МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ

НАЦІОНАЛЬНИЙ ТЕХНІЧНИЙ УНІВЕРСИТЕТ
«ХАРКІВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ»

Методичні вказівки з англійської мови до виконання самостійних завдань з читання до змістовного модуля «Пошук та обробка інформації» для студентів І курсу спеціальності «Матеріалознавство»

Methodical instructions in English for individual reading tasks to module "Information Search and Processing" for first-year students majoring in Material Science

Затверджено
редакційно-видавничою
радою університету,
протокол № __ від _____2023р.

Харків
НТУ «ХПІ»
2023

Методичні вказівки з англійської мови до виконання самостійних завдань з читання до змістовного модуля «Пошук та обробка інформації» для студентів І курсу спеціальності «Матеріалознавство». / уклад. О.О. Мартинчук, С.В. Сергіна – Харків: НТУ «ХПІ». – 48 с.

Укладачі: О.О. Мартинчук, С.В. Сергіна

Рецензент Є.В.Танько

Кафедра іноземних мов

Chapter I
READING AND VOCABULARY

Section 1
Introduction

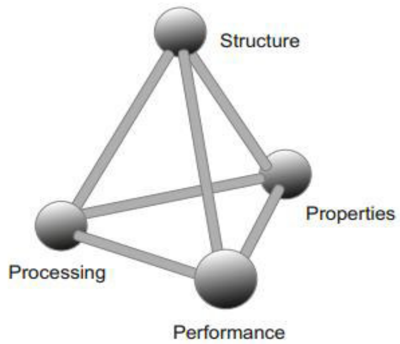

Figure 1: Materials science tetrahedron [wikipedia]

1.1 Historical Background

Glossary

to etch	cut into a surface, e.g. glass, using *an acid*
acid	a chemical, usually a sour liquid that contains hydrogen with a pH of less than 7
grain boundary	line separating differently oriented crystals in a polycrystal

Task 1. *Work with a partner. Fill the gaps in the text with words from the box in their correct form.*

alloy; characteristic; communication; clay; crystal; heat; housing; manipulate; metal; pottery; property (2); skin; specimen; substance; structure; technological; wood

Materials used in food, clothing, ……………… transportation, recreation and …………………… influence virtually every segment of our everyday lives. Historically, materials have played a major role in the development of societies, whose advancement depended on their access to materials and on their ability to produce and ……….…………… them. In fact, historians named civilizations by the level of their materials development, e.g. the Stone Age (beginning around 2.5 million BC), the Bronze Age (3500 BC), and the Iron Age (1000 BC). The earliest humans had access to only a very limited number of materials, those that occur naturally, e.g. ……………………, …….……………… and …………………….. With time they discovered techniques for producing materials that had properties superior to those of the natural ones; these new materials included ……………………… and various ……………………… Furthermore, early humans discovered that the properties of a material could be altered by ………………… treatments, e.g. to soften metals, and by adding other ……………………… to produce a new material, e.g. by melting copper, then mixing it with tin to form bronze which could be regarded as the first …………………………..

Until recently, selecting a material involved choosing from a number of familiar materials the one most appropriate for the intended application by virtue of its characteristics but without knowing much about its structure. Only in the 19th century did scientists begin to understand the relationships between the structural elements of materials and their …………………………. In 1864 the Englishman Henry Sorby first showed the microstructure of a metal when he developed a technique for etching the surface layer of a polished metal …………………………… by a chemical reaction. He used a light reflecting microscope to show that the material consisted of small …………………………… which reflected the light in different ways because they were oriented in different directions. The crystals were well fitted together and joined along grain boundaries. Modern techniques such as x-ray diffraction, transmittance electron microscopy (TEM) and scanning electron microscopy (SEM) make possible to see further into the ……………………… of materials, which leads to a better understanding of their characteristics and promotes intentional alteration and improvement of their …………………………….

By now more than 50,000 materials with specialized …………………………… have been developed and are available to the engineer, who has to choose the one best suited to serve the given purpose. Since much of what can be done …………………………… is limited by the available materials, engineers must constantly develop new materials with improved properties.

Task 2. *Give a short explanation for x-ray diffraction, TEM and SEM.*

1.2 Selection of Materials

Glossary

strength	the power to resist stress or strain; the maximum load, i.e. the applied force, a ductile material can withstand without permanent deformation
ductility, n **ductile,** adj	a material's ability to suffer measurable plastic deformation before fracture
plastic deformation	a non-reversible type of deformation, i.e. the material will not return to its original shape
corrosive, n**,** adj **to corrode, corrosion**	a corroding substance, e.g. an acid
commodity	article of trade
lb	pound, 453.592 grams
resin	a natural substance, e.g. amber, or a synthetic compound, which begins in a highly viscous state and hardens when treated
compound	a pure, macroscopically homogeneous substance consisting of atoms/ions of two/more different elements that cannot be separated by physical means
viscous, adj **viscosity,** n	having a relatively high resistance to flow

Selecting the right material from the many thousands that are available poses a serious problem. The decision can be based on several criteria. The in-service conditions must be characterized, for these will dictate the properties required of the material. A material does not always have the maximum or ideal combination of properties. Thus, it may be necessary to trade off one characteristic for another.

The classic example includes strength and ductility. Normally, a material having a high strength will have only a limited ductility. 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. If a compromise concerning desired in-service properties cannot be reached, new materials have to be developed.

Probably the most important consideration is that of economics. A material may be found that has the ideal set of properties but is extremely expensive. Some compromise is inevitable. The cost of a finished piece also includes any cost occurring during fabrication to produce the desired shape. For example: commodity plastics like polyethylene or polypropylene cost about $ 0.50/lb, whereas engineering resins or Nylon cost $ 1,000/lb.

Task 3. *Write short answers to the questions.*

What are necessary steps when considering a material for a certain application?

Which trade-offs are unavoidable when choosing a particular material?

1.3 Materials Science versus Materials Engineering

Glossary

to synthesize, **synthesis,** n	to produce a substance by chemical or biological reactions
predetermined	decided beforehand

The discipline of materials science and engineering includes two main tasks. Materials scientists examine the structure-properties relationships of materials and develop or synthesize new materials. Materials engineers design the structure of a material to produce a predetermined set of properties on the basis of structure-property relationships. They create new products or systems using existing materials and/or develop techniques for processing materials. Most graduates in materials programs are trained to be both materials scientists and materials engineers.

Task 4. *Read the text above. Then decide whether the statements are true or false. Rewrite the false statements if necessary.*

1. Materials scientists do research on finished materials.
2. New products are based on new materials only.
3. Materials science can be subdivided because different approaches to materials are employed.
4. Materials engineers investigate the correlation between structure and property.

Section 2

Characteristics of Materials

2.1 Structure

Glossary

nm	nanometer (10-9 m)

The structure of a material is usually determined by the arrangement of its internal components. On an atomic level, structure includes the organization of atoms relative to one another. Subatomic structure involves electrons within individual atoms and interactions with their nuclei. Some of the important properties of solid materials depend on geometrical atomic arrangements as well as on the interactions that exist among atoms or molecules.

Various types of primary and secondary interatomic bonds hold together the atoms composing a solid.

The next larger structural area is of nanoscopic scale which comprises molecules formed by the bonding of atoms, and particles or structures formed by atomic or molecular organisation, all within 1 nm – 100 nm dimensions. Beyond nanoscale are structures called microscopic, meaning that they can directly be observed using some kind of microscope.

