2 3 1 g Smart materials

Preparation

- Read pages 43 - 45

Resources

Electronic scales, slotted masses, polymorph, beaker, spatula, gloves, kettle, car parking barrier model, thermochromic liquid crystal displays, greetings card

Wider study

- Polymorph 1 http://www.technologystudent.com/equip1/poly1.htm
- Polymorph 2 http://www.technologystudent.com/equip1/poly2.htm
- Shape Memory Alloys (SMA) 1
  http://www.technologystudent.com/equip1/sma1.htm
- Shape Memory Alloys (SMA) 2
  http://www.technologystudent.com/equip1/sma2.htm
- Thermochromic liquid crystal display manufacturer
  http://www.hallcrest.com/bmbaby.cfm
- Wikipedia Piezoelectric crystal technology
  http://en.wikipedia.org/wiki/Piezoelectric_sensor
- Wikipedia Radio Frequency Identification technology
  http://en.wikipedia.org/wiki/RFID
- RFID company Airport baggage handling
  http://www.lyngsoesystems.com/airport/rfid_baggage.asp

Assignment

- Look around the world about you for examples of products made from these materials, eg refrigerator thermometers, greetings cards
- Keep up to date with the news about radio frequency identification

Homework

- As above

Revision questions

1. Explain how Smart materials have led to improved aesthetic and functional characteristics:
2. Explain the term ‘smart’ material
3. Explain characteristics and uses of, any TWO of the following SMART materials:
   piezo electric actuators
   shape memory alloys
4. New materials and new technology influence the design and manufacture of modern products. Identify a smart material and describe how it is used in a named product**.**

Specification and Learning Objectives

Structural composition, application and advantages/ disadvantages of the following smart materials used by the graphics industry:

- thermochromic liquid crystal displays
- piezoelectric crystals
- smart ink
- radio-frequency identification (RFID)

Solutions to revision questions

Next page

4. **Explain how Smart materials have led to Improved aesthetic and functional characteristics**:

Brief description of new material AND general reason for use, eg:

- carbon fibres used in car bodies/boat hulls,
- thermochromic liquid crystals used in thermometers
- phosphorescent pigments used in displays
- Kevlar used in body armour
- piezo-electric transducers used in musical greetings cards

OR brief description of new process AND general reason for use, eg:

- coating, laminating, fusion, micro-encapsulation, biostoning, biopolishing, laser cutting, digital printing
- Improved aesthetic characteristics, e.g. look, shape, colour, pattern, texture, drape, handle, weight, styling due to the new material, process with reference to the product example. Improvements in purpose, performance, function with reference to the product example.

Brief description of appropriate new material OR process and general reason for use x 2 marks PLUS
Example of improved characteristics in product – 1 mark for each point x 4
Note: SMART materials might be referred to as NEW materials on the examination paper.

2 Explain the term 'smart' material

- wide range of materials whose physical properties can be varied by an input
- stating an input would be another mark, e.g heat, light, sound, electricity, temperature, pressure
- material(s) that have a control capacity e.g. microprocessors
- these materials are used to replace devices that had sensing or actuating components / can detect a change e.g strain or temperature
- a single 'smart' material can reduce the overall size and complexity of certain devices
- 'Smart' materials can be divided into groups:
- Piezo-electrics
- Shape memory alloys / shape memory plastics

3 **Explain <u>characteristics</u> and <u>uses</u> of, any TWO of the following SMART materials:**

piezo electric actuators
shape memory alloys

piezo electric actuators

Characteristics

- produce movement in response to an applied voltage, or,
- produce a voltage in response to an applied pressure / they react to pressure
- the voltage is generated as a result of the material being 'deformed'
- the deformation is sufficient to light an LED
- p.e. transducers are capable of picking up small signals
- these can then be amplified / processed
- transducers are made form minerals / ceramics / polymers
- emits sound

Uses

- play tunes in greeting cards
- produce a sound from an electrical signal (when card is opened)
- input transducers (which respond to sound or pressure) used in burglar alarms
- p.e. transducers are used as sensors
- digital cameras
- a relevant example of component movement

shape memory alloys

Characteristics

- they appear to have a memory
- can be plastically deformed at certain temperatures/ react to changes in temp / change shape at higher (lower) temp.
- will retain their shape when held at this temp.
- revert to original shape when temp. is removed
- the heat change is usually provided by passing an electric current through the material
- these materials have a relatively high electrical resistance

Uses

- greenhouse window openers
- thermally activated fasteners for use as electrical cable
- fasteners and hydraulic pipe connectors

Table 2. Current examples of applications of shape memory alloys

Aids for disabled micro actuators
Aircraft flap/slat adjustors mobile phone antennas
Anti scaled devices orthodontic archwires
Arterial clips penile implant
Automotive thermostats pipe couplings
Braille print punch robot actuators
Catheter guide wires rock splitting
Cold start vehicle actuators root canal drills
Contraceptive devices satellite antenna deployment
Electrical circuit breakers scoliosos correction
Fibre optic coupling solar actuators

Filter struts spectacle frames
Fire dampers steam valves
Fire sprinklers stents
Gas discharge switch vibration damper
Graft stents thermostats
Intraocular lens mount underwired bras
Kettle switches vibration dampers
Keyhole instruments ZIF connectors
Key hole surgery instruments

4 New materials and new technology influence the design and manufacture of modern products. Identify a smart material and describe how it is used in a named product.

Piezo-electric actuators
Produces sound
Greetings cards
Shape memory alloys
Change shape at specified temperatures
Open greenhouse windows when it is hot
Polymorph
Soft/pliable at 62C, used for modelling/prototyping, used for moulds, vacuum forming moulds, joining components together

- Torches
- Armatures/ frames for models, inserts for compliant products
- Motor mountings

Smart wire
Electric current makes it contract – pulling force
Locks, small robots
Smart links
Ultra-hard silicon tube flexible joint – transmits rotary movement
Universal joint, flexible hinge, coupling
Smart grease
Sticky lubricant motion control gel – transforms behaviour of mechanism. Turns very slowly at uniform speed to provide stored energy
Between wheel and bearing of simple motor
Light emitting plastics (LEPs)
Low voltage applied to polymers to emit red, blue, green light
Hoarding, safety signage, mobile phones, CD players, TV/computer monitors
Smart ceramic
Re-emits absorbed light and energy
Watches, emergency signs, torches
Thermochromic materials
Microscopic liquid crystal capsules change colour at specified temperatures Alter colour ins response to change in environment

- Kettles, feeding spoons, thermometers, battery test strips

- Clothing that changes colour when hot/cold
- Signalling textiles
- Military camouflage

Fabrics that provide micro-climate around skin e.g. Gore-Tex, CoolMax
Engineered to be breathable, waterproof, windproof

- Sportswear, outdoor clothing
- Military, protective wear
- Tents, awnings
- Bags, shoes

Biomimetics, e.g. Fastskin, Stomatex
Automatic textile functions that mimic nature e.g. shark's skin, leaf

- Active sportswear
- Medical textiles

Phase change materials (PCMs) e.g. Outlast
Temperature regulation – absorbs body heat to keep cool / gives heat back to body when cold

- Space clothing
- Protective survival clothing
- Shoes

Microencapsulated fabric
Well-being factors, e.g. perfume / vitamins / anti-bac / anti-allergy microcapsules released through movement

- Underwear, socks
- Medical products
- Bed linen

Wearable electronics
Micro-electronics embedded in fabric incorporating mobile phone / computer / GPS / sensors to monitor body function

- Sportswear
- Medical products
- Childrens' jackets