Unit 3 Structure-Property Relationships of Materials

Today’s materials can be classified as metals and alloys, as polymers or plastics, as ceramics, or as composites; composites, most of which are man-made, actually are combinations of different materials.
译文：当今的材料可以分为金属和合金，聚合物或者塑料，陶瓷或复合材料；复合材料，它们大多数是人造的，实际上是不同材料组合而成。

Application of these materials depend on their properties; therefore, we need to know what properties are required by the application and to be able to relate those specification to the material.
译文：这些材料的应用取决于它们的性质；因此，根据应用的场合，我们需要知道什么样的性质是必需的，我们需要能够把这些详细说明同材料联系起来。

For example, a ladder must withstand a design load, the weight of a person using the ladder. However, the material property that can be measured is strength, which is affected by the load and design dimension. Strength values must therefore be applied to determined the ladder dimensions to ensure safe use. Therefore, in general, the structures of metallic materials have effects on their properties.
译文：比如，一个梯子必须能经受住设计的载荷，也就是使用这个梯子的人的重量。然而，能够测量的材料的性质是强度，它为载荷和设计尺寸所影响。强度值因此被用来判定梯子的尺寸大小以保证安全使用。因此，通常说来，金属材料的结构对它们的性质有影响。

In a “tensile test” a sample is gradually elongated to failure and the tensile force required to elongate the sample is measured using a load cell throughout the test. The result is a plot of tensile force versus elongation.
译文：在一个张力测试实验中，样品缓慢地拉长直到失败，并且拉长样品所必需的拉力在整个测试过程中，用测压元件测量。结果是拉力同伸长度之间的一个图。
结果是……图表。（有用的表示方法）

The problem is that the load required to elongated the sample by a certain extent depends upon the dimension of the sample. This would be a big problem if , for example, mechanical property data were to be used to design a bridge, since it is clearly impossible to test an entire bridge. Thus what is clearly needed is to make the data from the tensile test independent of the size of the sample.
译文：问题是，拉伸样品到一定程度所必需的载荷取决于样品的尺寸。比如，如果机械性质的数据被用于设计一座桥梁，既然测试整个桥梁是明显不可能的，这样，明显需要的就是从与样品尺寸无关的拉伸实验中获得数据。
Thus, what is clearly needed is to make the data from the tensile test independent of the size of the sample. To achieve this end, we use “stress” and “strain”.
译文：这样，明显所需要的是从拉力测试实验中得到和样品尺寸无关的数据。为了达到这个目标，我们使用“应力”和“应变”。

The "true" stress( ) is defined as : ,where F=force applied to the sample at any given instant and A= current cross-sectional area of the sample.

真正的应力（ ）可以这样定义：

这里 F 等于作用在样品上任何一个给定时刻的拉力，A 等于对应当时样品的哼截面面积。

The "true" strain( ) is defined as : ,where is the current gauge length and the origin gauge length of the sample.

译文：真正的应力 被定义为 ，这里 是当前测量长度， 是试样的原始测量长度。

True stress and true strain provide the most accurate description of <u>what actually happens to the material during testing</u> and so are widely used in materials science. For engineering design, however, there are two problems.

译文：真正的应力和真正的应变提供材料在测试过程中所发生的最精确的描述，并且被广泛使用在材料科学中。然而，对于工程设计来说，存在两个问题。

Firstly, true stress requires a knowledge of the value of A throughout the test, whereas in real world applications the designer of structures chooses an initial cross sectional area (A0). Secondly true strain is not very easy to visualize. Consequently <u>for engineering applications</u> <u>an "engineering" stress (s) and strain (e)</u> are used <u>in place of</u> true stress and true strain:

s = F / A0 and e = (l1 - l0) / l0

译文：首先，真实应力需要知道在整个测试过程中 A 的值，然而在实际应用过程中，结构设计者选择初始横截面面积 A0。第二，真实拉力非常不容易看见。相应的对于工程应用来说，工程压力（s）和拉力（e）被用来代替真实的应力和应变： s = F / A0 和 e = (l1 - l0) / l0

Stress has units of Pa (*i.e.* N m-2) and strain is dimensionless. The concept of a stress is clearly closely related to that of pressure. Using the definitions of stress and strain given above, the load versus elongation curve <u>produced by the tensile test</u> can be converted into true stress - strain or engineering stress - strain curves. Using these curves, it is now possible to describe the mechanical properties of metals and alloys.