Finally, structural elements that may be viewed with the naked eye are called macroscopic.

Task 1. *Work with a partner. Fill in the table with the different structural levels and their characteristics as described in the text.*

structural level	characteristics

Task 2. *Choose the correct terms for the following definitions.*

A sufficiently stable, electrically neutral group of at least two units in a definite arrangement held together by strong chemical bonds. ………………………

The smallest particle characterizing an element ………………………

A fundamental subatomic particle, carrying a negative electric charge. …………

It makes up almost all the mass of an atom. ………………………….

A positively charged subatomic particle. ……………………

An electrically neutral subatomic particle. ………………

2.2 Case Study: The Gecko

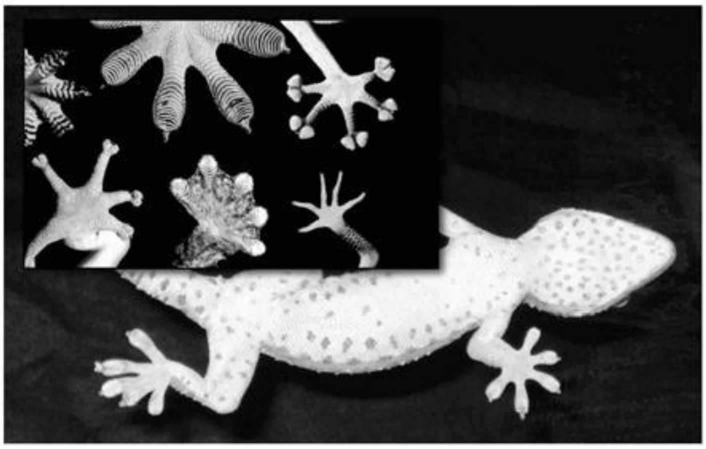

Figure 2: The underside of a gecko and its feet

Glossary

adhesive n, adj**, to adhere, adhesion,** n	a substance used for joining surfaces together, sticky
release, v, n	to let go
residue	the remainder of sth after removing a part
toe pad	a cushion-like flesh on the underside of animals' toes and feet
duct tape	an adhesive tape for sealing heating and air-conditioning ducts

Task 3*. Work with a partner. Fill the gaps in the text with words from the box in their correct form. Some terms are used more than once.*

adhesion; adhesive; design; horizontal; mass; microscopic; molecule; release; residue; selfcleaning; sticky; surface; underside; vertical

The photograph shows the ……………… of a gecko, a harmless tropical lizard, and its toes. Researchers worldwide are studying the animal's adhesive system. The scientists want to learn from nature how to ……………… dry adhesives such as geckos apply when moving their feet over smooth surfaces. The animals achieve high adhesion and friction forces required for rapid ……………… (running up walls) and inverted (running along the underside of …………………

surfaces) motion, since their ………………… feet will cling to virtually any surface. Yet they can easily and quickly release the sticky pads under their toes to make the next step. A gecko can support its body …………………with a single toe, because it has an extremely large number of ………………… small ordered fiber bundles on each toe pad. When these fibrous structures come in contact with a surface, weak forces of attraction, i.e. van der Waals forces, are established between hair …………………… and molecules on the surface. The fact that these fibers are so small and so numerous explains why the animal grips ………………… so tightly.

To …………………… its grip, the gecko simply curls up its toes and peels the fibers away 16 Chapter 2 Characteristics of Materials from the surface. Another fascinating feature of gecko toe pads is that they are ……………………… that is, dirt particles don't stick to them. Scientists are just beginning to understand the mechanism of ………………… for these tiny fibers, which may lead to the development of ………………………… self-cleaning synthetics. Imagine duct tape that never loses its stickiness or bandages that never leave a sticky ……………………….

2.3 Property

Glossary

glass transition temperature Tg	the temperature at which, upon cooling, a non-crystalline ceramic transforms from a supercooled liquid to a solid glass
supercooled	cooled to below a phase transition temperature without the occurrence of transformation
elastic modulus (E)	or Young's Modulus, a material's property that relates strain (, epsilon) to applied stress (————————————, sigma), cf. p. 9
conductivity	ability to transmit heat and/or electricity
resistivity	a material's ability to oppose the flow of an electric current

dielectric constant	a measure of a material’s ability to resist the formation of an electric field within it
tile	a flat, square piece of material
refraction	the bending of a light beam upon passing from one medium into another
reflectivity	the ability to reflect, i.e. to change the direction of a light beam at the interface between two media
propagation	the process of spreading to a larger area

While in use, all materials are exposed to external stimuli that cause some kind of response. A property is a material characteristic that describes the kind and magnitude of response to a specific stimulus. For example, a specimen exposed to forces will experience deformation, or a metal surface that has been polished will reflect light. In general, definitions of property 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 (including melting and glass transition temperatures)
– magnetic
– optical
– deteriorative

Mechanical Properties relate deformation to an applied load or force; examples include *elastic modulus* and strength.

Electrical Properties are, e.g. *electrical conductivity*, *resistivity* and *dielectric constant*. The stimulus is voltage or an electric field.

Thermal Properties of solids can be described by heat capacity and thermal conductivity. Poor thermal conductivity is responsible for the fact that space shuttle *tiles* containing amorphous, porous silica (SiO_2) can be held at the corners, even when glowing at 1000 °C.

Magnetic Properties demonstrate a material's response to the application of a magnetic field.

Optical Properties are a material's response to electromagnetic or visible light. The index of *refraction* and *reflectivity* are representative optical properties.

Deteriorative Properties relate to the chemical reactivity of materials. The chemical reactivity, e.g. corrosion, of a material such as an alloy, can be reduced by heat treating the alloy prior to exposure in salt water. Heat treatment changes the inner structure of the alloy. Thus crack propagation leading to mechanical failure can be delayed.

Task 4. *Work with a partner. Refer to the text and answer the questions.*

What is a material's property? ....

Do mechanical properties deal with deformation? ………………

How can the thermal behavior of solids be characterized? …………………

Section 3

Metals

3.1 Mechanical Properties of Metals

Glossary

rod	a thin, straight piece/bar, e.g. of metal, often having a particular function
perpendicular to	forming an angle of 90° with another line/surface
axle	a supporting shaft on which wheels turn
to shatter	to break suddenly into very small pieces

Bend Strength

Fracturing, e.g. *a rod* of brittle material can be done by fixing it tightly at both ends and applying a force upwards at two central points. Fracture will appear almost *perpendicular* to the length of the rod. This is one way of measuring the bend strength of material.

Shear Strength

Breaking the rod by fixing it at one end and twisting the other end, applying shear load or stress (τ, tau) will result in fracture that occurs at an oblique angle to the length of the rod. Stress (σ, sigma) is the ratio of a force F to the area A on which the force acts: σ = F/A = lb/in2 (lb meaning 453.592 grams, in meaning inch). Shear strength is important for rods of material that rotate like rotating *axles* in machinery which sometimes fail this way.

Tensile Strength

Most metals show macroscopically noticeable stretching. Brittle materials, like ceramics, show very little plastic, i.e. permanent deformation, before they fail. Materials with high tensile strength, like plastic and rubber, will stretch to several times their original length before they break.

