Smart Materials

Smart materials are those that change in response to changing conditions in their surroundings or in the application of other directed influences - such as passing an electric charge through them. Modern products increasingly use them as imaginative designers see the potential they offer. Shirts that **change colour** with changes in temperature and thermometers that are in the from of printed strips use thermo chromic inks whilst Photo chromic inks respond to changes in light conditions. Clothing also uses inks that have this characteristic and have patterns that change with altering light conditions.
Materials that respond to an electric current might be used as component parts of safety valves or as a part of a functional system that uses the change in shape with current to trigger some other process. These are 'shape memory alloys' (SMA).
Thermoelectric materials again use current but change temperature - in this way cooling or heating can take place and this effect is being used to design innovative.
"Smart" materials respond to environmental stimuli with particular changes in some variables. For that reason they are often also called responsive materials.
Depending on changes in some external conditions, "smart" materials change either their properties (mechanical, electrical, appearance), their structure or composition, or their functions.
Mostly, "smart" materials are embedded in systems whose inherent properties can be favourably changed to meet performance needs.

Photo chromic materials

Photo-chromic materials change reversibly colour with changes in light intensity. Usually, they are colourless in a dark place, and when sunlight or ultraviolet radiation is applied molecular structure of the material changes and it exhibits colour. When the relevant light source is removed the colour disappears.
Changes from one colour to another colour are possible mixing photo-chromic colours with base colours. They are used in paints, inks, and mixed to mould or casting materials for different applications.

Thermo-chromic materials

Thermo-chromic materials change reversibly colour with changes in temperature. They can be made as semi-conductor compounds, from liquid crystals or using metal compounds. The change in colour happens at a determined temperature, which can be varied doping the material.
They are used to make paints, inks or are mixed to moulding or casting materials for different applications.
This T-shirt uses thermo-chromic inks for decoration purposes. An increase in temperature produces a reversible change in colour.



The heat from direct sunlight is enough to produce the change. Also spoons to feed babies change colour according to the temperature of the food. A kettle can also change colour when the water inside it is hot.

Electroluminescent materials

Electroluminescent materials produce a brilliant light of different colours when stimulated electronically (e.g. by AC current). While emitting light no heat is produced. Like a capacitor the materials is made from an insulating substance with electrodes on each side. One of the electrodes is transparent and allows the light to pass. The insulating substance that emits the light can be made of zinc sulphide or a combination. They can be used for making light stripes for decorating buildings, or for industrial and public vehicles safety precautions.

Posters to advertise products can also use electroluminescent materials to allow them to light up and advertise a product. This iPod poster does exactly that.

Fluorescent materials

Fluorescent materials produce visible or invisible light as a result of an incident light of a shorter wavelength (i.e. X-rays, UV-rays, etc.). The effect ceases as soon as the source of excitement is removed.

Fluorescent pigments in daylight have a white or light colour, whereas under excitation by UV radiation they irradiate an intensive fluorescent colour. They can be used for paints, inks or mixed to moulding or casting materials for different applications. Trainers and motorcycle helmets use fluorescent matwerials that glow in the dark.

Phosphorescent or afterglow materials

Phosphorescent or afterglow materials produce visible or invisible light as a result of incident light of a shorter wavelength (i.e. X-rays, UV-rays, etc.), detectable only after the source of the excitement has been removed.
Afterglow effect pigments are polycrystalline inorganic zinc sulphide (green afterglow) or alkaline earth sulphides (red or blue afterglow), and can be used in paints, inks or mixed to moulding or casting materials for different applications. Game controllers and lighting uses these materials to glow in the dark.
This effect can be obtained mixing phosphorescent pigments based on alkaline earth sulphides to the plastics during the moulding process.

Conducting polymers

Conducting polymers are conjugated polymers, namely organic compounds that have an extended p-orbital system, through which electrons can move from one end of the polymer to the other. The most common are polyaniline (PAni) and polypyrrole (PPY). Polipyrrole has been used for the development of micro muscles. Polyaniline films sandwiched around an ion-conducting film are considered as material for artificial muscles for robots. A current flow reduces one side and oxidises the other. Ions are transferred. One side expands and the other contracts, resulting in a bending of the sandwich. Electrical and chemical energies are so transformed in mechanical energy.

Piezoelectric materials

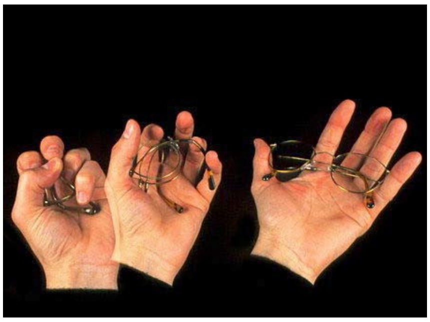
They produce an electric field when exposed to a change in dimension caused by an imposed mechanical force (piezoelectric or generator effect). Conversely, an applied electric field will produce a mechanical stress (electrostrictive or motor effect). They transform energy from mechanical to electrical and vice-versa. The stress is very small, 0.1-0.3%. They are used for sensing purposes (e.g. microphone, transducer), and for actuating applications. Similar to piezoelectric materials are electrostrictive and magnetostrictive materials used in high precision actuation. They are ferromagnetic materials, which experience an elastic strain when subjected to an electric or magnetic field respectively.

Polymer gels

Polymer gels consist of a cross-linked polymer network inflated with a solvent such as water. They have the ability to reversibly swell or shrink (up to 1000 times in volume) due to small changes in their environment (pH, temperature, electric field). Micro sized gel fibres contract in milliseconds, while thick polymers layers require minutes to react (up to 2 hours or even days). They have high strength and can deliver sizeable stress (approximately equal to that of human muscles). The most common are polyvinyl alcohol (PVA), polyacrylicacid (PAA) and polyacrylonitrile (PAN). Many potential applications (e.g. artificial muscles, robot actuators, absorbers of toxic chemicals), but presently, few of them have a commercial diffusion.
Examples of uses are in bike seats so that they alter their shape to fit the user. Mobile phone cases are also manufactured using polymer gels to protect the mobile phone. They can be manufactured in a range of colours if dyes are added to them when they are made.

Shape-Memory Alloys

Shape-Memory Alloys are metals that, after being strained, at a certain temperature revert back to their original shape. A change in their crystal structure above their transformation temperature causes them to return to their original shape. SMAs enable large forces (generated when encountering any resistance during their transformation) and large movements actuation, as they can recover large strains.



The new future iPhone is rumoured to use shape memory alloys to manufacture the phone screen and case as a part of a new phone design that allows the screen to collapse and fold inside the casing.
This unique light design is manufactured from a shape memory alloy. This allows the light to change its shape every time it is switched on and off.
Spectacles are also manufactured from a shape memory alloy. This allows the frames to keep their shape. If deformed they will spring back into their original shape.