schools affiliate scheme

CONNECTING TEACHERS TO THE WORLD OF MATERIALS, MINERALS AND MINING

news

Issue 35

Summer Term 2010

In this issue:

We're on the final straight for this year!

By the time you read this I will be a very proud, but sleep deprived mother of two! I won't be away from my desk for long though and am planning to be back in early June, albeit working part-time and not going out and about.

Over the last twelve months I know many members have experienced difficulties in booking visits as we have been short of staff and my maternity leave hasn't helped. However, from the autumn you should find it much easier to get a date in the diary as I am in the process of setting up a Scheme in which Institute members will be trained to deliver curriculum-related sessions in member schools and colleges. This should ensure that you have access to the same presentations, given to the same high standard with the same samples where ever in the country you are located. Please do bear with us while the new system gets up and running but hopefully this should be of benefit to all concerned. You can find out more on page 6.

Also in this issue you can find the dates and venues for this year's Autumn Open Day Programme. I am pleased to announce that we have another new venue on board this year – Edinburgh Napier University – so those of you north of the border will be able to participate more easily. There is also a reminder about the Nanotechnology conference on 13 October on page 2.

Finally, as ever, if you have any questions or comments regarding the Scheme please do get in touch. It is only by getting your feedback that we can tailor our resources, presentations etc. to your needs so give us a bell if you have something to say!

IoM3 The Institute of Materials, Minerals and Mining

This newsletter is written and edited by Dr Diane Aston, Education Co-ordinator. If you have any comments or articles please contact Diane by emailing Diane.Aston@iom3.org or write to her at The Institute of Materials, Minerals and Mining, Grantham Regional Centre, The Boilerhouse, Springfield Business Park, Caunt Road, Grantham, Lincolnshire, NG31 7FZ

Proposed programme

0915 Registration
0945 Welcome
1000 Plenary lecture
1100 Processing
1145 Nanotech in medicine
1230 Nanotech in electronics
1315 Lunch
1400 Nanotech in construction
1415 Open Q&A session
1445 IOM3 school support
1500 Tea
1515 Ideas for the classroom
1615 Feedback and close

The Venue

The Boilerhouse is located in Grantham, Lincolnshire and is only a couple of miles from the A1 with ample free parking available on site. Grantham is also on the east coast main line from London to Edinburgh and the venue is a short walk or taxi ride from the station.

Registration

This event is ***FREE OF CHARGE*** for ***any*** teacher at a school that is a member of our Schools Affiliate Scheme to attend. Non-members can join the Scheme for an annual fee of £30 and attend for free, or pay a £50 non-member delegate fee. The event has been designed to link in with the science curriculum, though it will also be of general interest to teachers from other departments. If you are unable to attend, please tell colleagues, both from your department and others, as they might be interested in coming along.

Nanotechnology – small world, big ideas

A conference for teachers on 13 October 2010

You should have received information and a registration form for this event in with your spring newsletter however, I thought that given that there is still plenty of time to get involved it might be worth a quick reminder. You can also get full details at http://www.iom3.org/events/nanotechnology-small-world-big-ideas.

The aim of this event is to give you an insight in to the field of nanotechnology with information on current and future applications of materials on the nanoscale, processing nanomaterials and the risks associated with handling and using them. Hopefully this will allow you to teach this upcoming area more knowledgeably and confidently!

The conference will be a full day event featuring technical presentations from experts in the field and ideas to improve your teaching of this topic in the classroom.

The plenary lecture will be given by Professor Alan Smith, a leading expert in the field who has given lectures on nanotechnology to a wide range of audiences all over the world. We are very pleased that he is able to attend and speak at this event. His presentation will give an overview to the topic before the other speakers look at more specific aspects. We hope the day will finish at 1630 at the latest and would encourage delegates to make their travel arrangements with this in mind.

Did you know?

Nanotechnology is nothing new! Nature has been using the nanoscale properties of materials for millennia and many plants and animals have evolved to make the best use of these materials.

- The gecko is able run upside down because it has millions of nanoscale hairs on the end of each toe. These are individually attracted to the surface by Van der Waals forces and when combined they produce an incredibly strong hold. A gecko could carry 200 times its own weight and still hang upside down.