Yield Strength (YS)

Yield strength or yield stress is the beginning of plastic deformation. The load required to permanently stretch a rod by 0.2 % of its original length is called yield strength. A 100 cm rod, for example, that has been loaded so that it has a permanent stretch of 0.2 % has been permanently lengthened to 100.2 cm, when the load is removed.

Compressive Strength

Compressive stress in comparison to tensile strength is negative stress. Failure occurs as yield for ductile metals, whereas brittle materials, e.g. cast iron, will *shatter*. Fracture occurs at an oblique angle to the length of the sample. It is unlikely that a clean break will result; rather, several pieces will occur from compressing the material.

Stiffness

If the same tensile stress is applied to two materials, the stiffer of the two will lengthen less. Stiffness is defined by Young's Modulus (YM) or elastic modulus, the ratio of applied stress to the strain it produces in the material. The smaller the strain, the greater the stiffness.

Task 1. *Complete the table.*

hard versus soft	equals	………… yield strength (resistance to plastic deformation) versus ………………yield strength
ductile versus	equals	appreciable plastic deformation before fracture versus ……………… plastic deformation before fracture
stiff ……………… easily bent	equals	High ……….. versus low Young's Modulus

3.2 Metal Alloys

Glossary

ferrous	of or containing iron
to refine	to make/become free from impurities
to be susceptible to **susceptibility,** n	to be easily affected/influenced by

A metal alloy is a metallic substance composed of two or more elements, which keep the same crystal structure in the alloy. Metals are combined with metals and/or with non-metal elements, for example carbon. Metal with metal alloys are made by mixing the molten substances and then cooling them until they solidify. Common alloys are brass (copper + zinc) and aluminum alloys (aluminum + copper, aluminum + magnesium), and steel. Plain carbon steel contains only iron and carbon, while alloyed steels, e.g. stainless steel, contain chromium as the main alloying element. Alloy systems are classified either according to the base metal, i.e. the metal serving as base of the alloy, or according to some specific characteristic that a group of alloys share. Depending on their composition, metal alloys are often grouped into two classes: ferrous and non-ferrous alloys.

Ferrous Alloys The principle constituent is iron as in, e.g. steel and cast iron. They are produced in larger quantities than any other metal type, being especially important as construction materials.

Iron and steel alloys can be produced using relatively economical techniques to be extracted, *refined*, alloyed and fabricated. Ferrous alloys have a wide range of physical and mechanical properties. However, they have relatively high density, which means they weigh a lot; their electrical conductivity is comparatively low and they are *susceptible* to corrosion in some common environments.

Nonferrous Alloys Since nonferrous alloys have distinct limitations; other alloy systems are used for many applications, e.g. copper, aluminum, magnesium, titanium alloys, super alloys, the noble metals, and other alloys, including those that have nickel, lead, tin, zirconium and zinc as base metals.

Task 2. *Practice so-called chain questions. Ask a classmate a question about information provided by the texts above. The student who has answered the question asks another student a question, who answers and so on.*

Question: What does the term metal alloy refer to?

Answer: It refers to ...

How ………………………?

Which...……………………?

What ………………………?

Why ……………………….?

3.3 Case Study: The Titanic

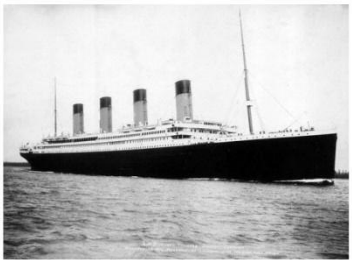

Figure 3: The Titanic

Glossary

hull	the body of a ship
sonar	a system using transmitted and reflected underwater sound waves to detect/locate/examine submerged objects
t/s	tons per second
median	relating to or constituting the middle value in a distribution, e.g. the median value of 17, 20 and 36 is 20

As is well known, the Titanic sank on her first trip across the Atlantic Ocean in 1912 after hitting an iceberg. 1,513 of the 2,224 people on board died, mainly because there were only 1,178 places in the ship's lifeboats. At the time of the collision, the Titanic was traveling at the relatively high speed of 22 knots, which equals 41 km/h, a dangerous speed at this time of the year, as icebergs are common in the North Atlantic in early spring. The *hull* of the Titanic was double-bottomed and divided into 16 compartments. As the ship would not sink even if four of these compartments filled with water, she was thought to be unsinkable.

After divers had found the wreck of the Titanic at a depth of about 13,000 ft (3,950 m) in 1985, a 1996 expedition used *sonar* imaging to discover a series of six narrow cuts in the hull. The damage totaled only 12 square ft, about the size of a human body, but the cuts were located 20 ft below the waterline, where water pressure forced the sea water through them at a rate of almost 7 *t/s.*

Researchers began questioning if poorly manufactured materials played a role in the ship's sinking. A major factor contributing to the disaster was the brittleness of the steel used.

Steel produced at the time the Titanic was built generally had a higher percentage of sulfur and phosphorous than would be allowed today, resulting in steel that fractured easily. Samples of Titanic fragments were tested to determine the steel's chemical make-up, tensile strength, microstructure and grain size, as well as its responses to low temperatures. As the metallurgists had suspected, the steel was full of large manganese sulfide impurities that created weak areas and caused the metal to be brittle.

Under extreme conditions, such as the unusually cold, 28 F water temperatures of the North Atlantic at the time of the disaster, the steel became fragile and, subjected to the violent impact, immediately fractured.

Task 3*. Read the text above, then decide whether the statements are true or false. Rewrite the false statements if necessary.*

Most passengers drowned because the ship sank fast. ……………………………

Median speed for a cruise ship was 22 knots. ………………

Divers found one deep cut in her hull. ………………………………

Impurities in the steel were responsible for the poor performance of the Titanic's steel. ....

Section 4
Ceramics

4.1 Structure of Ceramics

Ceramics are compounds between metallic and non-metallic elements. They are most frequently oxides, nitrides and carbides. A composite material of ceramic and metal is cermet. The most common cermets are cemented carbides, which are composed of an extremely hard ceramic, bonded together by a ductile metal such as cobalt or nickel. In addition, there are the traditional ceramics mentioned before, those composed of clay minerals, as well as cement and glass. As ceramics are composed of at least two and often more elements, their crystal structures are generally more complex than those of metals.

Task 1. *Read the text above and decide whether the statements are true or false. Rewrite the statements if necessary.*

Ceramics are non-metallic, inorganic materials. ………………………

Ceramics can be compounds of at least three elements. ………………..

4.2 Properties of Ceramics

Glossary

disposition	a physical property/tendency

Task 2. *Work with a partner. Fill the gaps in the text with words from the box in their correct form.*

characteristic; conductivity; deformation; ductility; fracture; load; magnetic; strength

With regard to mechanical behavior, ceramic materials are relatively stiff and strong. Their stiffness and ………….. are comparable to those of the metals. In addition, ceramics are typically very hard. On the other hand, they are extremely brittle, i.e. lack ………., and are highly susceptible to fracture, which limits their applicability in comparison to metals. The principal drawback of ceramics is a *disposition* to catastrophic ………………… in a brittle manner with very little energy absorption. At room temperature, both crystalline and non-crystalline ceramics tend to fracture before plastic ………………… can occur in response to an applied tensile ……………………. Ceramics typically insulate against the passage of heat and electricity, i.e. they have low electrical ……………………, and they are more resistant to high temperatures and harsh environments than metals and polymers. With regard to optical ……………………., ceramics may be transparent, translucent or opaque, and some of the oxide ceramics, e.g. Fe_3O_4, exhibit ……………………… behavior.