译文：应力有 Pa 的单位（比如 N/m2），应变是无量纲的。应力的概念是明显的同应变十分相关的。用上面给出的压力和拉力的定义，借助拉力试验得到的载荷同伸长之间的曲线可以转化为真实应力－应变或者工程应力－应变曲线。使用这些曲线，就可能描述金属和合金的机械性质。

In true and engineering stress-strain relationships for a "typical" metal, linear portion of the stress strain curves the material is deforming elastically at the Initial.

对一个典型的金属来说，在真实和工程应力－应变相互关系中，材料压力曲线的线性部分是在最初的弹性形变

In other words, if the load were removed the material will return to its initial, undeformed condition. In the linear elastic region, the "stiffness" or "elastic modulus" is the amount of stress required to produce a given amount of strain. For a tensile test, stiffness is described by Young's modulus (E), which is given by:
E = s / e or E = s / e
换句话说，如果载荷被除去，材料将返回到初始的，没有形变的状况。在线性弹性区域，"硬度"和"弹性模量"是产生一定量的应力所必须的应变。对一个拉伸测试，硬度借助 Young's 模量来描述，它由下面两式来给出： E = s / e 或者 E = s / e

The greater the value of the stiffness, the more difficult it will be to produce elastic deformation. Thus, for example, in selecting a material for the springs of a vehicle, stiffness would be a key engineering design criterion.
比较级………比较级
硬度值越大，产生弹性变形将越困难。比如，在选择材料作为交通工具的弹簧时，硬度将是一个重要的工程设计标准。

On exceeding a certain stress, known as the "yield stress" or "yield strength" (sy or sy in true and engineering stress respectively), the stress - strain curve ceases to be linear and the material begins to undergo permanent "plastic" deformation.
一旦超出某一种类应力，大家知道为"屈服应力"或者"屈服强度"（sy 或者 sy 分别对应于真实和工程应力），应力－应变曲线中止到线性部分，材料开始经历永久"塑性变形"。

In the plastic region of the stress - strain curve, it is apparent that the stress required to continue plastic deformation is higher than that required to make the material yield. This phenomenon is called "work hardening" or "strain hardening".
在应力－应变曲线的塑性区域，显然保持弹性形变所需的应力比使材料屈服所需的应力还要高。这个现象被称作"机械硬化"或者"应变硬化"。

In the true stress - strain curve, it can be seen that work hardening actually continues right up until failure at the failure stress sf. In contrast the engineering stress - strain curve shows a maximum stress, the "ultimate " (UTS), prior to final failure.
在真实的应力－应变曲线中，可以看到 机械硬化实际上往右向上增加直到断裂应力 sf 时才断裂。相反，工程应力－应变曲线显示在材料最后断裂之前，有一个最大应力，也就是"最终的"拉应力，

During final failure, the sample starts to "neck" down to failure and this is not accounted for when A0, rather than A, is used to calculate a stress. Nonetheless, for a design engineer, the UTS is a very useful datum and the UTS (rather than sf) is normally used as the measure of the "tensile strength" of a material.

