的关系以及生产工艺越熟悉，就越能熟练自信地根据这些标准选择出最合适的材料。

Exercises

1. *Choose the best answer for the following questions according to the text.*

(1) Why materials are so important in the modern times?

(A) Materials influence our everyday lives and accelerate the development and advancement of societies.

(B) They are deep-seated in our culture.

(C) There are many kinds of materials.

(D) They are very expensive.

(2) What is the relationship between structure and properties?

(A) Properties of materials depend largely on their structures.

(B) Structures of materials affect indirectly ontheir properties.

(C) Both of them have mutual effect.

(D) There are no direct relation between them.

2. *Translate the following sentences into Chinese.*

One of the reasons that synthetic polymers (including rubber) are so popular as engineering materials lies with their chemical and biological inertness. On the down side, this characteristic is really a liability when it comes to waste disposal. Polymers are not biodegradable, and, as such, they constitute a significant land-fill component; major sources of waste are from packaging, junk automobiles and domestic durables. Biodegradable polymers have been synthesized, but they are relatively expensive to produce. On the other hand, since some polymers are combustible and do not yield appreciable toxic or polluting emissions, they may be disposed of by incineration.

3. *Translate the following words into English.*

高分子化合物；多晶体；功能；化学反应活性；弹性体；参数；原子结构；参考标准；加工工艺；多孔材料；延展性；弹性模量

4. *Translate the following words into Chinese.*

aluminum oxide; characteristics of materials; specimens; processing-structure-properties-performance principles; mechanical strength; investigation and design of materials; transparent, translucent and opaque

Supplementary Reading

Metals and Polycrystalline Metals

Metals are an especially important class of materials. They are distinguished by several special properties, namely their high thermal and electrical conductivity, their ductility and the characteristic lustre of their surfaces. Their ductility, together with the high strength that can be achieved by alloying, renders metals particularly attractive as engineering materials.

In nature, metals occur only seldom as they possess a high tendency for oxidation. If one looks at the pure elements, more than two thirds of them are in a metallic state. Many elements are soluble in metals in the solid state and thus allow to form a metallic alloy. For instance, steels can be produced by alloying iron with carbon. The large number of metallic elements offers a broad range of possible alloys. Of most technical importance are alloys based on iron (steels and cast irons), aluminum, copper (bronzes and brasses), nickel, titanium, and magnesium.

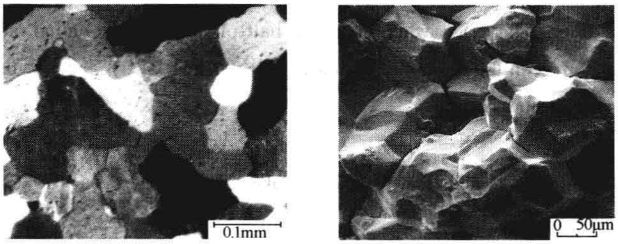
In this section, we start by explaining the nature of the chemical bond of metals. We will see that metals usually arrange themselves in a regular, crystalline order. Therefore, we will afterwards discuss the structure of crystals and, finally, explain how a metallic material is composed of such crystals.

Atoms in a metallic solid arrange themselves so that their electrons can spread over many atoms. This spreading is most easy if the atoms are arranged in a dense and regular manner. Therefore, metals form crystals which are distinguished by their well-ordered structure. To understand the different types of crystal structures found in nature, it is useful to think rather generally about the problem of arranging objects.

If a metal is cooled down from a melt and solidifies, it starts to crystallize. Depending on the cooling rate, many small **nuclei of crystallization** (晶核) form, small solidified regions with crystalline structure. These nuclei then grow and coalesce.

As the initial nuclei develop independently, they possess no **long-range order** (长程有序) between them. Therefore, a metal does not usually consist of one single crystal with long-range order, but rather of several crystalline regions called **crystallites** (微晶) or grains. They have a diameter of the order of a few micrometers up to a fraction of a millimeter, but can also be much larger in special cases. Grains can be made visible by polishing the surface of the metal and then etching it because the acid attacks differently oriented grains differently [Fig. 1.2(a)]. The structure of the grains of a metal is usually termed its microstructure.

The grain boundaries i. e., the interfaces between the grains, do not have a perfectly crystalline order as differently oriented regions adjoin here. Therefore, they can be considered aslattice imperfections. Frequently, they strongly influence the properties of a material because, for example, they may be preferred diffusion paths for corroding media. This kind of weakening of grain boundaries may then lead to failure of the material. This is called intercrystalline fracture and is shown in Fig. 1.2(b).



(a) (b)

Fig. 1.2 Exemplary microstructures of metals

(a) Micrograph (optical microscope). (b) Micro structure of a nickel-based alloy (scanning electron microscope (电子扫描显微镜) picture of an intercrystalline fracture surface)

Technical alloys frequently consist of different phases i. e., regions with differing chemical composition or crystal structure. As we will see later, particles of a second phase that are enclosed by a matrix of a first phase are especially important to influence mechanical properties (力学性能). One example for this is iron carbide (cementite, Fe_3C) that increases the strength of steels when precipitated (沉淀) as fine particles.

Depending in the crystal structure of the two phases, the interface between them may adopt different structures: If the crystal structures and the crystal orientation of both phases are identical and the lattice constants do not differ too much, the particles of the second phase will be coherent i. e., the lattice planes of the matrix continue within the particle [see Fig. 1.3 (a)]. If the lattice structure and orientation are identical, but the lattice constants differ strongly, the particles will be semi-coherent because some lattice planes of the matrix continue inside the particle but others do not [Fig. 1.3(b)]. Generally, the crystal lattice is distorted near to the coherent or semi-coherent particle. If the lattice structure of both phases or the lattice orientation differ,