Task 3. *Define the following terms:*

transparent …………………………

translucent …………………………

opaque ……………………………

4.3 Case Study: Pyrocerams

Figure 4: Ceramic cook ware

Glossary

creep, n	time-dependent permanent deformation of materials at high temperatures or stress
slip casting	the process of pouring liquefied material into a mold; after the liquid is drawn out, the solid is removed from the mold

Task 4. *Add captions to the following paragraphs.*

Pyrocerams or glass ceramics are widely used for ovenware, manufactured by, e.g. CorningWare or the German manufacturer Schott. The covalently bonded silicon carbide, silicon nitride and silicon aluminum oxynitrides, or sialons (alloys of Si_3N_4 and Al_2O_3), are the best materials for high-temperature structural use.

………………………………

The *creep* resistance of the materials is outstanding up to 1300 °C, and their low thermal expansion and high conductivity make them resist thermal shock well in spite of their typically low toughness, the thermal shock resistance being better than that of most other ceramics. Pyrocerams exhibit excellent resistance to corrosion, which accounts for their use in the chemical industry.
…………………………………

These materials are manufactured by the high-temperature reaction of silicon nitride with aluminum oxide. They can be formed by hot pressing fine powders and sintering them in the process, or *slip casting* followed by pressureless sintering, which provides greater shape and manufacturing flexibility. If the constituents are varied, the properties of the final ceramic vary too. However, continuous exposure to high temperatures can result in the material's degrading back to these constituent parts.

…………………………

Typical uses include burner and immersion heater tubes, injectors for nonferrous metals and protection tubes for nonferrous metal melting and welding fixtures.

Task 5. *Work with a partner. Reconstruct statements about high-temperature ceramics from the jumbled words without referring to the text. The first word is given*

better ceramics is most of other resistance shock than that

Thermal ……………………..……………………………….

corrosion excellent exhibit resistance to too

Pyroceramss ……………….……………………………….

and be by can fine formed hot powders pressing sintering them

They ..……………………..……………………………….

are ceramics constituents final of properties the too varied vary

If …………………………..…………………………

are best for high materials structural temperature the use
Sialons ..……………………..…………………………

ceramics for high include melting metal nonferrous of temperature tubes uses
Typical ……………….……………………………..

4.4 Case Study: Spheres Transporting Vaccines

Glossary

to stray	to move away from the place where sth/sb should be
sphere	a solid figure that is completely round
aqueous	watery
nozzle	a device with an opening for directing the flow of a liquid

In order to find a way of delivering waterproof, time-release payloads of vaccines to the body, researchers at Cambridge Biostability Laboratory (CBL) in the UK studied the way body cells called osteoclasts remove *stray* bone fragments by attacking and dissolving them. Using calcium phosphate, the main mineral constituent of bone, the researchers developed *spheres* that can be slowly dissolved by osteoclasts, thus releasing the enclosed vaccine.
To build the spheres, a mixture of vaccine and calcium phosphate crystals in an *aqueous* solution is sprayed out of a *nozzle* into a stream of gas at around 170°C. The crystals are surrounded by a cloud of water molecules, which evaporate in the gas. As the water molecules evaporate, the crystals partially join together to form solid glassy spheres, five micrometer in diameter, with the vaccine embedded inside. The heat of the gas is absorbed by evaporative cooling before it can destroy the vaccine. The spheres prevent the vaccines from deteriorating or breaking down

if not kept dry before release. They can be injected as a follow-up booster dose at the same time as the initial dose, releasing their contents over a period of months.

Task 6. *Read the text above then answer the following questions.*

Why do researchers study the way the body removes bone fragments? …………………

How are the embedded vaccines released from the spheres?

…………………………

Why is the evaporation of the water molecules essential?

…………………………

Section 5

Polymers

5.1 Introduction

Glossary

starch	a white, tasteless powder found in plants, e.g. rice, potatoes
to synthesize, **synthesis**, n	to prepare a substance by chemical reaction
monomer	a molecule that can combine with others of the same kind to form a polymer
thermoset	a polymeric material that, once having cured or hardened by chemical reaction, will not soften or melt when heated
counterpart	here sth that has a similar function

Task 1. *Work with a partner. Fill the gaps in the text with words from the box in their correct form.*

animal; application; cotton; industry; leather; molecule; plant; produce; property; rubber; silk; synthetic; wool

Naturally Occurring and Synthesized Polymers Naturally occurring polymers, those derived from plants and animals, have been used for many centuries, for example wood, ……………………..…………………………………………………. Other natural polymers such as proteins, enzymes, starches and cellulose are important in biological and physiological processes in ………………………. and ………………. With modern research tools it is possible to determine the molecular structures of these groups of materials and to develop numerous polymers that are synthesized from small organic ……………………. referred to as monomers. Most monomers form the basis for plastics, rubbers, thermosets, fibers and adhesive and coating materials. Most monomers for such polymers are the products of the petrochemical ……………………. For such applications, as well as for the structural function of some biopolymers in nature, adequate mechanical …………………………. such as stiffness and strength are required. The synthetics can be ……………………. inexpensively, and their properties may be controlled so that many are superior to their natural counterparts. In some …………………………, metal and wood parts have been replaced by plastics, which have satisfactory properties and may be produced at lower costs.

5.2 Case Study: Case Study: Ubiquitous Plastics

Figure 5: Objects made of polymers

Glossary

velvet	a type of cloth with a thick, soft surface

Plastics today Uta Scholten, of the German Plastics Museum Association in Düsseldorf says: "Most people today don't know there was a time before plastics." This was a time when a soccer ball still was made of leather, not foamed PU, and a surfboard was made of wood not PE.

Today, yogurt tubes are made of PS, CDs of PC, shoes of PU, waste baskets of PP, computer keyboards of ABS (a copolymer of acrylonitrile, butadiene and styrene), and soda bottles of PET poly(ethylene terephthalate). These materials, called plastics in English, were given the name Kunststoffe by the German chemist Dr. Ernst Richard Escales in 1910, later also referred to as Plastik in a critical way. But over the last few years they have shaken off their image as cheap or inferior substitutes. "These days, plastics have a high-quality image," says Dirk Ziems, manager of a market research institute in Köln, Germany. "The elegant appearance of the iPod cannot be topped, and the functionality of modern athletic clothing will not be surpassed soon."

Plastics in architecture, fashion and design

The Swiss architects Jacques Herzog and Pierre de Meuron gave the Allianz Arena in Munich an inflatable covering made of EFTE (ethylene – tetrafluoroethylene copolymer) plastic that can be illuminated in white, blue and red, the colors of Munich's two professional soccer teams.

The Allianz Arena consists of 66,500 square meters of EFTE film, 0.2 mm thick, cut into rhombus-shaped cushions. Fans inflate the cushions, which have an estimated service life of 25 years. Karsten Moritz from Rosenheim who engineered the arena's plastic façade is convinced that film skins give architects new opportunities, especially when combined with sophisticated technologies, such as liquid crystal layers that can be laminated with film, or the special effects created when light hits the edges of the film.

Fashion is another field with its sight set on plastics. Fashion guru Karl Lagerfeld surprised an interviewer by naming not velvet or silk as his favorite material, but plastics.

