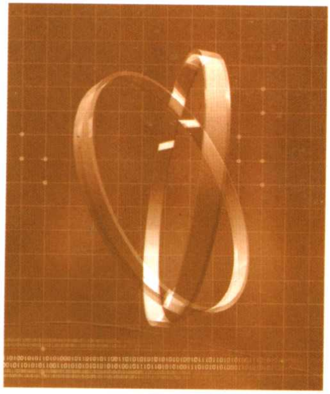

材料科学与工程专业英语

（第4版）

主编　李洪涛　费维栋

English in Materials Science and Engineering

哈爾濱工業大學出版社

材料科学与工程专业英语

（第4版）

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主审　李洪涛　费维栋

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内 容 提 要

本书是为提高从事材料科学与工程专业学习和研究人员的英语阅读能力而编写的。全书共分六部分:材料科学与工程简介、材料、焊接工艺、铸造工艺、成型工艺、热处理工艺。本书可作为相关专业的专业英语阅读教材,也可供有关人员阅读参考。

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前言(第4版)

本书是国家"九五"重点图书《材料科学与工程丛书》之一,是为材料科学与工程专业的三、四年级本科生而编写的专业英语教材。

编写本教材的目的是为了让本科生在经历了大学一、二年级的基础英语学习后,通过阅读本书,实现英语教学的不断线,使英语水平再上一个新台阶。

在第一、二、三版的基础上补充了材料科学与工程的总体介绍,材料的基础知识,更新了焊接工艺部分,将焊接领域的新进展融入其中,同时,缩减了科技英语选读部分,强化本书的可读性。

本书选材新颖,覆盖面广,不仅包含了材料科学与工程领域的基础专业而且涉及除此之外的其他各学科的基础知识,从而开阔了学生的视野,丰富了学生的知识。

本书编排独具匠心,把一篇较长的文章分成若干段落,并在每段后提供了几个问题,供学生回答或讨论。这不仅有利于学生及时检查自己对文章的理解情况,还便于教师安排教学。书中用星号(*)把那些较生僻的词标在每个段落的后面并给出相应的汉语注释,以减少翻字典的次数,提高阅读效率。另外,文中的难句在段后进行了标注,这将更有助于学生对文章的理解。

本书由哈尔滨工业大学材料科学与工程学院刘爱国主编,由崔成松、刘祖岩等人共同编写,由李洪涛、费维栋主审。因编者水平所限,疏漏之处在所难免,敬请批评指正。

主　编

2007年10月 于哈尔滨工业大学

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Introduction to Materials Science and Engineering

Materials have always been important to the advance of civilization: entire eras are named for them. After evolving from the Stone Age through the Bronze and Iron Ages, now in the modern era we have vast numbers of tailored materials to make use of. We are really living in the Materials Age.

Work and study in the field of materials science and engineering is grounded in an understanding of why materials behave the way they do, and encompasses how materials are made and how new ones can be developed. For example, the way materials are processed is often important. People in the Iron Age discovered this when they learned that soft iron could be heated and then quickly cooled to make a material hard enough to plow the earth; and the same strategy is used today to make high-strength aluminum alloys for jet aircraft. Today we demand more from our materials than mechanical strength, of course—electrical, optical, and magnetic properties, for example, are crucial for many applications. As a result, modern materials science focuses on ceramics, polymers, and semiconductors, as well as on materials, such as metals and glasses, that have a long history of use.

1.1 Definition of Materials Science and Engineering

Material science is the investigation of the relationship among processing, structure*, properties, and performance of materials.[1] The relationship is depicted with a tetrahedron* of materials science and engineering as shown in Figure 1.1.

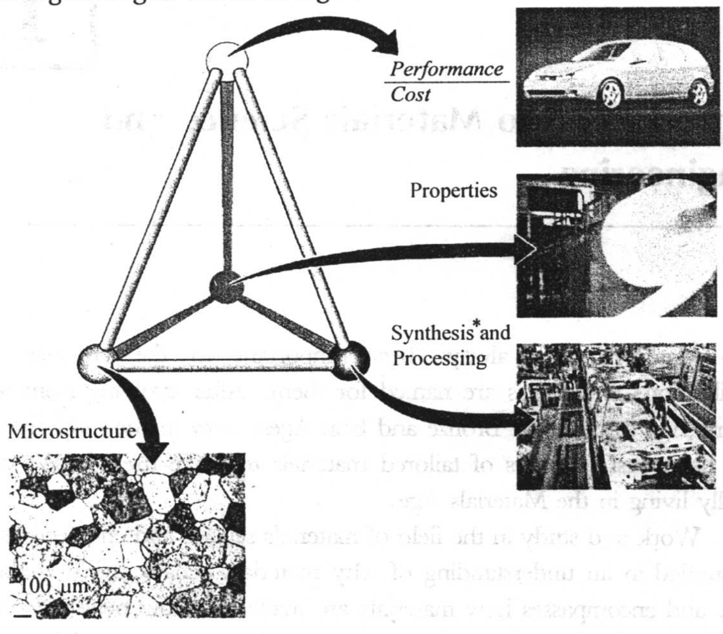

Figure 1.1 Relationship among processing, structure, properties, and performance of materials

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.[2]

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 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.[3] Finally, structural elements that may be viewed with the naked eye are termed "macroscopic".

