Chapter 1 Introduction

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1 Words

1. *fabricate*
   制造
2. *beverage*
   饮料
3. *ceramic*
   陶瓷制品；陶瓷的
4. *polymer*
   聚合物，多聚物，高分子聚合物
5. *cite*
   引用，引述，提及
6. *component*
   成分，部件，组成部分
7. *utilization*
   利用，利用
8. *interrelationship*
   相互关联，相互影响
9. *segment*
   部分，片
10. *intimately*
    紧密地
11. *fiber*
    纤维
12. *sophisticated*
    精密的，复杂的
13. *synthesize*
    人工合成
14. *nebulous*
    模糊不清的
15. *notion*
    想法
16. *elaboration*
    精细工作
17. *stimuli*
    刺激
18. *deformation*
    变形
19. *translucent*
    半透明的
20. *opaque*
    不透明的
21. *portion*
    份
22. *essence*
    本质
23. *paradigm*
    范例
24. *illustrate*
    解释
25. *ductile*
    柔软的，可塑的
26. *catastrophically*
    灾难性的
27. *propagate*
    繁殖，增殖
28. *subsequent*
    随后的

29. *brittle*
脆性

30. *ductile-to-brittle*
韧性-脆性转变

31. *hatch*
孵化；仓口

32. *prefabricated*
预制的

33. *unimpeded*
无障碍的，无阻挡的

34. *conjunction*
组合

35. *lithium*
锂

36. *catalyst*
催化剂，触媒

37. *depleted*
减少的

38. *cradle-to-grave*
从摇篮到坟墓

2 Learning Objectives

1. *The six different property classfications of materials that determine their applicability are:*

   (a) ***Mechanical properties:***
   力学性能
   Relate deformation to an applied load or force; examples include elastic modulus (stiffness), strength, and resistance to fracture.
   将变形与施加的载荷或力联系起来；例子包括弹性模量（刚度），强度以及抗断裂性能。

   (b) ***Electrical properties:***
   电性能
   The stimulus is an applied electric field; typical properties include electrical conductivity and dielectric constant.
   刺激源是一个施加的电场；典型性质包括电导率和介电常数。

   (c) ***Thermal properties:***
   热性能
   They are related to changes in temperature or temperature gradients across a material; examples of thermal behaviour include thermal expansion and heat capacity.
   与材料的温度或温度梯度变化有关；热行为的例子包括热膨胀和热容。

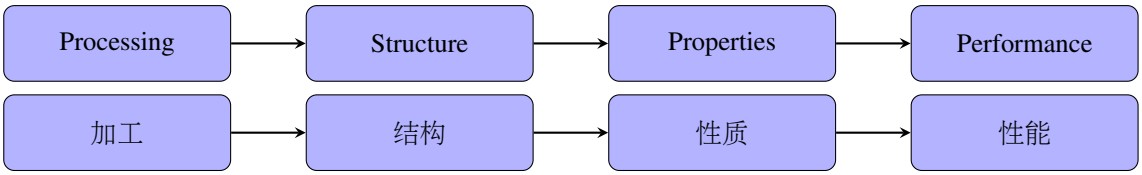
   (d) ***Magnetic properties:***
   磁性能
   The responses of a material to the application of a magnetic field; common magnetic properties include magnetic susceptibility and magnetization.
   材料对施加的磁场的回应；常见的磁特性包括磁化率和磁化强度。

   (e) ***Optical properties:***
   光学性能
   The stimulus is electromagnetic or light radiation; index of refraction and reflectivity are representative optical properties.
   刺激源是电磁作用或光辐射；折射率和反射率是代表性的光学性质。

   (f) ***Deteriorative characteristics:***
   老化特性

Relate to chemical reactivity of materials; for example, corrosion resistance of metals.
与材料的化学反应性有关；例如，金属的耐腐蚀性。

2. *The four components are:*



The structure of a material depends on how it is processed. Further, a material's performance is a function of its properties.
材料的结构取决于它的加工方式，此外，材料的性能与其特性有关。

3. *The three criteria are:*

   (a) *The in-service conditions must be characterized, for these dictate the properties required of the materials.*
   必须对材料的服役条件加以描述，因为这些条件决定了所需的材料所具备的性能。

   (b) *Any deterioration of material properties that may occur during services operation should be considered.* 应当考虑在使用过程中可能发生的任何材料性能的变化。