According to the local newspaper of San Francisco, the Chronicle, "Plastic furniture has become the focal point in some of the most elegantly designed rooms." The Prada Store in Beverly Hills, designed by Rem Kohlhaas, has wall coverings made of spongy, translucent PU mats. Spaces for items on display are simply cut out as needed. "No other material can be so lightweight and luminescent," says the designer.

Plastics in aircraft engineering

Jets have to be safe and airlines need planes that can fly economically. Consequently, the percentage of plastics integrated in jet planes is rising steadily. The development of the giant Airbus 380 has taken the use of plastics to a new level. For the first time in civil aviation, fiber composites were used to build wing boxes, which are the heart of any jet. Compared to a conventional aluminum structure, fiber composites help to reduce the total weight by 1.5 tons, which reduces fuel consumption while increasing payload and range. In comparison with the new jumbo jet, the proportion of plastics in an older Boeing is less than 5 % of the total weight. The A380 brings the figure up to 20 %, and in the Boeing 787, plastics make up more than half of the material used.

Plastics as a Commodity

For commodity manufacturers, plastic has become the material of choice for getting ahead of the competition. With its brightly colored iMac models, Apple proved that computers don't have to be gray boxes. However, the greater the demands imposed by industry on plastics, the more expensive their manufacturing becomes. For this reason, industry is called on to develop corresponding methods that make the cost of manufacturing equal to or less than that of metallic materials.

Task 2. *Work with a partner. Match the following terms with the definitions.*

commodity ....

cushion……………

foam ….....…………………

luminescent …………………

payload …………………………………

spongy ………………………………………………………

ubiquitous ....

Definitions:

bubbles of air together in a mass

emitting light

found everywhere

merchandise

resembling an artificial or natural material that is soft, light and full of holes

soft, protective pad

total weight an airplane can carry

Task 3*. Work with a partner. Make a list of plastic objects and their characteristics mentioned in the text. Refer to architectural design, interior design and aircraft engineering.*

5.3 Case Study: Different Containers for Carbonated Beverages

Figure 6: Carbonated beverage containers

Task 4. *Work in a group. Scan the text, then discuss and decide which material you would choose as manufacturer and as consumer for containers for carbonated beverages. Give reasons.*

Glossary

diffusion	the movement of atoms/molecules from an area of higher concentration to an area of lower concentration

A common item that represents some interesting material property requirements is a container for carbonated beverages.

The Material of Choice

should provide a barrier to the passage of carbon dioxide (CO_2), which is under pressure in the container;

must be nontoxic, unreactive with the beverage (including carbonic acid from dissolved CO_2), and preferably be recyclable;

should be relatively strong and capable of surviving a drop from a height of several feet when containing the beverage;

should be inexpensive, and the cost to fabricate the final shape should be relatively low;

should keep its optical clarity if optically transparent;

should be capable of being produced having different colors and/or labels

All three of the basic material types, metal (aluminum), ceramic (glass), polymer (PET) are used. They are all non-toxic and unreactive with the contained beverages. In addition, each material has its pros and cons.

Aluminum alloy is relatively strong but easily damaged. It is a very good barrier to the diffusion of CO_2 and can easily be recycled. The beverages are cooled rapidly and labels may be painted onto its surface. On the other hand, the cans are optically opaque and relatively expensive to produce. 62 Chapter 5 Polymers.

Glass is a very good barrier to the diffusion of CO_2 and a relatively inexpensive material. It may be recycled, but it cracks and fractures easily and glass bottles are relatively heavy.

Plastic is relatively strong and can be made optically transparent. It is inexpensive, lightweight and recyclable. But plastic is not as good a barrier to the diffusion of CO_2 as aluminum and glass.

Your choice material as manufacturer:

…………………………………………………………………………………………
………………………………………………..

Your choice material as consumer:

…………………………………………………………………………………………
……………………………………………….

Chapter 6 Composites

6.1 Introduction

Glossary

abrasion, to abrade	the process of being rubbed away by friction, to rub away
abrasive, n, adj	a substance that abrades, abrading
impact	a high force or load acting over a short time only
constituent phase	one of the phases from which a substance is formed
phase	a form or state of matter (solid/liquid/gas/plasma) depending on temperature and pressure
interface	the area between systems where they come into contact with each other
to disperse, dispersion, n	to distribute particles evenly through a medium

Task 1. *Work with a partner. Fill the gaps in the text with words from the box in their correct form.*

artificial; aerospace; bone; cellulose; corrosion; dissimilar; phase; transportation; underwater; wood

A number of composites occur in nature: ……………………consists of strong and flexible ………………………… fibers surrounded and held together by a stiffer material called lignin. ………………………… is a composite of the strong yet soft protein collagen and the hard, brittle mineral apatite. Yet many modern technologies require materials with unusual combinations of properties that cannot be met by natural composites or the conventional metal alloys, ceramics and polymeric materials. This is especially true for materials that are needed for ……………., ……………… and …………… applications. Aircraft engineers for example, are increasingly searching for structural materials that have low densities, are strong, stiff and resistant to abrasion and impact as well as ……………………, a rather impressive combination of characteristics. The problem is that strong materials frequently are relatively dense, i.e. heavy. Increasing the strength or stiffness typically results in a decrease in impact strength. Generally speaking, a composite is considered to be any …………………… made multiphase material that shows properties of both constituent phases so that a better combination of properties is realized. The constituent phases in a composite are chemically …………………… and separated by a distinct interface. Many composite materials are composed of just two ……………………, the one phase being the matrix, which is continuous and surrounds the other phase, which is often called the dispersed phase. The properties of composites are a function of the properties of the constituent phases, their relative amounts and the geometry of the dispersed phase, which means the shape, particular size, distribution and orientation of the particles.

Task 2. *Work with a partner. Answer the following questions.*

What is the number of individual materials a composite is composed of? …………..……………………………………………………………………

What is the design goal of a composite? …………..…………………………...

………………………………………………………………………………………

6.2 Case Study: Snow Ski

Glossary

glass transition temperature Tg	the temperature at which, upon cooling, a non-crystalline ceramic or polymer transforms from a supercooled liquid to a solid glass
supercooled	cooled to below a phase transition temperature without transforming
torsion, torsional, adj	the stress/deformation caused when one end of an object is twisted in one direction and the other end is twisted
to damp(en)	to make sth less strong, to soften
to shatter	to suddenly break into pieces

Task 3. *Work with a partner. Draw the cross-section of a snow ski, showing the different layers of the composite structure as described.*

Task 4. *The notes on a snow ski contain several expressions that can be used to describe a purpose. Make a list of the expressions. Then use them in sentences.*

Section 7

Advanced Materials

7.1 Introduction

Glossary

integrated circuit	*millions of electronic circuit elements*

	incorporated on a very small silicon chip
rocketry	the science and technology of rocket design, construction and flight

Task 1. *Work with a partner. Write an outline of the following presentation about advanced materials. Then give a short presentation on the basis of this outline. Take turns.*

"Good afternoon, Ladies and Gentlemen,

The topic of my short presentation today will be an introduction to advanced materials.

First, I am going to discuss two material types that belong to this category.

Second, I will mention current applications of advanced materials.

Advanced materials can be of all material types, e.g. metals, ceramics and polymers.

