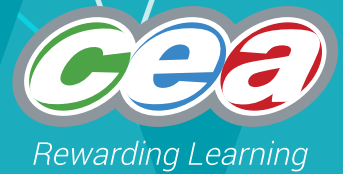


FACTFILE: GCSE

Technology and Design



UNIT: 1.2 – MATERIALS AND THEIR GENERAL PHYSICAL, AESTHETIC AND STRUCTURAL CHARACTERISTICS



Graphene

Learning Outcomes

You should be able to:

- demonstrate awareness of graphene and be able to provide some examples of its properties and potential use.

Course Content

What is Graphene?

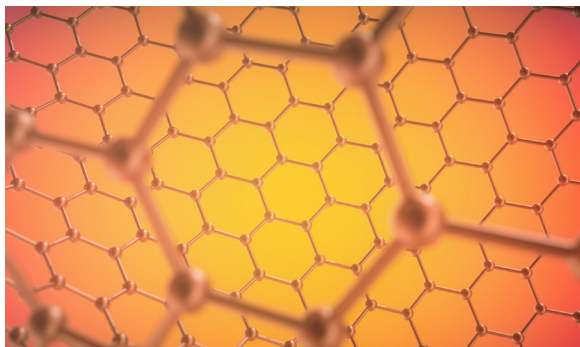


Figure 1

Graphene is a super thin layer of graphite. In more complex terms, it is an atom thick layer of carbon shaped in a honeycomb lattice (hexagons) as shown in Figure 1. It is almost invisible to the human eye but material scientists and engineers have already used graphene to enhance products such as touch screens and electronic components. Graphene enhanced composite materials have also been developed such as tennis rackets, skis and tyres.

Where does Graphene come from and how is it made?



Figure 2

Graphene comes from graphite which is basically a type of rock as shown in Figure 2. Since graphite is naturally occurring, it has always been around and there is plenty available but it was only in 2004 when scientists managed to isolate and create graphene.

Two Russian scientists working at the University of Manchester used the process of mechanical exfoliation to obtain graphite residue which simply involved peeling sticky tape off a graphite rock and analysing the residue under a microscope.

Like many newly developed materials, graphene is expensive to produce but given its game changing properties, the race is on to develop it for mass production in a cost effective way. Several multinational companies already hold graphene related patents in relation to potential applications as outlined below. Some of these products are already being produced commercially whilst others are still prototypes. Many other potential applications could however be several years if not decades away.

Properties of Graphene

Graphene is the new 'miracle material' of the 21st century. Imagine a material which is stronger than titanium, more conductive than copper, more flexible than rubber, more transparent than glass and with the hardness of a diamond. Now imagine all of these properties in a single material which is thinner than paper and you have a technology which could revolutionise practically every product we use. Here are some of the amazing facts about graphene:

- Thinnest material in the world (1 million times thinner than a human hair)
- Strongest material in the world (200 times stronger than steel)
- Most conductive material in the world (conducts electricity faster than copper or silicon)
- Most flexible material in the world (more flexible than paper, rubber and plastic)
- It is almost transparent (only absorbs about 2% of light).

Applications for Graphene

Graphene can be produced in several ways which can be quite complex to understand but it essentially acts as a scaffolding to improve the performance and efficiency of other materials. Current applications for graphene include:

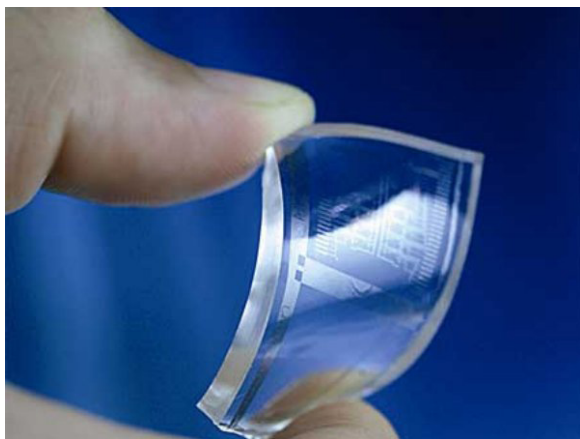


Figure 3 – Vapour Deposited Graphene

Electronics

The superior conductive properties of graphene are paving the way for huge possibilities in electronics and opto-electronics. Graphene enhanced electronics will allow for increased miniaturisation and conductivity pushing aside silicon and copper. Graphene can be deposited onto material surfaces as shown in Figure 3 which could lead to enhanced electronic products such as flexible mobile phones and other wearable technologies.



Figure 4

Sports and recreation

Many companies are creating graphene enhanced products and prototypes such as the tennis racquet shown in Figure 4. Graphene enhanced tennis racquets are lighter (especially at the handle) which allows optimisation of weight distribution. This basically means that players can generate more kinetic energy with less effort when they hit the ball.

Other sports and recreation equipment such as skis, tyres, helmets and fishing rods have been improved in a similar way.

Future applications for Graphene

Graphene in its purest two dimensional form is still many years away from mainstream use but the race is on to develop many potentially remarkable products which may include:

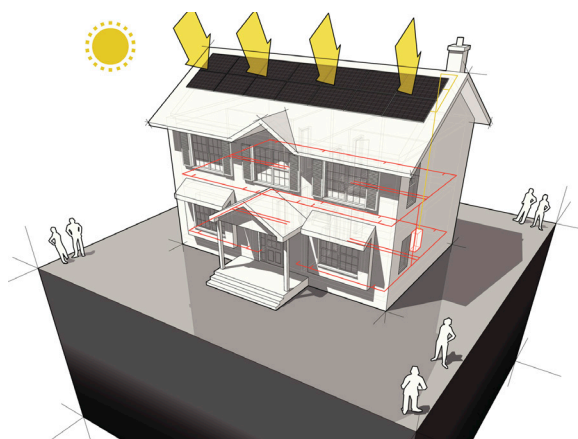


Figure 5

Battery and Solar technologies

As well as flexible electronics, graphene may also have a huge impact on the ability of solar cells to produce electricity coupled with super capacitors that could charge within seconds making batteries obsolete. This would pave the way for solar powered drones that need not land for recharging and perhaps allow homes to generate their own electricity and live off the grid as shown in Figure 5.

Graphene Composites

Graphene has the potential to give modern composites such as carbon fibre even greater mechanical strength. Paint and coatings with conductive or anti-corrosive capability is also being pioneered making graphene a huge player within military and aerospace. This could lead to a revolution in air travel making aeroplanes stronger, lighter and even faster.

Student Task

Conduct some online research into the possible impact of graphene on car technology. Write down five ways in which graphene is being trialled or could be used to improve car performance, safety, comfort etc. The following links may help.

<http://www.digitaltrends.com/cars/road-rave-how-graphene-could-revolutionize-automobiles/>

<https://www.youtube.com/watch?v=675eM-V8t08>

Revision questions

1. Outline **four** properties which make graphene so significant.

2. Identify **one** product which currently makes use of graphene and explain how this product has been improved.

3. Give **two** ways in which graphene could potentially change future homes or products found within the home.