在最终断裂时，样品开始下滑止到断裂，并且这不是说明当 A0，优于 A，被用来计算应力时。但是，对于一个设计工程师来说，UTS 是一个非常有用的数据，UTS（优于 sf）通常被用来测量材料的抗拉强度。

"Ductile" materials are those that can undergo plastic deformation and so the greater the extent of plastic deformation, the higher the "ductility". The engineering strain to failure is a common measure of ductility. Note: if l1 is measured *after* the sample has failed, then the elastic portion of the sample's elongation will be removed, since the applied load is removed when the sample fails. Thus only plastic deformation and not elastic deformation will contribute to an l1 measured *after* failure.
延展材料是那些能够经受塑性形变的材料，并且塑性形变量越大，延展性越大。工程应力到断裂是一个普通的延展性的测量。标记：如果当试样断裂以后，l1 被测量，然后试样延长的弹性部分将被除去，当试样断裂时应用载荷被除去。当材料断裂以后，这样仅仅只有塑性形变和非塑性形变将对测量的 l1 有贡献。

The "hardness" of a material is a measure of the resistance to plastic deformation. Hardness is measured by determining the depth or projected area of an indentation produced by a standard indentor (these can be *e.g.* tool steel balls or diamonds in the shape of an inverted pyramid, depending on the technique used).
材料的"硬度"是阻碍弹性形变的一个量度。硬度通过测定由标准压针产生的凹槽的深度或者投影面积来测量（这些可以是比如钢球或者漏斗形的钻石，取决于使用的技术）。

The higher the hardness of the material, the shallower the indentation for a given load and the smaller the projected area. Hardness is an important property in many applications. Consider, as an example, a material intended to serve as the liner for a bearing supporting a rotating shaft. Many bearing alloys consist of a hard phase in a soft phase. The purpose of the hard phase is to resist abrasion as the shaft turns. The soft phase serves both to bind the hard phase into place and allows wear debris to become embedded, thus preventing the debris from damaging the shaft.
材料的硬度越高，对于一定的载荷凹槽的深度越浅并且凹陷面积越小。硬度在许多应用中是一个重要性质。作为一个例子，考虑一种目的是用作轴瓦，用作旋转轴的支撑体材料。许多轴承合金由在软相中的硬相组成。硬相的目的是耐磨损当轴转动的时候。软相起把硬相镶嵌在其中的场所，并且允许磨损的碎片进入软相，这样阻止碎片损坏轴。

The "toughness" of a material is a measure of how much energy can be absorbed by the material before failure. Toughness is determined by subjecting the material to an impact from a swinging hammer and measuring the amount of energy absorbed from the swing (the less energy is absorbed, the higher the hammer will swing after fracturing the sample).
材料的"韧度"是材料在断裂之前能够吸收多少能量的量度。韧度这样测量：材料受到一个摆动的铁锤的冲击后，测量从摆动的中吸收的能量来测量。（能量吸收的越少，破坏试样以后铁锤将摆动的越高）

Energy is absorbed by plastic deformation and hence ductile materials show a high toughness. In contrast, brittle materials can have a high strength, but have negligible toughness. For example, it is preferable for the crumple zones in your car to absorb as much of an impact as possible through extensive plastic deformation (even if this totals the car!) than to have your bones undergo brittle failure.
能量被塑性形变吸收，因此延展性材料显示一个很高的韧性。相反，脆性材料能有高的强度，但是有少量的硬度。比如，对在你汽车里的一个褶皱区域来说，比起使你的骨骼遭受脆性的断裂，通过大规模的塑性形变尽可能多的吸收冲击是可取的（尽管这个占据整个汽车！）

Likewise, a concrete guard rail is good for protecting construction workers, because the kinetic energy of an oncoming vehicle is absorbed by deformation of the vehicle (which can be tough luck on the occupants of the vehicle if the impact exceeds the energy absorbing capability of the crumple zones in the car!!).
同样，一个混凝土的保护栏对保护建筑工人是有益的，因为一辆临近的交通工具的动能被交通工具的形变所吸收（如果这个冲击超出汽车里面褶皱区域的吸收能量容量，这对于交通工具的主人来说，可能是一个噩耗）。

In contrast, a steel guard rail protects drivers because plastic deformation of this absorbs energy efficiently in the event of an impact (but is not so good at protecting construction workers because the vehicle is not brought to a sudden halt). So do what the signs say and slow down for construction!
相反，一个钢的保护栏保护司机，因为在冲击出现时，这些钢的保护栏的塑性形变有效的吸收能量（但是不擅长保护建筑工人因为使用这种材料，交通工具是不能带来一个紧急的停止）。因此按照标志所说的做，对建筑来说可以减慢。

