

# TECHNOLOGYSTUDENT

MOBILE REVISION

## SMART MATERIALS

This mobile revision pdf is based on detailed work found in the 'MATERIALS' section.

Tap on the green link button below to go to the complete website section



Tap the blue button to view all Smart Materials covered by this Revision PDF



# SMART MATERIALS

1. POLYMORPH (Some exam boards still refer to this as a Smart Material)

2. SHAPE MEMORY ALLOY (SMA)

3. HYDROCHROMIC INKS

4. THERMOCHROMIC INKS

5. PHOTOCHROMIC INK

6. HYDROMORPHIC POLYMERS

7. HYDROCARBON  
ENCAPSULATING POLYMERS

8. AROMA PIGMENTS

9. PHOSPHORESCENT PIGMENTS

10. SELF-HEALING MATERIALS

11. QUANTUM TUNNELLING  
COMPOSITE (QTC)

12. PIEZOELECTRIC MATERIALS

13. REVISION CARDS – SMART  
MATERIALS

# POLYMORPH

Polymorph is a thermoplastic material that can be shaped and reshaped any number of times. It is normally supplied as granules that look like small plastic beads. In the classroom it can be heated in hot water and when it reaches 62 degrees centigrade the granules form a mass of 'clear' material. When removed from the hot water it can be shaped into almost any form and on cooling it becomes as solid as a material such as nylon.

Although expensive, polymorph is suitable for 3D modelling as it can be shaped by hand or pressed into a shape through the use of a mould.

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for detailed information



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# POLYMORPH – SHAPING BY HAND

Tap on the image  
for detailed information

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1.



POLYMORPH  
GRANULES

2.



ADD HOT  
WATER

3.



GRANULES SLOWLY  
JOIN TOGETHER

4.



MASS OF  
POLYMORPH

5.



REMOVE  
POLYMORPH

6.



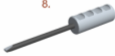
MOULD  
POLYMORPH  
GRANULES

7.



MODEL ERGONOMIC  
SCREWDRIVER HANDLE

8.



ADD SCREWDRIVER BLADE  
FOR REALISM

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page on this smart material.



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# SMART MATERIALS - POLYMORPH USING A MOULD

A mould can be made by hand by a skilled craftsman. However, CAD software can be used to design a mould and a CNC machine can then be used to cut / mill the shape.

Polymorph is a material suited to fast prototyping rather than the lengthy use of CAD software and CNC machines.

**Tap on the image** for detailed information

1.



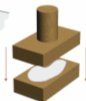
PREPARE MOULD ON CNC MACHINE

2.



PLACE POLYMORPH IN MOULD

3.



PRESS TWO PARTS OF MOULD TOGETHER

4.



POLYMORPH MOULD NEEDS TRIMMING

5.



MODEL ERGONOMIC SCREWDRIVER HANDLE

6.



ADD SCREWDRIVER BLADE FOR REALISM

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# POLYMORPH

**TAP THE LINK BUTTONS  
BELOW FOR MORE DETAIL  
ON THE MATERIAL /  
MODERN MATERIAL  
POLYMORPH**

Remember to check with your  
teacher – Your examination  
board may regard polymorph  
as a smart OR modern  
material



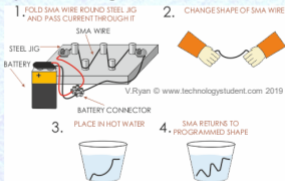
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# SHAPE MEMORY ALLOY (SMA)

SMA wire - called 'Nitinol', as it is a composed of nickel and titanium. A wire that looks like ordinary wire. It can be 'programmed' to remember a shape. This can be achieved by folding the wire to a particular shape and clamping it in position. Then heat for a approximately five minutes, at precisely 150 degrees or pass an electric current through the SMA wire. If the wire is now folded into another shape and then placed in hot water it returns to the original 'programmed' shape.

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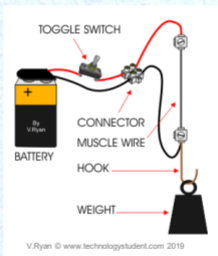


# SHAPE MEMORY ALLOY (SMA)

## MUSCLE WIRE

Muscle wire is also a nickel and titanium alloy. At room temperature it can be stretched by a small force. However, when a small current is passed through the wire it returns to a much harder form and to its original length with a reasonable force.

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# SHAPE MEMORY ALLOY (SMA)

**TAP THE LINK BUTTONS  
BELOW FOR MORE DETAIL  
ON SHAPE MEMORY  
ALLOYS (SMA)**



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## INKS THAT CHANGE AFTER CONTACT WITH WATER (HYDROCHROMIC INKS)

Another group of inks are those that change when they make contact with water. These are called hydrochromic inks. A possible application of this type of ink is a gardeners moisture tester.

A plastic moisture tester is pushed into the soil alongside the plant. If the water content of the soil is at the right level, the colour of the moisture tested should remain blue.

However, if the soil loses too much water then the colour changes to yellow. If too much water is added to the soil then the colour changes to red.



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# INKS THAT CHANGE WITH TEMPERATURE (THERMOCHROMIC INKS)

Colour changing inks were introduced during the 1970s with novelty items such as cups that change colour when hot liquids such as coffee or tea are poured in to them.

The cup below is empty and so the colour of the cartoon's nose remains the same.

The cup below is full of hot tea and the colour of the cartoon's nose has changed from grey to red.

