MODULE 2

ELECTRONICS

1 *Before reading the following text, answer these questions.*

1. Do you remember the difference between active and passive electronic components?
2. Is the diode a passive or active component?
3. What is its function?

A. SOLID STATE LIGHTING

Solid state lighting applications, which use light-emitting diodes (LEDs), organic light-emitting diodes (OLEDs) or light-emitting polymers, are commonly referred to as solid-state lighting (SSL). Unlike incandescent or fluorescent lamps, which create light with filaments and gases encased in a glass bulb, solid-state lighting consists of semiconductors that convert electricity into light. LEDs have been around for nearly 50 years, but until a decade ago were used only in electronic devices as indicator lamps. In the last two decades, technological developments have allowed LEDs to be used in signal devices, like traffic lights and exit signs and in some limited illumination applications, such as flashlights. However, cutting-edge research now shows a bright future for solid-state lighting as the next generation of light sources for general illumination, from homes to commercial applications. Solid-state lighting promises to change the way we light the world, yet much work and research are still needed. Solid-state lighting is increasingly used in a variety of lighting applications because it offers many benefits, including:

- Long life – LEDs and OLEDs can provide 50,000 hours or more of life, which can reduce maintenance costs. In comparison, an incandescent light bulb lasts approximately 1,000 hours.
- Energy savings – The best commercial white LED and OLED lighting systems provide three times the luminous efficacy (lumens per watt) of incandescent lighting. Coloured LEDs are especially advantageous for coloured lighting applications because filters are not needed.
- Better quality light output – LEDs and OLED have minimum ultraviolet and infrared radiation.
- Intrinsically safe – LED OLED systems are low voltage and generally cool to the touch.
- Smaller, flexible light fixtures – The small size of LEDs and OLEDs makes them useful for lighting tight spaces and for creating unique applications.
- Durable – LEDs and OLEDs have no filament to break and can withstand vibrations.

2 *swer the following questions.*

a. What is the difference between incandescent or fluorescent lamps and solid-state lighting?
b. What were diodes used as for a long time?
c. And what have they been used for, in more recent times?
d. What can be their future applications?
e. Why can they help to in saving energy?
f. Why are they considered safer than incandescent or fluorescent lamps?
g. What is the advantage of their small size?
h. What does the absence of filaments result in?

3 *Match each term with its definition and then read the following texts about materials used in electronics.*

a.	enclosure	☐	**1.** Not easily broken or made weaker
b.	width	☐	**2.** Pressed
c.	ore	☐	**3.** Natural substance that makes something a different colour
d.	tough	☐	**4.** Very thin layer
e.	pigment	☐	**5.** Extremely small
f.	squeezed	☐	**6.** Rock or earth from which metal can be obtained
g.	tiny	☐	**7.** Distance from one side of something to the other
h.	film	☐	**8.** Something used to separate a part from the rest

B. MATERIALS

Electronic products include both circuits and enclosures. The knowledge of materials is important to be able to design and make enclosures.

PROPERTIES OF MATERIALS

The choice of a material will depend upon the properties needed by the product. For example, the enclosure for an outside alarm will need to be waterproof. A conductor will be needed if electricity has to flow through it, whereas an insulator will be chosen to avoid that.

Property needed for the enclosure	Material property needed
Does the material need to allow (or prevent) electricity from passing through it?	Electrical conductivity
Does the material need to allow heat to pass through it?	Thermal conductivity
Does the enclosure need to resist scratches and wear?	Hardness
Does the material need to be resistant to knocks and bumps?	Toughness
Does the enclosure need to be within a certain price range?	Cost
Does the enclosure have to work in an environment that could damage it?	Corrosion resistance

TYPES OF MATERIALS

Materials are grouped into **five main categories**, based on what they are made from:

- wood
- metals
- polymers
- ceramics
- composites

In addition, some new materials have been developed with properties that can react to changes in their environment. Although each of these new materials falls into one of the five types, they are often classed as a separate group called smart materials.

Wood is time consuming to process and only comes in relatively narrow widths, due to the sizes of tree trunks. Medium density fibreboard (MDF) is a manufactured board made from wood pulp which is bonded with a polymer called *urea formaldehyde*. The wood pulp is often made from the waste from cutting solid wood. It has several advantages:

- it is available in larger widths than solid wood;
- its properties can be uniform in different directions;
- it is much cheaper than solid wood.

Metal is made from metal ores, which have to be mined and processed to transform them into usable materials. It is rare for metals to be used in pure form. Normally they are mixed with other metals to improve their properties: the mixture is called an *alloy*. Most metals are good conductors. There are two main types of metal alloys: *ferrous* and *non-ferrous*. Ferrous metals contain iron. Non-ferrous metals do not contain iron. Both types of metals can be recycled.

The most common type of ferrous metal is low-carbon steel. This contains up to 0.3 percent carbon. It is stronger than most non-ferrous metals, woods and plastics. Compared to other metals, it is easy to machine, tough and cheap. However, it is prone to corrosion and rusting.

Most of the common non-ferrous metals have good corrosion resistance. These include:

- aluminium alloys: lighter than steel, but more expensive and not as strong;
- copper: one of the best electrical conductors; this is commonly used to make electrical wires.

The correct term for plastics is **polymers**. Most polymers are good insulators. Some of the stronger polymers compare favourably with metals. They are not normally painted, but their colour can be changed by adding pigments to them.

Most polymers are made from oil, which is a non-renewable resource. They are made by a chemical reaction called **polymerisation**.