In addition to the properties discussed above, other mechanical properties are very important. These include resistance to “fatigue” failure due to cyclic loading and to thermally assisted, time-dependent “creep” deformation and failure.
除了上面谈论到的性质以外，其他力学性能是非常重要的。这些力学性质包括由于循环的载荷产生的抗疲劳断裂，和热助的，时间有关的蠕性形变和断裂。

There are many possible examples of the relationship between processing, structure and properties. However, the following example is chosen because it illustrates a number of the features discussed in material science.
有许多加工、结构和性能之间联系的例子。然而，下面的例子被选择是因为它被用来举例说明许多材料科学中讨论的特征。

Nickel - boron alloys form the basis of brazes used to join many nickel-base alloys, especially in aerospace. An eutectic forms between nickel and the nickel boride Ni3B and so a nickel-boron braze can melt and flow without melting the nickel-base materials to be joined.

镍-硼合金形成青铜的基底，这些青铜被用来联接许多基于镍的合金，尤其是在航空和航天领域。一个共晶形成位于镍和镍化硼 Ni3B 之间，因此没有基于镍的材料加入进去，镍硼钎焊可以熔化并流动。

However, boron diffuses as an interstitial in nickel and can diffuse rapidly away into the substrates. Dispersing the boron removes the liquid (which was only there because, by forming an eutectic, boron depresses the melting-point of nickel) and this allows components to operate at high temperatures without these melting in service.
然而，硼在镍中间扩散并且能够快速的扩散进底金属。把硼分散开来除去液体（仅仅只有只是在那里，通过形成共晶，因为硼压低了镍的熔点），这允许零件在高温下操作不会在使用过程中产生熔化现象。

A problem with using boron-containing brazes is that Ni3B is very brittle and this means <u>that these brazes can not be produced as a sheet by conventional means, such as rolling</u>. Thus, these types of brazes are often used as a powder <u>which is inconvenient to handle</u> and oxide from the surface of the powder particles can reduce the strength of joints. As an alternative, a molten nickel - boron alloy can be sprayed onto the surface of a rapidly spinning copper wheel, which carries heat away very efficiently.
使用含硼的青铜的一个问题就是， Ni3B 是非常脆的，这就意味着这些青铜不能制造成薄片通过常规的方法，比如滚扎。这样，这些类型的青铜通常被用作粉末，这些粉末是不方便处理的，粉末颗粒表面的氧化物可以减少连接处的强度。另外一种可供选择的，一个熔化的镍-硼合金可以快速的喷射到纺纱铜盘表面，铜盘能快速散热。

This process is called “melt-spinning” (caution: a completely different process for making polymer fibers has the same name!). Given the very high cooling rate, the liquid can not crystallize and a metallic glass is formed. Thus, no borides are formed and the resulting foil is quite ductile and can easily be placed into position in the joint. During heating to the bonding temperature, as soon as the temperature becomes hot enough for diffusion to occur, the metallic glass crystallizes.
这个加工被称作“熔纺”（注意：一个完全不同于制备聚合物纤维的加工过程）。给定一个非常高的冷却速度，液体不能结晶，一个金属玻璃就形成了。这样，没有硼化物形成，合成的薄片是非常有韧性的，能够轻易地放进连接处地位置。在加热到焊接温度过程中，一旦温度变得足够热使得扩散发生，金属玻璃就结晶了。

Crystallization takes place far below the equilibrium melting temperature and the result is lots and lots of nucleation and very little growth so that a very fine grain size is produced. Ni3B is precipitated during crystallization and this does make the foil brittle, but this doesn’t matter at this stage since the foil is about to be melted for the brazing operation.
结晶发生在平衡熔点温度以下，结果就是形成许许多多晶核和非常小地生长以便一个非常小地晶粒尺寸生长。 在结晶过程中，Ni3B 是被沉淀下来，这确实使得薄片有脆性，既然薄片在铜焊操作过程中将熔化，所以在这个阶段是无关紧要的。