ENGLISH LANGUAGE II

-lectures and exercises-

METALLURGY AND TECHNOLOGY

4 April 2020

week 8

Dragana Čarapić, PhD

6.4 Case Study: Carbon Fiber Reinforced Polymer (CFRP)

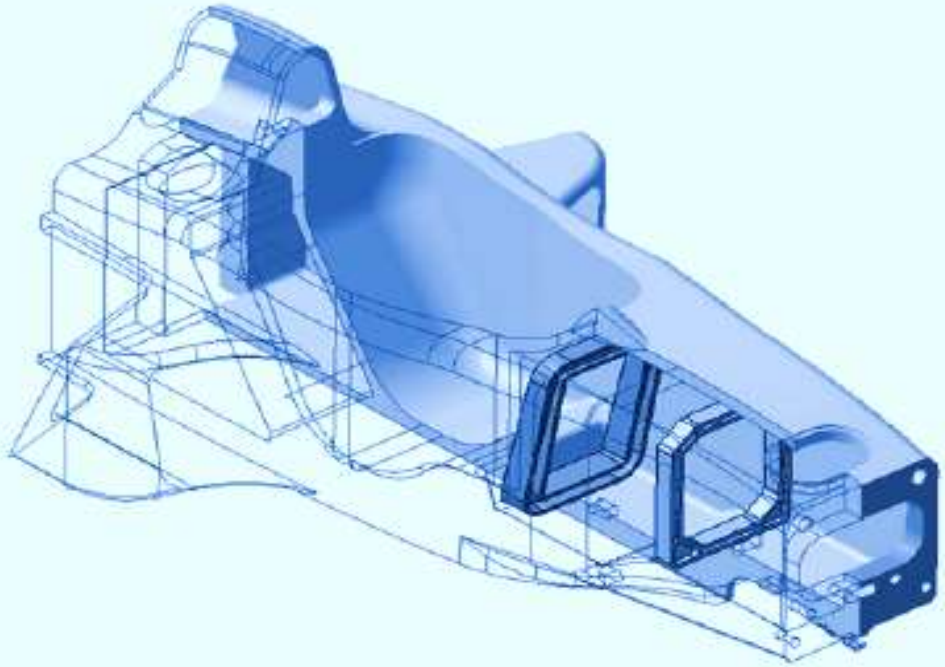

Figure 15:
Cross-section of the safety cell of a race car
[M. Trzesniowski]

This composite material is commonly referred to by the name of its reinforcing fibers, namely carbon fibers. To manufacture, e.g. body parts for race cars, carbon fibers are embedded as reinforcement into a matrix, which usually is epoxy. This is done by layering sheets of carbon fibers into a mold in the shape of the final product, the arrangement of the cloth fibers depending on the desired strength and stiffness properties of the product. The mold is then filled with epoxy and heated or air cured.

CFRP is a technologically important material. It is very strong and light-weight, non-corroding, heat-resistant, will not *ignite* and shrinks very little when exposed to high temperatures. Unfortunately, carbon fibers are expensive to manufacture.

Glossary

to ignite	to start to burn, make sth start to burn

VOCABULARY

- Embed (verb) – to make something an integral part of
- Epoxy (noun) – Incorporating such ingredients as carbon and aramid fibers, graphite, *epoxies* and ceramics, these corrosion-resistant composites could replace steel cables and concrete decks, cutting weight by as much as two-thirds.

Task 1. Work with a partner. Read the text above. Then answer the question in a few sentences. Add anything you know about the subject.

Why is CFRP used in racecar and, to some extent, mainstream car manufacturing?

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KEY

6.4 Case Study: Polymer-Matrix Composites (PMCs)

Task 1. Suggested Solution

CFRPs are applied in, e.g. racecar manufacturing for the chassis as well as other components of high-end race cars. Since low weight is essential, the material is used for its excellent strength-to-weight ratio in spite of the high cost of manufacturing carbon fibers. Recently, manufacturers have also started to use CFRP for body panels in everyday road cars because of its increased strength and decreased weight, which results in lower fuel consumption.

Chapter 7 Advanced Materials

7.1 Introduction

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 are 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.