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.

In addition to structure and properties, two other important components are involved in the science and engineering of materials. They are "processing" and "performance." With regard to the relationships of these four components, the structure of a material will depend on how it is processed. Furthermore, a material's performance will be a function of its properties.

Key words:

tetrahedron [四面体]	structure [组织]
deteriorative [劣化]	provoke [诱发]
synthesis [合成]	

Notes:

[1] 材料科学是研究材料的加工、组织、性能和功能之间关系的科学。

[2] 而材料工程是在组织－性能关系的基础上,对材料的组织进行设计,以获得一系列预定的性能。

[3] 下一级尺寸大一些的组织称为"显微组织",由聚集在一起的大量原子构成,使用某种类型的显微镜可以直接观察。

Questions:

1) What is the relationship of materials science and materials

engineering?

2) What is the relationship among processing, structure, properties, and performance of materials?

1.2 Classification of Materials

Materials are classified into five groups: metals, ceramics*, polymers, semiconductors, and composite materials*. Materials in each of these groups possess different structures and properties.

Metals

Metals and alloys generally have the characteristics of good electrical and thermal conductivity, relatively high strength, high stiffness*, ductility* or formability, and shock resistance. They are particularly useful for structural or load-bearing applications. Although pure metals are occasionally used, combinations of metals called alloys provide improvement in a particular desirable property of permit better combinations of properties.[1]

Ceramics

Ceramics are compounds between metallic and nonmetallic elements; they are most frequently oxides, nitrides*, and carbides*. The wide range of materials that falls within this classification includes ceramics that are composed of clay minerals, cement, and glass. These materials have poor electrical and thermal conductivity. Although ceramics may have good strength and hardness, their ductility, formability, and shock resistance are poor. Consequently, ceramics are less often used for structural or load-bearing applications than are metals. However, many ceramics have excellent resistance to high temperatures and certain corrosive media and have a number of unusual and desirable optical, electrical and thermal properties.

Polymers

Polymers include rubber, plastics, and many types of adhesives*. They are produced by creating large molecular structures from organic molecules, obtained from petroleum* or agricultural products, in a process known as polymerization*.[2] Polymers have low electrical and thermal conductivity, have low strengths, and are not suitable for use at high temperatures. Some polymers (thermoplastics*) have excellent ductility, formability, and shock resistance while others (thermosets*) have the opposite properties. Polymers are lightweight and frequently have excellent resistance to corrosion.

Semiconductors

Semiconductors have electrical properties that are intermediate between the electrical conductors and insulators. Furthermore, the electrical characteristics of these materials are extremely sensitive to the presence of minute concentrations of impurity atoms, which concentrations may be controlled over very small spatial regions. The semiconductors have made possible the advent of integrated circuitry that has totally revolutionized the electronics and computer industries.

Composites

Composites are formed from two or more materials, producing properties that cannot be obtained by any single material. Concrete and fiberglass are typical examples of composite materials. A composite is designed to display a combination of the best characteristics of each of the component materials. With composites we can produce lightweight, strong, ductile, high temperature-resistant materials that are otherwise unobtainable, or produce hard yet shock-resistant cutting tools that would otherwise shatter.

Key words:

ceramic [陶瓷]
stiffness [刚度]
nitride [氮化物]
adhesive [胶]
polymerization [聚合]
thermosets [热固性塑料]
composite materials [复合材料]
ductility [塑性]
carbide [碳化物]
petroleum [石油]
thermoplastics [热塑性塑料]

Notes:

[1] 偶尔才使用纯金属,而把金属组合起来可以获得更好的性能组合,可以使需要的某一特定性能获得提高,这种金属组合称为合金。

[2] 它们是用从石油或农产品中获得的有机物分子,通过一个称为聚合的工艺生成大分子结构而制造出来的。

Questions:

1) How are materials classified?

2) What are the differences between metals and ceramics?

1.3 Structure of Materials

The structure of a material can be considered on several levels, all of which influence the final behavior of the product. At the finest level is the structure of the individual atoms that compose the material. The arrangement of the electrons surrounding the nucleus of the atom significantly affects electrical, magnetic, thermal, and optical behavior and may also influence corrosion resistance. Furthermore, the electronic arrangement influences how the atoms are bonded to one another and helps determine the type of material - metal, ceramic, or polymer.