To obtain advanced materials, properties of traditional materials have been improved, that is significantly changed in a controlled manner. Advanced materials include semiconductors, biomaterials as well as smart materials and nano-engineered materials. Two important classes of advanced materials I want to introduce here are smart materials and nano-engineered materials.

Smart materials respond to external stimuli, such as stress, temperature, electric or magnetic fields. By way of example, consider shape memory alloys or shape memory polymers, which are thermo responsive materials, where deformation can be induced and recovered through temperature changes, as can be seen in this figure.

As I have already mentioned, advanced materials also include nano-engineered materials which have unique properties. These properties arise from structural features which are of nanoscale dimensions, i.e. 1 to 100 nanometers. A prominent example is carbon nano-tube filled polymers which can be employed as electrically conducting materials or high performance materials.

Please refer to the next diagram showing room temperature electrical conductivity ranges of these polymers.

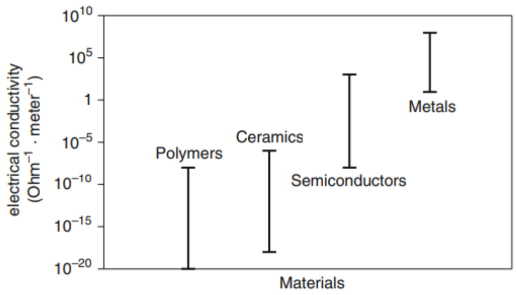

Figure 6: Room temperature electrical conductivity ranges for metals, ceramics, polymers and semiconducting materials

Having looked at two classes of smart materials, I will now turn to some applications. Advanced materials are used in high-tech applications for, among others, lasers, *integrated circuits*, magnetic information storage, and liquid crystal displays (LCDs). They function in everyday electronic equipment such as computers, camcorders, or CD/DVD players. But advanced materials also operate in state-of-the-art devices for spacecraft, aircraft, and military *rocketry*.

In conclusion we have seen the structural versatility and wide range of potential applications of advanced materials. This is why they are being investigated in academic and industrial research laboratories worldwide, and further developed and optimized for various tasks in industry.

Thank you for your attention, Ladies and Gentlemen. I'll be pleased to answer questions now."

7.2 Case Study: Integrated Circuits

Glossary

vacuum tube	an electron tube from which all or most of the gas has been removed, letting electrons move without interacting with remaining gas molecules
manual assembly	putting together manufactured parts to make a completed product by hand

Task 2. *Work with a partner. Fill the gaps in the text with words from the box in their correct form.*

advancement; approach; consume; electronic; improvement; manufacture; miniaturize; perform

In electronics, an integrated circuit, also known as IC or microchip, is a ……………………… electronic circuit consisting mainly of semiconductor devices as well as passive components. These circuits are ………………… on the surface of a thin substrate of semiconductor material. ICs revolutionized the world of electronics and nowadays appear in almost all …………………… equipment. Integrated circuits were made possible by discoveries which showed that semiconductor devices could ………………..... the functions of *vacuum tubes.* Thanks to technological …………………..... in semiconductor device fabrication in the mid 20th century, large numbers of tiny transistors could be integrated into a small chip.

This was an enormous ………………..... over the *manual assembly* of circuits. The fact that reliable integrated circuits could be mass produced using a building-block ………………..... in circuit design resulted in the fast adoption of standardized ICs in place of designs using transistors. The cost of integrated circuits is low because of mass production and because much less material is used. Being small and close together, the components switch quickly and ………………..... less power than their discrete counterparts. In 2006, chip areas ranged from a few square millimeters to around 350 mm2, with up to 1 million transistors per mm2.

7.3 Nanotechnology

Glossary

scanning probe microscope	(SPM), a microscope that scans across the specimen surface line by line, from which a topographical map of the specimen surface (on a nanometer scale) is produced

The history of science shows that, to understand the chemistry and physics of materials, researchers generally have begun by studying large and complex structures and then later investigated smaller fundamental building blocks of these structures.

However, *scanning probe microscopes*, which permit observation of individual atoms and molecules, make it possible to manipulate and move atoms and molecules to form new structures and thus design new materials that are built from simple atomic-level constituents, an approach called ‘materials by design’. This ability to arrange atoms provides opportunities not otherwise possible to develop and study mechanical, electrical, magnetic and other properties. In the term nanotechnology, the prefix nano denotes that the dimensions of these structural entities are on the order of a nanometer (10-9 m). As a rule, they are less than 100 nanometers (equivalent to approximately 500 atom diameters).

Task 3. *The text refers to two kinds of scientific approaches, the top-down and the bottom-up approach. Explain.*

In the so-called top-down approach to the chemistry and physics of materials, researchers study ……………..

In the so-called bottom-up approach, ……………………………

7.4 Case Study: Carbon Nanotubes

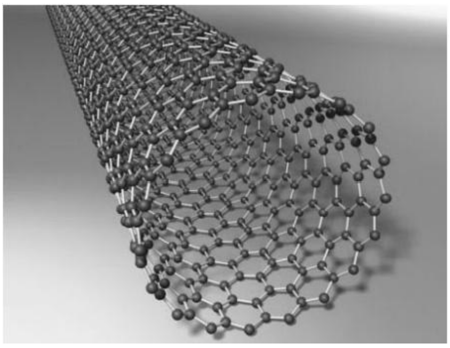

Figure 7: Carbon nanotube structure

Glossary

fullerene	carbon molecule named after R. Buckminster Fuller, sometimes called buckyball, composed entirely of C in the form of a hollow sphere, ellipsoid or tube

Task 4. *Work with a partner. Fill the gaps in the text with words from the box in their correct form.*

applicable; atom; consist; diameter; ductile; efficient; end; field; know; molecule; thickness

The structure of a nanotube …………………… of a single sheet of graphite, one atom in ……………………, which is rolled into a tube. At least one ……………………………….. of the tube is capped with a C_{60} *fullerene* hemisphere. Each nanotube is a single ………………… composed of millions of ……………………. The length of the molecule is thousands of times greater than its ………………………. Nanotubes are extremely strong and stiff and relatively ……………………. For single-walled nanotubes, tensile strengths range between 50 and 200 GPa, which is the strongest …………………… material so far.

Nanotubes have unique electrical properties and are …………….. conductors of heat. Because of their unique properties, nanotubes are extremely useful as reinforcement in composite materials and will be ……………………. in many ways in nanotechnology, electronics, optics and other …………………… of materials science.

Chapter II

GRAMMAR IN USE

- **The passive voice** appears in scientific texts rather frequently. This is appropriate for an impersonal use of the language, where the acting person is of no importance and therefore does not have to be mentioned. The passive is also used to describe a process.