VOCABULARY

- Chassis (noun) – the supporting frame of a structure
- Induce (verb) – to call forth or bring about by influence or stimulation

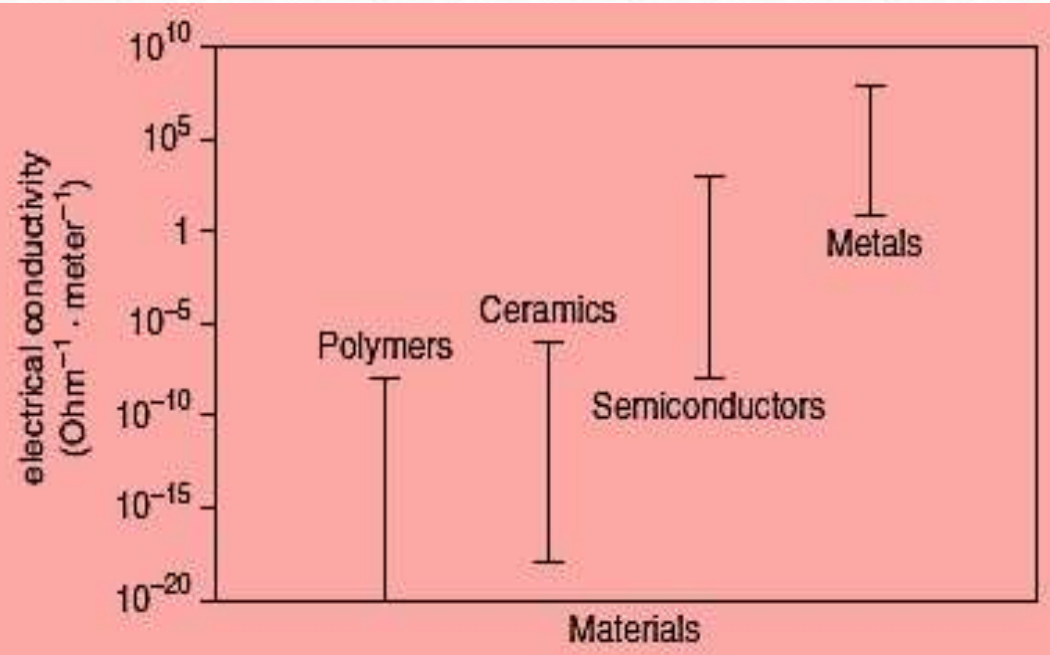

Figure 16: Room temperature electrical conductivity ranges for metals, ceramics, polymers and semi-conducting materials

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 world wide, 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."

(data from Callister, modified and abridged)

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

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VOCABULARY

- State-of-the-art (adjective) – the level of development (as of a device, procedure, process, technique, or science) reached at any particular time usually as a result of modern methods
- Versatility (noun) – the quality or state of being versatile

7.2 Semiconductors

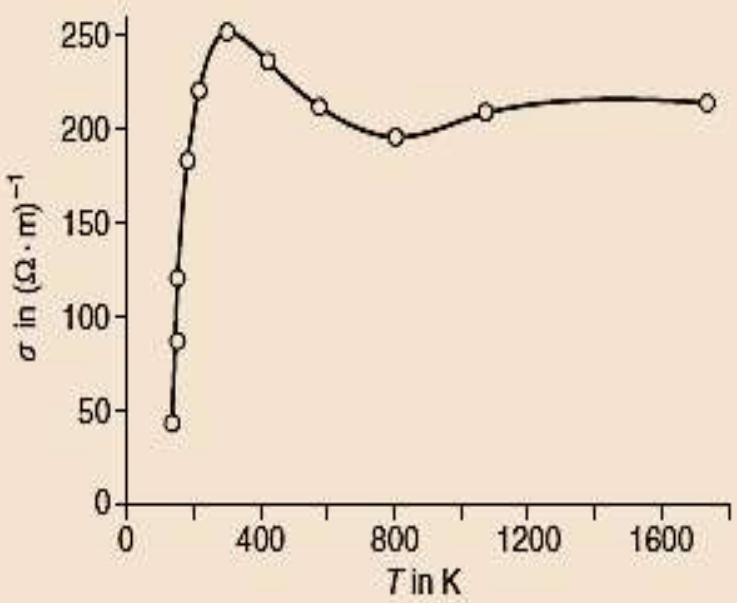

Figure 17:
Temperature dependence of electrical conductivity for semiconductors

Task 1. Fill in the names of the elements.