There are two main types of polymer: thermosets and thermoplastics. **Thermosets** are normally made into products by moulding. Once moulded, they cannot be reshaped and they cannot be recycled.

Thermoplastics soften when heated and can be shaped when hot. The shape will harden when it is cooled, but can be reshaped when heated up again. Thermoplastics are softer and more flexible than thermosets. They can normally be recycled.

Smart materials have properties that react to changes in their environment. This means that one of their properties can be changed by an external condition, such as temperature, light, pressure or electricity. This change is reversible and can be repeated many times. There are a wide range of different smart materials. Each offers different properties that can be changed.

For most materials, if they are bent out of shape, they stay that way. However, if a part made from a **shape-memory alloy (SMA)** is bent out of shape, when it is heated above a certain temperature, it will return to its original shape.

This property makes it useful for making spectacle frames – they return to their original shape if they are put in hot water after bending them.
SMAs are used as triggers to start the sprinklers in fire alarm systems, controllers for hot water valves in showers or coffee machines and for spectacle frames.
When a **piezoelectric material** is squeezed rapidly, it produces a small electrical voltage for a moment. If a voltage is put across the material, it makes a tiny change in shape. Piezoelectric materials are being used for contact sensors for alarm systems and in microphones and headphones.
Quantum-tunnelling composite (QTC) is a flexible polymer which contains tiny metal particles. It is normally an insulator but if it is squeezed, it becomes a conductor. QTC can be used to make membrane switches like those used on mobile phones, pressure sensors and speed controllers.
Electroluminescent materials give out light when an electric current is applied to them. Among many possible applications are safety signs and clothing for use at night.
Thermochromic materials change colour as the temperature changes. These are used on contact thermometers made from plastic strips and test strips on the side of batteries (where the heat comes from a resistor under the thermochromic film). They are also used as food packaging materials that show you when the product they contain is cooked to the right temperature.
Photochromic materials change colour according to different lighting conditions. They are used for security markers that can only be seen in ultraviolet light.

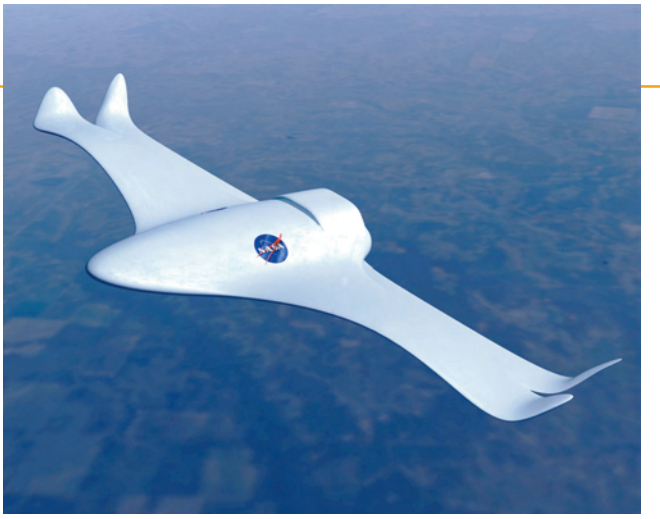
COMPARING MATERIALS

A chart like this can help to identify the possible materials to use in an application. Once the possible materials have been identified, the list of those suitable should be tested to see how well they meet the needs of the product.

Material	Conductivity	Strength	Hardness	Toughness	Weight	Corrosion resistance	Cost
Pine wood	Very poor	Medium/ low	Low	Low	Low/ medium	Poor	Low
MDF	Very poor	Low	Low	Low	Low/ medium	Poor	Low
Low-carbon steel	Very good	Very good	Good	Very good	High	Poor	Low
Stainless steel	Very good	Excellent	Very good	Very good	High	Good	High
HIPS	Very poor	Medium	Low	Good	Low	Very good	Low
Acrylic (PMMA)	Very poor	Medium	Low/ medium	Good	Low	Good	Medium
SMA	Very good	Very good	Good	Very good	Medium	Good	High

4 *Now try this test.*

1. In terms of material properties, what is a conductor?
2. What does MDF stand for?
   - **a.** Maximum-density fibreboard
   - **b.** Manufactured dense fibreboard
   - **c.** Medium-density fibreboard
3. What is meant by a smart material?
   - **a.** A material that has a property that can be changed in response to its environment
   - **b.** A material that includes a microcontroller
   - **c.** A material that will produce a protective film on its surface when it is put in a corrosive environment
4. Which property of a material describes how resistant it is to knocks and bumps?
   - **a.** Toughness
   - **b.** Strength
   - **c.** Hardness
5. Which of the following statements describes a thermoplastic polymer?
   - **a.** Once moulded it cannot normally be reshaped.
   - **b.** It softens when heated and can be shaped when hot.
   - **c.** It allows electricity to flow through itself easily but is resistant to heat
6. What type of metal alloy contains iron? _____
7. Which type of material will produce a small electrical voltage when its shape is changed rapidly?
   - **a.** Quantum tunnelling composite
   - **b.** Piezoelectric
   - **c.** Electroluminescent
8. Which material property shows how resistant it is to scratches and wear?
9. A photochromic material changes colour in response to changes in which of the following?
   - **a.** Temperature
   - **b.** Pressure
   - **c.** Light



Aircraft of the future will employ fully-integrated, embedded "smart" materials with actuators that will enable aircraft wings with unprecedented levels of aerodynamic efficiencies and aircraft control. (Artist's rendering of an aircraft of the future.)