



Al-Mustaqbal University
Department (Chemical Engineering and Petroleum Industries Department)
Class (2nd)
Subject (material engineering)
Lecturer (Mohammed Ali Saihood Al- Shujairi)
1st term – Lect. (materials science and engineering)

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Subject: Materials Science and Engineering

2nd Class

Lecture one



After the lesson, the student will be able to :

- **Define the Materials Science and Engineering.**
- **Classification of Materials.**
- **Properties of some Type of Materials.**
- **Classification of materials Based on Structure.**
- **Classification of materials Based on Function.**

بعد الدرس سيكون الطالب قادرا على :

- تعريف علوم وهندسة المواد.
- تصنيف المواد.
- خصائص بعض أنواع المواد.
- تصنيف المواد على أساس الهيكل.
- تصنيف المواد على أساس وظيفتها.

1. MATERIALS SCIENCE AND ENGINEERING

Sometimes it is useful to subdivide the discipline تخصص of materials science and engineering into materials science and materials engineering sub-disciplines تخصصات فرعية. Strictly speaking , بالمعنى الدقيق للكلمة “materials science” involves investigating the relationships that exist between the structures and properties of materials. In contrast, في المقابل “materials engineering” is, on the basis of these structure–property خاصية correlations الارتباطات , designing or

engineering the structure of a material to produce a predetermined set of properties. From a functional perspective, دور من منظور وظيفي the role of a materials scientist is to develop or synthesize تصنيع new materials, whereas a materials engineer is called استدعاء upon to create new products or systems using existing موجوده materials, and/or to develop techniques for processing معالجة materials. Most graduates معظم الخريجين in materials programs are trained تدريبهم to be both materials scientists and materials engineers.

Four important components are involved in the science and engineering of materials namely structure and properties, processing and performance (Figure 1).

هناك أربعة مكونات مهمة تشارك في علم وهندسة المواد وهي البنية والخصائص والمعالجة والأداء (الشكل 1).



Figure 1 The four components of the discipline of materials science and engineering and their interrelationship

An example of these processing-structure-properties- خصائص بنية المعالجة performance principles مبادئ أداء with Figure 2, a photograph showing three thin disk specimens placed over some printed matter. It is obvious that the optical properties الخصائص البصرية (i.e., the light transmittance نفاذية الضوء) of each of the

three materials are different; the one on the left is transparent شفاف whereas the disks in the center and on the right are, respectively, translucent and opaque معتمة.

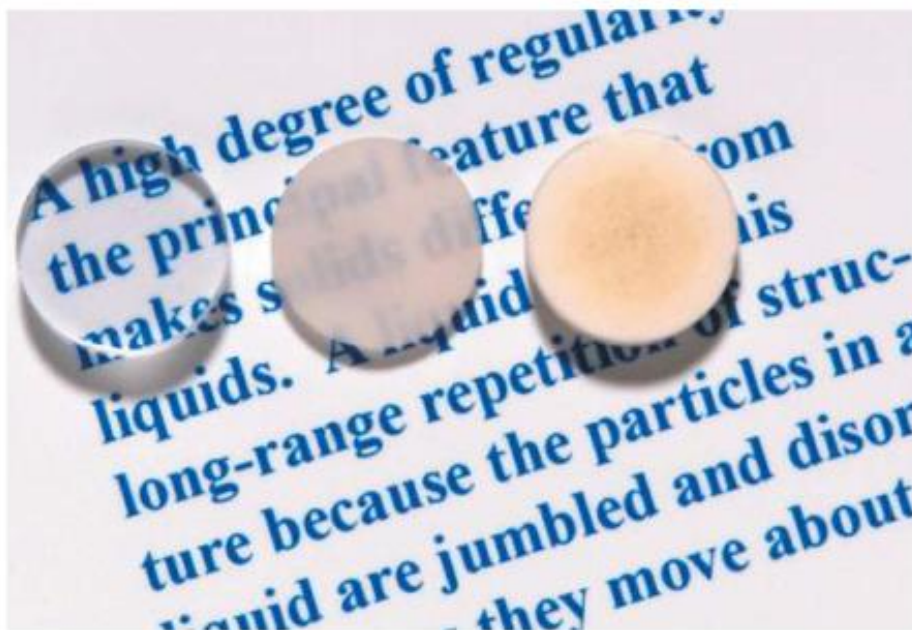


Figure 2

All of these specimens are of the same material, aluminum oxide أكسيد الألومنيوم, but the leftmost أقصى اليسار one is what we call a single crystal البلورة المفردة that is, it is highly perfect مثالية للغاية which gives rise to its transparency. The center one is composed of numerous and very small single crystals that are all connected; the boundaries الحدود between these small crystals scatter تشتت a portion of the light reflected الضوء المنعكس from the printed page, which makes this material optically translucent شفافة بصريا. Finally, the specimen on the right is composed not only of

many small, interconnected crystals البلورات الصغيرة المترابطة , but also of a large number of very small pores المسام الصغيرة جدًا or void spaces المساحات الفارغة . These pores also effectively scatter the reflected light and render this material opaque. Thus, the تعمل هذه المسام أيضًا على تشتيت الضوء المنعكس بشكل فعال وتجعل هذه المادة معتمة structures of these three specimens are different in terms of crystal boundaries الحدود البلورية and pores المسام , which affect the optical transmittance properties. مما Furthermore, علاوة على ذلك, يؤثر على خصائص النفاذية البصرية each material was produced using a different processing technique معالجة مختلفة . And, of course, the performance of each material will be different.