At the next level, the arrangement of the atoms in space is considered. Metals, many ceramics, and some polymers have a very regular atomic arrangement, or crystal structure. The crystal structure influences the mechanical properties of metals such as ductility, strength, and shock resistance. Other ceramic materials and most polymers have no orderly atomic arrangement—these amorphous* or glassy materials behave much differently from crystalline materials. For instance, glassy polyethylene* is transparent while crystalline polyethylene is translucent*. Defects in this atomic arrangement exist and may be controlled to produce profound changes in properties.

A grain* structure is found in most metals, some ceramics, and occasionally in polymers. Between the grains, the atomic arrangement changes its orientation and thus influences properties. The size and shape of the grains play a key role at this level.

Finally, in most materials, more than one phase* is present, with each phase having its unique atomic arrangement and properties. Control of the type, size, distribution and amount of these phases within the main body of the material provides an additional way to control properties.

Key words:
amorphous [无定形的,非晶的]
translucent [半透明的]
phase [相]
polyethylene [聚乙烯]
grain [晶粒]

1.3.1 Atomic-scale Structures

Atomic structure influences how the atoms are bonded together, which in turn helps us to categorize materials as metals, ceramics, and polymers and permits us to draw some general conclusions concerning the mechanical properties and physical behavior of these three classes of materials.

There are four mechanisms by which atoms are bonded together. In three of the four mechanisms, bonding is achieved when the atoms fill their outer *s* and *p* levels.

1.3.1.1 *Ionic Bonding**

Ionic bonding is always found in compounds that are composed of both metallic and nonmetallic elements, elements that are situated at the horizontal extremities of the periodic table*.[1] A metallic atom easily gives up its valence electrons* to the nonmetallic atom. Both atoms now have filled (or empty) outer energy levels but both have acquired an electrical charge and behave as ions. The atom that contributes the electrons is left with a net positive charge and is a cation*, while the atom that accepts the electrons acquires a net negative charge and is an anion*. The oppositely charged ions are then attracted to one another and produce the ionic bond. For example, attraction between sodium and chloride* ions (Figure 1.2) produces sodium chloride.

When a force is applied to a sodium chloride crystal, the electrical balance between the ions is upset. Partly for this reason, ionically bonded materials behave in a brittle manner. Electrical conductivity is also poor; the electrical charge is transferred by the

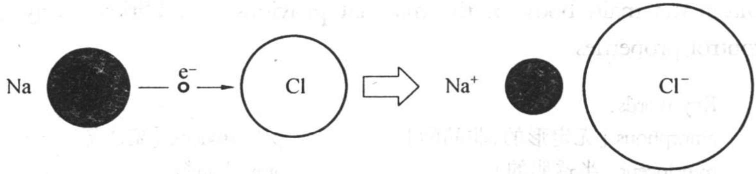

Figure 1.2 Ionic bonding

movement of entire ions, which do not move as easily as electrons. Many ceramic materials and minerals are at least partly bonded by ionic bonds.

1.3.1.2 *Covalent Bonding**

Covalently bonded materials share electrons between two or more atoms. For example, a silicon* atom, which has a valence of four, obtains eight electrons in its outer energy shell by sharing its electrons with four surrounding silicon atoms (Figure 1.3). Each instance of sharing represents one covalent bond; thus each silicon atom is bonded to four neighboring atoms by four covalent bonds.

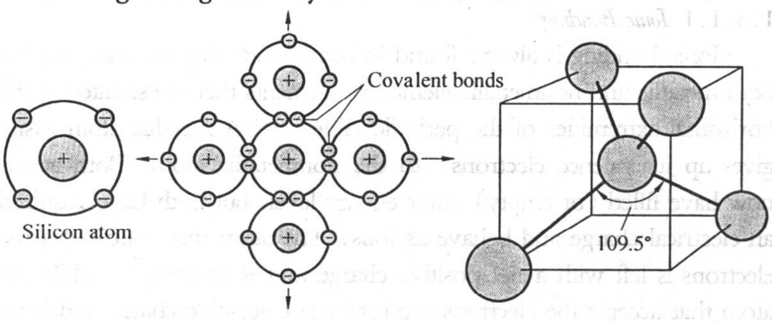

Figure 1.3 Covalent bonding

In order for the covalent bonds to be formed the silicon atoms must be arranged so the bonds have a fixed directional relationship with one another. In the case of silicon, this arrangement produces a tetrahedron, with angles of about 109° between the covalent bonds. Covalent bonds are very strong, and materials bonded in this manner have poor ductility and poor electrical conductivity. Many ceramic and polymer materials are fully or partly bonded by covalent bonds.