***Task 1**. Work with a partner. Put in the verbs in brackets in the correct form.*

Glossary

pig iron	crude iron
blast furnace	the oven in which ore is melted to gain metal
ore	a mineral from which a metal can be extracted
pear-shaped	having a round shape becoming gradually narrower at the end
to tap	to remove by using a device for controlling the flow of a liquid
scrap iron	metal objects that have been used

The Steel-Making Process

There is no single substance ………………… steel: there are dozens of different types of steel – of different compositions and with different properties. (call) "Ordinary" steel can …………………… as an alloy of iron containing a small but fixed amount (up to 1.5 %) of carbon. (describe) The many special steels which are available have several other metals ………………… in as well. (mix) The properties of steel depend not only on its composition but also on any heat treatment ………………… to it after manufacture. (give) Pig iron, with its high proportion of impurities, is too brittle for most purposes, and the bulk of what ………………… in blast furnaces …………………… into steel. (convert; produce) The steelmaking process requires that, after most of the carbon and practically all of the other impurities (Si, S, P) …………………… by oxidizing, the right amount of each of the required elements …………………… (add; remove) Of the main steelmaking processes …………………… today, the one by which most steel is manufactured is the basic oxygen process. (use) This method is fast and over 300 t of steel can ………………… in as little as 40 min. (produce)

A converter, which is a huge steel, pear-………………..… container, called vessel, of up to 300 t capacity, is mounted so that it can ……………….…… either way for charging and tapping. (move; shape) It is charged with ……………….…… pig iron from the blast furnace, along with up to about half of its mass of scrap iron or steel. (melt) A water-………………..… tube, called lance, can ………………..… vertically into the vessel, delivering a high powered jet of pure oxygen, thus burning the carbon ……………….…… in the iron. (cool; dissolve; lower) The impurities ………………..… rapidly, (C to CO_2 and S to SO_2) and escape as gases. (oxidize) (p.39)

- Scientific and technical texts in English frequently use **the present tense**, since in most cases they state facts. Sometimes, **the present perfect** and **past simple** have to be used, as the text about the historical development of materials science shows.

Task 2. *Work with a partner. Fill the gaps in the sentences with the verbs in their correct tense (present perfect or simple past).*

Glossary

resilience, n **resilient,** adj	elasticity; property of a material to resume its original shape/position after being bent/stretched/compressed
binder	a polymeric material used as matrix in which particles are evenly distributed
matrix	a substance in which another substance is contained

Materials ……………………….. (always play) a major role in the development of societies. Civilizations …………………….. (designate) by the level of their materials development. The earliest humans …………………….. (have) access to only a very limited number of materials. The microstructure of a metal

……………………… (be) first revealed in 1864 by the Englishman Henry Sorby who ……………………… (develop) a technique for etching the surface layer of a polished metal. Modern techniques such as x-ray diffraction, transmission electron microscopy (TEM) and scanning electron microscopy (SEM) ……………………………… (make) it possible to better understand their characteristics. By now, more than 50,000 materials ……………………………… (develop). Materials scientists ………………… (long envy) the resilience of certain naturally occurring materials. Past efforts to reproduce the architecture of, e.g. a shell …………………… (not be successful). To copy the microstructure of the shell, the researchers ……………………… (mix) water with finely ground ceramic powder and polymer binders. .(p.4)

Task 3. *Choose the correct (simple, progressive or perfect) verb form in each of the following sentences.*

1. In this process, the mixture is (heated/is heating) to 120°C, 2. Once the salts (are dissolving/have dissolved) the heat is reduced, 3. Several people have (survived/are surviving) the earthquake and are treating/are being treated in hospital at the moment. 4. For security purposes the employees (change/are changing) their passwords regularly. 5. Up until now people in this area (have taken/taken) waste plastic to recycling centers, but at present we (have tried/are trying) a curbside collection system.

Task 4. *Fill the gaps in the text with words from the box in their correct forms.*

Glossary

clay	a kind of earth that is soft when wet and hard when dry
china	high-quality porcelain, originally made in China
brick	a rectangular block of baked clay used for building

phenomenon, **phenomena,** pl	a fact/event that can be identified by the senses

Come; evolve; make; occur; achieve; call; take

The term ceramic ……………from the Greek word *keramikos*, which means burnt substance. The desirable properties of these materials normally ………….. through a high-temperature heat treatment called firing. Up until the past sixty years, the most important materials in this class ………….. traditional ceramics, for which the raw material is clay, e.g. china, bricks, tiles and in addition, glasses and high-temperature ceramics. Recently, significant progress ……………. in understanding the fundamental character of these materials and of the phenomena that ………….. in them that are responsible for their unique properties. Consequently, a new generation of these materials…………., and the term ceramic ………….. on a much broader meaning. These new materials are applied in, e.g. electronics, computers, communication technology, biomedical implants and aerospace.
(P. 40)

- **Comparing** Two or more Things in English

Task 5. *Fill the gaps in the table with the correct forms.*

Irregular Forms:

good ....

bad ....

far .... (when referring to distance)

far .... (when referring to extent/degree)

little .... (when referring to amount)

little .... (when referring to size)

much/many ....

Optical Fibers versus Copper Cables

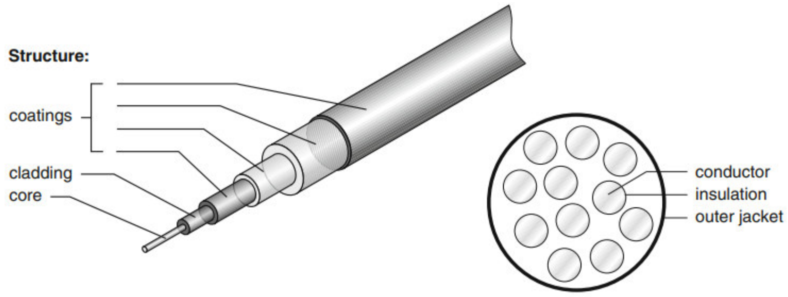

Figure 8: Optical fiber

Glossary

duct	a pipe for electrical cables and wires
to ignite, **ignition,** n	to begin to burn, to cause to burn
flammable	easily ignited, capable of burning, inflammable
to splice, e.g. cables	to join two pieces at the end

Optical fibers, used in modern optical communication systems are an example for the application of an advanced ceramic material. They are made of extremely high-purity silica, which must be free of even extremely small levels of impurities and other defects that would absorb, scatter or weaken a light beam. Sophisticated processing has been developed to produce fibers that meet the rigorous restrictions required for this application, but such processing is costly.

Optical fibers started to replace some uses of copper cables in the 1970s, e.g. in telecommunications and cable TV. In these applications they are the preferred material, because the fibers carry signals more efficiently than copper cable and with a much higher bandwidth, which means that they can carry more channels of information over longer distances. For optical fibers, the longer transmission distances require fewer expensive repeaters. Also, copper cable uses more electrical power to transport the signals. In addition, optical fiber cables are much lighter and thinner (about 120 micrometers in diameter) than copper cables with the same bandwidth so that they take up less space in underground cabling ducts. It is difficult to steal information from optical fibers and they resist electromagnetic interference, e.g. from radio signals or lightning. Optical fibers don't ignite so they can be used safely in flammable atmospheres, e.g. in petrochemical plants.

Due to their required properties, optical fibers are more expensive per meter than copper. In addition, they can't be spliced as easily as copper cable, thus special training is required to handle the expensive splicing and measurement equipment.

Task 6. *Read the text above. Compare glass fibers to copper cables, listing the pros and cons of each material.*

…………………………………………………………………………………………….