2. Classification of Materials:

Familiar objects أشياء مألوقة made of metals and metal alloys (from left to right): silverware أدوات فضية (fork and knife), scissors, coins, a gear, a wedding ring, and a nut and bolt.



Common objects **الأشياء الشائعة** made of ceramic materials: scissors, a china teacup **فنجان شاي صيني**, a building brick **طوب بناء**, a floor tile **بلاط أرضي**, and a glass vase **مزهريّة زجاجية**.



Several common objects made of polymeric materials **العديد من الأشياء الشائعة المصنوعة** من المواد البوليمرية: plastic tableware (spoon, fork, and knife) **أدوات المائدة البلاستيكية**, billiard balls **كرات البلياردو**, a bicycle helmet **خوذة دراجة**, two dice **عجلة جزاة العشب**, a lawn mower wheel (plastic hub and rubber tire) **محور**, and a plastic milk carton **علبة حليب بلاستيكية**.



Solid materials have been conveniently grouped into three basic categories تصنيف
المواد الصلبة بشكل ملائم إلى ثلاث فئات أساسية: metals, ceramics, and polymers, a scheme
التركيب الكيميائي and atomic الذري based primarily أساساً on chemical makeup مخطط
structure. Most materials fall into one distinct grouping متميزة or another. In
addition, there are the composites that are engineered combinations of two or
more different materials أكثر. A brief explanation موجز تقديم شرح موجز
of these material classifications and representative characteristics is offered next بعد
ذلك. Another category is advanced materials المواد المتقدمة those used in high-
technology applications, such as semiconductors أشباه الموصلات, biomaterials المواد
والمواد المهندسة smart materials الذكية, and nanoengineered materials النانوية
النانوية.



Metals

Metals are composed of one or more metallic elements (e.g., iron, aluminum, copper, titanium, gold, nickel), and often also nonmetallic elements غالبًا (e.g., carbon, nitrogen, oxygen) in relatively small amounts كميات صغيرة نسبيًا. Atoms in metals and their alloys are arranged in a very orderly manner يتم ترتيب الذرات في المعادن وسبائكها بطريقة منظمة للغاية.

Ceramics

Ceramics are compounds مركبات between metallic and nonmetallic elements; they are most frequently أكاسيد , nitrides نيتريدات , and carbides كربيدات. For example, common ceramic materials المواد الخزفية الشائعة include aluminum oxide أكسيد الألومنيوم (or alumina, Al_2O_3), silicon dioxide ثاني أكسيد السيليكون (or silica, SiO_2), silicon carbide كربيد السيليكون (SiC), silicon nitride نيتريد السيليكون (Si_3N_4), and, in addition, what some refer to as the traditional ceramics إلى ما يشير those composed of clay minerals معادن طينية (e.g., porcelain الخزف), as well as cement and glass.

Polymers

Polymers include the familiar المألوفة plastic and rubber المطاطية materials. Many of them are organic compounds مركبات عضوية that are chemically based on carbon, hydrogen, and other nonmetallic elements (i.e., O, N, and Si). Furthermore علاوة , they have very large molecular جزيئية structures, often chainlike in nature . عمود فقري , that often have a backbone of carbon atoms ما تكون ذات طبيعة متسلسلة.



Some common and familiar polymers are polyethylene (PE), nylon, poly(vinyl chloride) (PVC), polycarbonate (PC), polystyrene (PS), and silicone rubber.

بعض البوليمرات الشائعة والمألوفة هي البولي إيثيلين (PE)، والنايلون، والبولي (كلوريد الفينيل) (PVC)، والبولي كربونات (PC)، والبوليسترين (PS)، ومطاط السيليكون.

Composite

A composite is composed of two (or more) individual **فرديتين** materials that come from the

categories **الفئات** previously discussed metals, ceramics, and polymers. The design goal of a composite **الهدف من تصميم المركب** is to achieve **تحقيق** a combination **مزيج** of properties that is not displayed **لا يتم عرضها** by any single material and also to incorporate **دمج** the best characteristics of each of the component materials. A large number of composite types are represented by different combinations **بمجموعات** of metals, ceramics, and polymers. Furthermore, **علاوة على ذلك** some naturally occurring materials **المواد الموجودة في الطبيعة** are composites for example, wood and bone. However, **مع ذلك** most of those **معظم تلك** we consider in our discussions are synthetic **صناعية** **مركبات** (or human-made **صنع الإنسان**) composites. One of the most common **الألياف** and familiar **المألوفة** composites is fiberglass **الألياف** **الزجاجية**, in which small glass fibers **ألياف زجاجية صغيرة** are embedded **دمج** within a polymeric material **مادة بوليمرية** (normally an epoxy or polyester **بوليستر** أو **إيبوكسي**). The glass fibers are relatively **نسبيًا** strong and stiff (but also brittle **هشة**), whereas the polymer is more flexible **أكثر مرونة**.