1.3.1.3 *Metallic Bonding**

The metallic elements, which have a low valence, give up their valence electrons to form a "sea" of electrons surrounding the atoms (Figure 1.4). Since negatively charged electrons are missing from the core, the core becomes an ion with a positive charge. The valence electrons, which are no longer associated with any particular atom, move freely within the electron sea and become associated with several atom cores. The positively charged atom cores are held together by mutual attraction to the electron, thus producing the strong metallic bond.

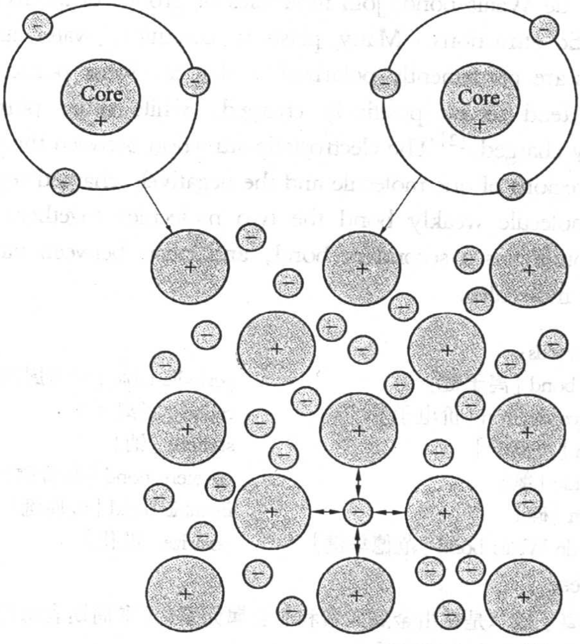

Figure 1.4 Metallic bonding

Metallic bonds are nondirectional. The electrons holding the atoms together are not fixed in one position. When a metal is bent and the atoms attempt to change their relationship to one another, the direction of the bond merely shifts, rather than the bond breaking. This permits metal to have good ductility and to be deformed into useful shapes.

The metallic bond also allows metals to be good electrical conductors. Under the influence of an applied voltage, the valence electrons move causing a current to flow if the circuit is complete. Other bonding mechanisms require much higher voltages to free the electrons from the bond.

1.3.1.4 *Van de Waals Bonding**

Van de Waals bonds join molecules or groups of atoms by weak electrostatic attractions. Many plastics, ceramics, water and other molecules are permanently polarized* ; that is, some portions of the molecule tend to be positively charged, while other portions are negatively charged.[2] The electrostatic attraction between the positively charged regions of one molecule and the negatively charged regions of a second molecule weakly bond the two molecules together. Van de Waals bonding is a secondary bond, and exists between virtually all atoms or molecules.

Key words:

ionic bond [离子键]
periodic table [元素周期表]
valence electron [价电子]
cation [正离子]
anion [负离子]
sodium [钠]
chloride [氯]
covalent bond [共价键]
silicon [硅]
metallic bond [金属键]
Van de Waals bond [范德华键]
polarize [极化]

Notes:

[1] 离子键总是在由金属元素和非金属元素(元素周期表每行最靠两端的元素)组成的化合物中出现。

[2] 多种塑料、陶瓷、水还有其他分子是永久极化的,就是说,分子的某些部分倾向于带正电,而另外一些部分带负电。

Questions:

1) What is the difference between the ionic bonding and covalent bonding?

2) How is the metallic bond produced?

1.3.2 Crystal Structures

Solid materials may be classified according to the regularity with which atoms or ions are arranged with respect to one another. A crystalline material is one in which the atoms are situated in a repeating or periodic array over large atomic distances. The atoms form a regular, repetitive gridlike pattern, or lattice*. The lattice is a collection of points, called lattice points, which are arranged in a periodic pattern so that the surroundings of each point in the lattice are identical.[1] One or more atoms are associated with each lattice point. The lattice differs from material to material in both shape and size, depending on the size of the atoms and the type of bonding between the atoms. The crystal structure* of a material refers to the size, shape, and atomic arrangement within the lattice.

1.3.2.1 *Unit Cells*

The unit cell is a subdivision of the lattice that still retains the overall characteristics of the entire lattice.[2] By stacking identical unit cells, the entire lattice can be constructed. We identify 14 types of unit cells, or Bravais lattices, grouped in seven crystal structures (Figure 1.5). Lattice points are located at the corners of the unit cells and, in some cases, the faces or the center of the unit cell.

1.3.2.2 *Metallic Crystal Structures*

The atomic bonding in this group of materials is metallic, and thus nondirectional in nature. Consequently, there are no restrictions as to the number and position of nearest-neighbor atoms; this leads to relatively large numbers of nearest neighbors and dense atomic packing for most metallic crystal structures. Three relatively simple crystal