Chapter III

DESCRIBING A PROCESS, FIGURES, DIAGRAMS

Some Phrases for Describing Figures, Diagrams

Graph/Diagram

the graph/diagram/figure represents …

it shows a value for …

it shows the relationship between …

the curve shows a steep slope, a peak, a trough

the curve rises steeply/flattens out/drops/extrapolates to zero

Plot

to plot points on/along an axis

to plot/make a plot … versus … for …

x is plotted as a function of y

Coordinate System

abscissa (x-axis) and ordinate (y-axis)

the coordinate system shows the frequency of … in relation to/per …

Angle

parallel; perpendicular; horizontal to

right angle (90°)

acute angle (smaller than 90°)

obtuse angle (larger than 90°)

straight angle (180°)

Task 1. *Write a short paragraph for the plot in the figure below describing what is shown.*

The graph in the figure above shows ……………………………………………………

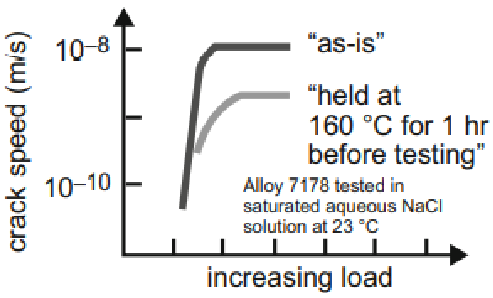

Figure 9: Crack propagation and load

Glossary

propagation	the process of spreading to a larger area

Task 2. *Work with a partner. Complete the short paragraph for the figure below, explaining the difference in optical properties.*

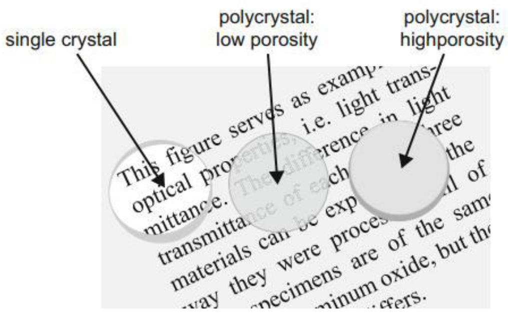

Figure 10: Crystallinity and light transmittance

This figure serves as example for optical properties, i.e. light transmittance. The difference in light transmittance of each of the three materials can be explained by the way they were processed. All of these specimens are of the same material, aluminum oxide, but their crystal structure differs.

Glossary

boundary	the interface separating two neighboring regions having different crystallographic orientation
to scatter	to distribute in all directions

Figure 9 illustrates the relationship among processing, structure, properties and performance. The photograph shows three thin disk specimens of the same material,…………………… placed over ………………… The optical properties (i.e. the light transmittance) of each of the three materials are different. The one on the left …………………………, i.e. virtually all of the light reflected from the printed page passes through it. The disk …………………… translucent, meaning that some of this ………………… through the disk. The disk on the right is ……………………, i.e. none of the ………………….. passes through. Optical properties are a consequence of ……………………… of these materials which result from the way the materials were processed. The leftmost one is a ……………………… which causes its …………………The polycrystal in the center is composed of numerous small crystals that are all connected, the boundaries between these small crystals scatter a portion of the ……………………………………………, so this material is optically translucent. The specimen on the right is not only composed of many small interconnected crystals but also of many very small pores. These pores also effectively scatter the reflected light and make this material opaque.

Task 3*. Work with a partner. Draw a diagram of the chain structure of polyethylene with its repeat units.*

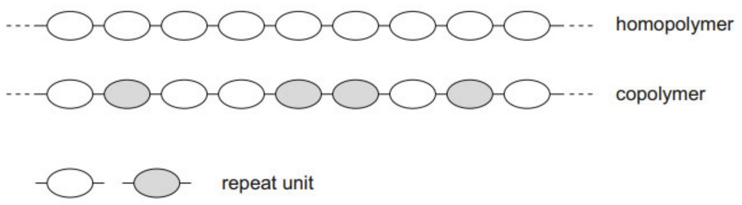

Figure 11: Structure of a homopolymer and a copolymer

Polymer can be defined as a substance whose molecules consist of many parts (Greek poly + meros). The term refers to molecules with many units joined to each other through covalent bonds, often repeating the units. That is why the units are called mers or repeat units. When the units are all of the same kind and joined together linearly, it is a homopolymer, whereas a copolymer has more than one type of repeat unit. Polymers can contain up to several hundreds or thousands of repeat units. Because of the resulting long chain, high molecular weight and large size, these polymers are called macromolecules. Polymers can be named on the basis of the monomer(s) from which they are derived by adding the prefix polyto the monomer. Alternatively, a polymer can be named on the basis of its repeat unit structure. Complex biopolymers, e.g. cellulose, or synthetic polymers are often referred to by their trivial name, e.g. Nylon 6,6, the structure-based name of which is poly(hexamethylene adipamide).

Chapter IV

VOCABULARY

to etch	гравірувати, травити на металі (кислотою)
acid	кислота
grain boundary	межа зерна
strength	сила, міцність, потужність
ductility, n	тягучість

ductile, adj	гнучкий; ковкий, тягучий
plastic deformation	пластична деформація
corrosive adj **to corrode** **corrosion** n	корозійний піддаватися корозії корозія
commodity	товар, продукт
lb	фунт
resin	смола
compound	компонент
viscous, adj **viscosity,** n	в'язкий в'язкість
to synthesize, **synthesis,** n	синтезувати синтез
predetermined	зумовлений, наперед визначений
adhesive n, adj**,** **to adhere,** **adhesion,** n	клей, липкий липнути прилипання, склеювання
release, v, n	випускати, вивільнення
residue	осад, залишок
toe pad	подушка між пальцями
duct tape	скотч
rod	прут, стрижень, палка
perpendicular to	перпендикулярно
axle	вісь
to shatter	розбивати вщент
glass transition temperature Tg	температура склування
supercooled	переохолоджений
elastic modulus (E)	модуль пружності
conductivity	провідність, електропровідність

resistivity	питомий опір
dielectric constant	діелектрична постійна
tile	кахель, плитка
refraction	заломлення, рефракція
reflectivity	відбивна здатність, рефлективність
propagation	поширення
ferrous	залізний, залізистий
to refine	очищати, удосконалювати
to be susceptible to **susceptibility,** n	бути сприйнятливим до сприйнятливість
hull	корпус
sonar	гідролокатор
t/s	тонн на секунду
median	середній, медіанний
disposition	схильність
creep, n	повзучість
slip casting	шлікерне лиття
to stray	відхилятися, заблудитис
sphere	сфера, шар
aqueous	водний
nozzle	насадка, патрубок, форсунка
starch	крохмаль
to synthesize, **synthesis**, n	синтезувати, синтез
monomer	мономер
thermoset	термореактивний
counterpart	двійник, аналог
velvet	оксамит, вельвет

diffusion	дифузія
integrated circuit	інтегральна схема
rocketry	ракетобудування
vacuum tube	вакуумна трубка
manual assembly	ручна збірка
scanning probe microscope (SPM)	скануючий зондовий мікроскоп
fullerene	фулерен
pig iron	чушковий чавун
blast furnace	доменна піч
ore	руда
pear-shaped	грушовидний
to tap	викачувати рідину
scrap iron	залізний брухт
resilience, n **resilient,** adj	еластичність, пружність еластичний, пружний
binder	сполучна речовина
matrix	матриця
clay	глина
china	порцеляновий, фарфоровий
brick	цегла
phenomenon, **phenomena,** pl	явище явища
duct	труба для електрокабелів і проводів
to ignite, **ignition,** n	запалювати, розжарювати до світіння запалювання, займання
flammable	горючий, легкозаймистий
to splice, e.g. cables	зрощувати, напр. кабелі
propagation	поширення
boundary	межа

to scatter	розкидати, розсіюватися