Semiconductors may be either elements, namely Si (.....) and Ge (.....), or covalently bonded compounds. Si is used to create most semiconductors commercially.

A semiconductor is a solid material with electrical properties that are intermediate between the electrical conductors such as metals and metal alloys and insulators, namely ceramics and polymers. The electrical characteristics of these materials are extremely sensitive to temperature and *minute* concentrations of *impurity* atoms, called doping. Depending on the type of the impurity, the impurity atom either adds an electron or creates a hole, i.e. a site where one electron is missing.

Intrinsic Semiconductors

The electrical properties are inherent in the pure material, and electron and hole carrier concentration are equal. With rising temperatures, the intrinsic electron and hole concentration increases dramatically.

Extrinsic Semiconductors

An extrinsic semiconductor has been doped, giving it different electrical properties from the intrinsic one. The electron and hole carrier concentration at thermal equilibrium has been changed. For extrinsic semiconductors, with increasing impurity dopent content, the room temperature carrier concentration increases whereas carrier mobility diminishes.

(from Callister, modified and abridged)

Glossary

minute	extremely small
impurity atoms	here atoms of a substance that are present in a different substance

VOCABULARY

- Inherent (adjective) – involved in the constitution or essential character of something **:** belonging by nature or habit **:** intrinsic
- Dope (verb) – to treat with dope or a dopant - The airfoil leading edge and ribs are fiberglass moldings, and the skin, as on early airplanes, is fabric *doped* to drum-tightness.
- Diminish (verb) – to make less or cause to appear less; lessen, decrease

Task 2. Work with a partner. Write questions that elicit the answers contained in the sentences. Different questions are possible. Practice questions and answers with a partner, then switch roles.

Which element is most often used to create semiconductors commercially?	Si is used to create most semiconductors commercially.
	Semiconductors have electrical properties that are intermediate between electrical conductors and insulators.
	The electrical characteristics of these materials are extremely sensitive to the presence of impurity atoms.
	The intrinsic electron and hole concentration increases dramatically with rising temperatures.
	Semiconductors are classified as either intrinsic or extrinsic on the basis of their electrical behavior

7.2 Semiconductors

Task 1.

Si silicon; Ge germanium

Task 2. Suggested Solutions

Do semiconductors have high electrical conductivity? Are semiconductors good electrical conductors?	Semiconductors have electrical properties that are intermediate between the electrical conductors.
What are the electrical characteristics of these materials sensitive to? What do the electrical characteristics of these materials depend on?	The electrical characteristics of these materials are sensitive to the presence of impurity atoms.
When does the intrinsic electron and hole concentration increase? What effect do rising temperatures have on hole concentration?	The intrinsic electron and hole concentration increases with rising temperatures.
How are semiconductors classified? What makes a semiconductor intrinsic or extrinsic?	Semiconductors are classified as either intrinsic or extrinsic on the basis of their electrical behavior.

7.3 Case Study: Integrated Circuits

Task 1. 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 mm^2, with up to 1 million transistors per mm^2.

KEY

- minitaturized;
- manufactured;
- electronic;
- perform;
- advancements;
- improvement;
- approach;
- consume

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

7.4 Grammar: Subordinate Clauses

Subordinate clauses are phrases that give answers to questions like Why? What … for?

Why are impurity atoms added to these materials?

Impurity atoms are added **in order to influence electrical properties.**

Expressions Introducing Subordinate Clauses

in order to/so as to + the infinitive of the verb

The properties of the material were changed in order to/so as to improve performance.

so that

The properties of the material were changed so that performance improved.

for + noun + to + infinitive

For the metal to melt, higher temperatures must be used.

Task 1. Rewrite the following sentences, using the expressions in brackets.

Scientists planned to make possible the development of integrated circuitry. That's why they introduced semiconductors. (in order to)

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The audience stayed in the lecture hall because they wanted to be able to hear the second lecture. (so that)

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Researchers added impurities, because conductivity had to be optimized. (so as to)

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Circuit breakers were installed, because one did not want the system to overload. (for … to …)

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7.4 Grammar: Subordinate Clauses

Task 1.

Scientists introduced semiconductors in order to make possible the development of integrated circuitry.

The audience stayed in the lecture hall so that they could hear the second lecture.

Researchers added impurities so as to optimize conductivity.

For the system not to overload, circuit breakers were installed.

THANK YOU FOR YOUR ATTENTION