**Tap on the images** for detailed information



**COLD**



**HOT**

Tap the red button to return to the Contents page



## INKS THAT CHANGE WITH THE LEVEL OF LIGHT (PHOTOCHROMIC INK)

Photochromic ink darkens, as the light level increases. Some photochromic inks change colour. In fact, it is UV light that causes the darkening of the ink, which means the ink works best in natural light. This special ink has two main applications; sunglasses and spectacles. However, it is also used in novelty items such as embroidery thread and toys, where colour change takes place according to light level. Nail lacquer / varnish is also available with photochromic technology.

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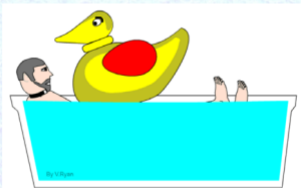


## POLYMERS THAT EXPAND/ CONTRACT ON CONTACT WITH WATER (HYDROMORPHIC POLYMERS)

These are polymers that expand and contract on contact with water. This smart material is sometimes used in toys that can expand up to five times their original size, such as bath toys.

The toy duck, shown below, has been manufactured from a hydromorphic polymer.

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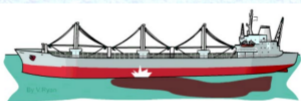
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# POLYMERS THAT ABSORB OIL (HYDROCARBON ENCAPSULATING POLYMERS)

These are polymers that absorb oil, forming a rubbery substance. This has a potential application for the prevention of oil slicks, at sea. They are environmentally 'friendly' products, developed to manage hydrocarbon-based liquid spills

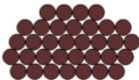
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HC POLYMER WITH  
ABSORBED CRUDE OIL

HC POLYMER



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## INK/PAINTS THAT PRODUCE AN AROMA WHEN SCRATCHED (AROMA PIGMENTS)

These are inks / paints that produce an aroma when scratched. They are popular in 'scratch and sniff' products, such as perfume samples etched into magazines.

The reader scratches the sample aroma pigment, releasing an aroma matching the selected perfume.

**Tap on the image** for detailed information



The greetings card (a Christmas Card), has been printed with aroma pigment. When the popup tree is scratched, it emits the scent of pine trees.

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# PIGMENTS THAT ABSORB THE ENERGY OF LIGHT AND RELEASE IT LATER (PHOSPHORESCENT PIGMENTS)

Phosphorescence is a process whereby energy from the sun is absorbed by a 'material' and it is released slowly over a long time, in the form of light. A good example is a 'luminous' watch. Even the most basic watch will absorb the sun's energy, during daylight hours and artificial light from a lamp. At night, the stored energy is slowly released.

**Tap on the image** for detailed information



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## WHAT ARE SELF-HEALING MATERIALS?

This is a category of smart materials and are materials that are designed to be self-healing. They have been developed to repair damage to their micro-structure. This is why some of these materials are called 'smart structures'. One obvious advantage, is that human intervention is not required. Self-healing materials also reduce the number of diagnostic checks required by a skilled technician or computer controlled sensors. The ability of a material to self-heal, extends its useful, working life time.

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# SELF-HEALING - POLYMERS AND ELASTOMERS

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The diagram below, shows the process of self-healing, by some polymers and elastomers.

Self-healing polymer coating can be applied to metals, as a spray. In the event of corrosion occurring on the metals surface, corrosion inhibitors are released in the area affected, from micro-capsules. This can occur at a nano level.

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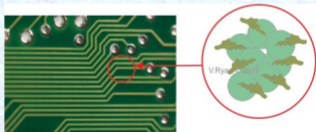


# SELF-HEALING - POLYMERS AND ELASTOMERS

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In a circuit, if the copper track is damaged at a micro level, this prevents electrical conduction. The polymer coating releases 'Intrinsically Conducting Polymer' (ICP), from micro-capsules. This 'heals' the copper track, allowing electricity to be conducted.

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# SELF-HEALING CONCRETE

Self-healing concrete (also called bio-concrete), is a material that heals itself, if cracks or minor damage occurs.

How it works: When the concrete 'cracks', water enters the crack and reacts with bacteria, which is found in the limestone, one of the constituent parts of concrete. The reaction results in the formation of more limestone, repairing the crack.

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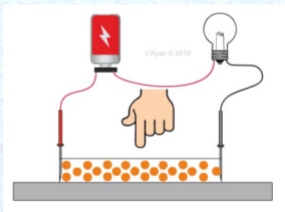


# QUANTUM TUNNELLING COMPOSITE (QTC)

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Quantum Tunnelling Composite (QTC), is, composed of a insulating material (a polymer) and particles of a conducting material. When pressure is applied, the conducting particles are pressed together, allowing electricity to flow through them. The electrical current is said to be able to, 'tunnel' through the non-conductive material.

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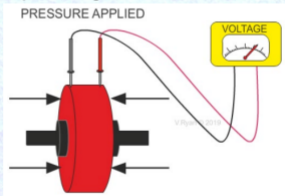
# PIEZOELECTRIC MATERIALS

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When pressure is applied to a Piezoelectric material, it produces an electrical charge.

Piezoelectric materials include naturally formed crystals (quartz), synthetic crystals, piezoelectric polymers, bone, ceramics and some proteins. If an electric charge is put through a piezoelectric material, it will change shape slightly, called 'converse piezoelectric effect'..

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# SMART MATERIALS REVISION CARDS

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Cards



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