   (c) *Economics.*
   经济性。

4. (a) *Solid materials have been conveniently grouped into these basic categories: metals, ceramics, and polymers.*
   固体材料可以被方便地分为三个基本类别：金属、陶瓷和聚合物。

      i. ***Metals:***
      金属
      Metals are composed of one or more metallic elements(e.g. iron, aluminium, copper, titanium, gold, nickel), and often also nonmetallic elements(e.g. carbon, nitrogen, oxygen) in relatively small amounts.
      金属由一种或多种金属元素（如铁、铅、铜、钛、金、镍）组成，通常还包括相对少量的非金属元素（如碳、氮、氧）。
      Atoms in metals and their alloys are arranged in a very orderly manner and are relatively dense in comparison to the ceramics and polymers.
      金属及其合金中的原子排列成非常有序的方式，与陶瓷和聚合物相比相对致密。
      With regard to mechanical characteristics, these materials are relatively stiff and strong, yet are ductile(i.e., capable of large amounts of deformation without fracture), and are resistant to fracture, which accounts for their widespread use in structural applications.
      关于机械性能，这些材料相对较硬和坚固，但同时兼具延展性（即能够大幅度变形而不发生断裂），并且抗断裂，这就是它们在结构应用十分广泛的原因。
      Metallic materials have large numbers of nonlocalized electrons-that is, these electrons are not bound to particular atoms.
      金属材料中有大量非定域电子，即这些电子不与特定的原子结合。
      Metals are extremely good conductors of electricity and heat, and are not transparent to visible light; a polished metal surface has a lustrous appearance. Some of the metals(i.e., Fe, Co, and Ni) have desirable magnetic properties.

金属是电和热的极好导体，对可见光不透明；抛光的金属表面具有光泽的外观。一些金属(即铁，钴，镍）具有理想的磁性。

ii. ***Ceramics:***

陶瓷

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

陶瓷是由金属元素和非金属元素组成的化合物；它们最常见的是氧化物、氮化物和碳化物。

For example, common ceramic materials include aluminum oxide (or alumina, Al_2O_3), silicon dioxide (or silica, SiO_2), silicon carbide (SiC), silicon nitride (Si_3N_4), and, in addition, what some refer to as the traditional ceramics—those composed of clay minerals (e.g., porcelain), as well as cement and glass.

例如，常见的陶瓷材料包括氧化铝（或氧化铝，Al_2O_3）、二氧化硅（或硅石，SiO_2）、碳化硅（SiC）、氮化硅（Si_3N_4），此外，还有一些被称为传统陶瓷的材料——这些材料由粘土矿物（例如瓷器）组成，以及水泥和玻璃。

With regard to mechanical behaviour, ceramic materials are relatively stiff and strong—stiffnesses and strengths are comparable to those of the metals. In addition, they are typically very hard.

关于机械性能，陶瓷材料相对刚硬和强度高——刚度和强度可与金属相媲美。此外，它们通常非常坚硬。

Historically, ceramics have exhibited extreme brittleness (lack of ductility) and are highly susceptible to fracture . However, newer ceramics are being engineered to have improved resistance to fracture; these materials are used for cookware, cutlery, and even automobile engine parts. 历史上，陶瓷表现出极端的脆性（缺乏延展性）且极易断裂。然而，新的陶瓷材料正在被设计以提高抗断裂性能；这些材料被用于炊具、餐具，甚至是汽车发动机部件。

Furthermore, ceramic materials are typically insulative to the passage of heat and electricity (i.e., have low electrical conductivities) and are more resistant to high temperatures and harsh environments than are metals and polymers. With regard to optical characteristics, ceramics may be transparent, translucent, or opaque, and some of the oxide ceramics (e.g., Fe_3O_4) exhibit magnetic behaviour.

此外，陶瓷材料通常对热和电的传导具有绝缘性（即，电导率低），并且比金属和聚合物更能耐高温和恶劣环境。在光学特性方面，陶瓷可以是透明、半透明或不透明的，其中一些氧化物陶瓷（例如，Fe_3O_4）表现出磁性。

iii. ***Polymers:*** *include: plastic, rubber*

聚合物，包括塑料，橡胶

Many of polymers are organic compounds that are chemically based on carbon, hydrogen, and other nonmetallic elements (i.e., O, N, and Si).

许多聚合物是有机化合物，化学成分主要基于碳、氢及其他非金属元素（如氧、氮和硅）。

They have very large molecular structures, often chainlike in nature, that often have a backbone of carbon atoms.

它们具有非常大的分子结构，通常呈现链状，其主链通常由碳原子构成。

Some common and familiar polymers are polyethylene (PE), nylon, poly(vinyl chloride) (PVC), polycarbonate (PC), polystyrene (PS), and silicone rubber. These materials typically have low densities , whereas their mechanical characteristics are generally dissimilar to those of the metallic and ceramic materials—they are not as stiff or strong as these other material types.

一些常见且熟悉的聚合物包括聚乙烯（PE）、尼龙、聚氯乙烯（PVC）、聚碳酸酯（PC）、聚苯乙烯（PS）和硅橡胶。这些材料通常具有较低的密度，而它们的机械特性通常与金属和陶

瓷材料不同——它们不像这些其他材料那样刚硬或强度高。

However, on the basis of their low densities, many times their stiffnesses and strengths on a per-mass basis are comparable to those of the metals and ceramics.

然而，基于它们的低密度，许多时候它们的刚度和强度按质量计算是可以与金属和陶瓷相媲美的。

Many of the polymers are extremely ductile and pliable (i.e., plastic), which means they are easily formed into complex shapes.