ADVANCED MATERIALS

Materials utilized **المواد المستخدمة** in high-technology (or high-tech) applications are sometimes termed advanced materials **المواد المتقدمة** .
تطبيقات التكنولوجيا المتقدمة

-Semiconductors:

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

-Biomaterials: **المواد الحيوية**

The length and the quality of our lives are being extended and improved **إطالة** , in part, due to advancements **التقدم** in the ability **القدرة** to replace diseased and injured body parts **أجزاء الجسم المريضة والمصابة** . Replacement implants are constructed **من المواد الحيوية غير قابلة** of biomaterials nonviable **يتم إنشاء الغرسات البديلة** (i.e., nonliving **أي غير حية**) materials that are implanted into the body **يتم زرعها** for life **للحياة** , so that they function in a reliable **موثوقة** , safe **آمنة** , and physiologically satisfactory manner **ومرضية من الناحية الفسيولوجية** , while interacting **التفاعل** with living tissue **الأنسجة** .

-Smart materials

Smart (or intelligent **الذكى**) materials are a group of new and state-of-the-art materials **مجموعة من المواد الجديدة والمتطورة** now being developed **تطويرها** that will have



سيكون لها تأثير كبير على العديد من technologies من significant influence on many of our technologies. The adjective smart implies تشير that these materials are able to sense تقنياتنا. تستشعر changes in their environment بيئتها and then respond الاستجابة to these changes in predetermined manners traits بسلوكيات محددة سلفا that are also found in living organisms الكائنات الحية .

Components of a smart material (or system) تتضمن مكونات المادة الذكية (or system) include some type of sensor (which detects an input signal التي تكتشف إشارة) نوعاً ما من أجهزة الاستشعار (الإدخال) and an actuator (which performs a responsive and adaptive function المشغل). Actuators may be called upon يُطلب to change shape, position, natural frequency, or mechanical characteristics in response to changes in temperature, electric fields, and/or magnetic fields.

Nano-materials,

One new material class that has fascinating properties بخصائص رائعة and tremendous technological promise واعدة is the Nano-materials المواد النانوية, which may be any one of the four basic types metals, ceramics, polymers, or composites. However, unlike these other materials, they are not distinguished on the basis of their chemistry كيميائيتها but rather their size على أساس but لا تتميز على أساس كيميائيتها. the nano prefix البادئة النانوية denotes that the dimensions of these structural entities are on the order of a nanometer (10^{-9} m) as a rule كقاعدة عامة , less than 100 nanometers.



3 Properties of Some Types of Materials

3.1 Metals and Alloys

- They usually have a crystalline structure and are good thermal and electric conductors. عادة ما يكون لها بنية بلورية وهي موصلة للحرارة والكهرباء بشكل جيد
- Many metals have high strength and high elastic module. تتمتع العديد من المعادن بقوة عالية ومرونة عالية
- They also have sufficient ductility, which is important for many engineering applications. كما أنها تتمتع بالليونة الكافية، وهو أمر مهم للعديد من التطبيقات الهندسية.
- They are least resistance to corrosion. فهي الأقل مقاومة للتآكل.

3.2 Ceramics and glasses

- They are good electrical and thermal insulators. تعتبر عوازل كهربائية وحرارة جيدة.
- They have high hardness, high moduli, and high temperature strength. أنها تتمتع بصلابة عالية، ومعامل عالية، وقوة درجة حرارة عالية
- They are resistant to high temperature and corrosive environments. إنها مقاومة لدرجات الحرارة المرتفعة والبيئات المسببة للتآكل
- They are very brittle. فهي هشة للغاية.

3.3 Polymers

- They are generally have low density and are not stable at high temperatures. هي عموماً ذات كثافة منخفضة وغير مستقرة عند درجات الحرارة المرتفعة
- They generally have a good strength to weight ratio. لديهم عموماً نسبة جيدة من القوة إلى الوزن



- Most of them are corrosion resistant, but cannot be used at high temperatures. معظمها مقاومة للتآكل، ولكن لا يمكن استخدامها في درجات حرارة عالية.
- They provide a good electrical and thermal insulation. أنها توفر العزل الكهربائي والحراري الجيد

4 . Classification of materials Based on Structure:

a. Crystalline البلورية materials

-Single Crystals

-Polycrystalline متعدد البلورات

b. Amorphous materials. مواد غير بلورية.

5 . Classification of materials Based on Function:

a . Mechanical material

b . Electronic material

c .Magnetic material

d .Optical material

e .Medical material