许多聚合物具有极高的延展性和可塑性，这意味着它们可以很容易地被塑造成复杂的形状。

In general, they are relatively inert chemically and unreactive in a large number of environments. Furthermore, they have low electrical conductivities (Figure 1.8) and are nonmagnetic. One major drawback to the polymers is their tendency to soften and/or decompose at modest temperatures, which, in some instances, limits their use.

总体而言，聚合物在化学上相对惰性，在许多环境中不易发生反应。此外，它们具有低电导率且不具磁性。聚合物的一个主要缺点是它们在适中的温度下容易软化和/或分解，这在某些情况下会限制它们的使用。

(b) *Semiconductor*

半导体

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).

半导体的电学性能介于导电体（如金属和金属合金）与绝缘体（如陶瓷和聚合物）之间。

(c) *Biomaterials*

生物材料

Biomaterials must be biocompatible—compatible with body tissues and fluids with which they are in contact over acceptable time periods.

生物材料必须具备生物相容性——即在与身体组织和体液接触的可接受时间内，与其兼容且不引起不良反应。

(d) *Smart Materials*

智能材料

i. *Shape-memory alloy*
   形状记忆合金

ii. *piezoelectric ceramics*
   压电陶瓷

iii. *magnetostrictive materials*
   磁致伸缩材料

iv. *electrorheological/magnetorheological fluids*
   电流变/磁流变流体

(e) *Nanomaterials*

The dimensions of these structural entities are on the order of a nanometer ($10^{-9}m$)—as a rule, less than 100 nanometers.
这些结构实体的尺寸通常在纳米尺度，即大约1纳米（10^{-9}米），一般小于100纳米。

5. (a) *The adjective smart implies that these materials are able to sense changes in their environment and then respond to these changes in predetermined manners.*
"智能"这个形容词意味着这些材料能够感知环境中的变化，并以预定的方式对这些变化做出响应。

(b) *However, with the development of scanning probe microscopes, which permit observation of individual atoms and molecules, it has become possible to design and build new structures from their atomic-level constituents, one atom or molecule at a time (i.e., "materials by design").*
然而，随着扫描探针显微镜的发展，这些显微镜允许观察单个原子和分子，使得从原子级别的组成部分设计和构建新结构成为可能，一次一个原子或分子（即，"按设计制造材料"）。

3 Summary

1. ***Materials Science and Engineering***

(a) *Six different property classifications of materials determine their applicability: mechanical, electrical, thermal, magnetic, optical, and deteriorative.*
材料的适用性由六种不同的属性分类决定：机械性能、电性能、热性能、磁性能、光学性能和耐久性能。

(b) *One important relationship in the science of materials is the dependence of a material's properties on its structural elements. By structure, we mean how the internal component(s) of the material is (are) arranged. In terms of (and with increasing) dimensionality, structural elements include subatomic, atomic, nanoscopic, microscopic, and macroscopic.*
材料科学中一个重要的关系是材料性能对其结构元素的依赖性。所谓结构，是指材料内部组成成分的排列方式。按照维度（并且从低到高维度），结构元素包括亚原子、原子、纳米级、显微级和宏观级。

(c) *With regard to the design, production, and utilization of materials, there are four elements to consider—processing, structure, properties, and performance. The performance of a material depends on its properties, which in turn are a function of its structure(s); structure(s) is (are) determined by how the material was processed. The interrelationship among these four elements is sometimes called the central paradigm of materials science and engineering.*
在材料的设计、生产和使用方面，需要考虑四个要素——加工、结构、性能和表现。材料的表现取决于其性能，而性能又是其结构的函数；结构由材料的加工方式决定。这四个要素的相互关系有时被称为材料科学与工程的核心范式。

(d) *Three important criteria in materials selection are in-service conditions to which the material will be subjected, any deterioration of material properties during operation, and economics or cost of the fabricated*

piece.
材料选择的三个重要标准是材料在使用过程中所承受的条件、材料性能在运行期间的任何劣化，以及制造成本或经济性。

2. ***Classification of Materials***

(a) *On the basis of chemistry and atomic structure, materials are classified into three general categories: metals (metallic elements), ceramics (compounds between metallic and nonmetallic elements), and polymers (compounds composed of carbon, hydrogen, and other nonmetallic elements). In addition, composites are composed of at least two different material types.*
根据化学成分和原子结构，材料一般分为三类：金属（由金属元素组成）、陶瓷（由金属和非金属元素组成的化合物）和聚合物（由碳、氢和其他非金属元素组成的化合物）。此外，复合材料由至少两种不同类型的材料组成。

3. ***Advanced Materials***

(a) *Another materials category is the advanced materials that are used in high-tech applications, including semiconductors (having electrical conductivities intermediate between those of conductors and insulators), biomaterials (which must be compatible with body tissues), smart materials (those that sense and respond to changes in their environments in predetermined manners), and nanomaterials (those that have structural features on the order of a nanometer, some of which may be designed on the atomic/molecular level).*
另一类材料是用于高科技应用的先进材料，包括半导体（其电导率介于导体和绝缘体之间）、生物材料（必须与身体组织兼容）、智能材料（能以预定方式感知和响应环境变化）以及纳米材料（具有纳米级结构特征，有些可能在原子/分子层面设计）。