- The Stenocara beetle from the Namib Desert does not waste a drop of precious water. Most of its body is covered in a superhydrophobic layer which channels any water droplets directly in to its mouth.

AUTUMN OPEN DAY PROGRAMME 2010

This year a record number of venues have agreed to take part in the Autumn Open Day Programme giving you even more choice over date and venue.

These events have been designed to support the teaching of the materials topics in the A-level (or equivalent) physics, chemistry and design technology curriculum and generally run for two to three hours in the morning or afternoon.

This year events will be taking place at the following:

Venue	Max numbers	Dates and times available
University of Birmingham	30	
Cambridge University	32	
Edinburgh Napier University	40	03/11, 24/11 1230 to 1530
University of Exeter	40	03/11, 10/11, 17/11, 24/11 Afternoon tba with school
Imperial College	20	03/11, 10/11, 17/11, 24/11 1230 to 1600
University of Leeds	40	03/11, 10/11, 17/11, 24/11 1230 to 1600
University of Liverpool	30	03/11, 17/11 Afternoon tba with school
Loughborough University	15	02/11, 04/11 1300 to 1530
University of Manchester	30	03/11, 10/11, 17/11, 24/11 1400 to 1600
University of Newcastle	30	
University of Oxford	20	18/11, 25/11 1000 to 1230
Queen Mary (University of London)	30	
University of Sheffield	20	03/11, 10/11, 17/11 1000 to 1200 or 1400 to 1600
University of Wales, Swansea	20	03/11, 10/11 1300 to 1600

If you would like to register to take a group of students along to one of these events please return a completed registration form (available on the back of the A5 flyer included with this newsletter) as soon as possible as many venues are very popular and book up by return of post.

For more information and the latest list of available dates please contact diane.aston@iom3.org

Typical activities

The exact nature of the activities varies from venue to venue, but they are all designed to give students a greater insight into the world of materials and link in with the curriculum.

Typical activities include:

- Mechanical testing. Tensile testing and impact testing of a range of materials to look at how properties are related to structure.
- Optical and electron microscopy. Students will be able to view materials on a range of scales.
- General introductory lecture on materials and their uses.
- Special sessions on biomaterials, smart materials, nanomaterials, magnets and forensics.

If you would like to know more about the activities at a specific venue please get in touch.

These events are free of charge for you and your students to attend; you just need to make your own arrangements to get to and from the venue.

Curious about Copper

At a recent MADE event here at The Boilerhouse, I was made aware of a new resource on copper that I thought was rather good and might be of interest to you.

This booklet, which is also available on-line is called Curious about Copper (which I thought was a great play on words!) and it covers a whole range of difference aspects of this very useful metal. It features information on:

Copper and sustainability: Copper has been used by Man for over 10,000 years but recently there has been an increased emphasis on the environmental impact of mining copper, and the ways in which copper can be reused and recycled.

Copper and electricity: The main use of copper is as an electrical conductor. It is used in the electronics industry for wires, cabling and contacts, it is coated with enamel and used for the windings of motors and transformers and it is used in computer networks for carrying signals.

Copper around the home: Copper tubing and piping is used around the home in plumbing systems for heating and water supply. Alloys of copper, such as brass, are also extensively used in domestic applications.

Copper in transport: Copper and copper alloys are used in all forms of transport. It has a long tradition of being used in marine applications as it does not readily corrode in sea water. Copper is used in electrical applications in aircraft and trains and an electrically powered car will typically contain up to 33 kilograms of copper in the motor, battery and wiring.

Copper for life: Copper is an essential trace element for all higher forms of plant and animal life where it helps with a number of functions. In farming copper-based chemicals are used as fungicides and supplements are added to livestock feed to promote healthy growth. Copper is naturally antimicrobial and it has been found to render viruses such as flu inactive in a very short time.

Copper for leisure: Copper is a ductile, malleable, lustrous sonorous metal and is has been used (mainly in alloy form) for centuries for making musical instruments and for decorative architecture and jewellery.

You can obtain this resource and a number of others directly from the Copper Development Agency's website: http://www.copperinfo.co.uk/

What is MADE?

The Materials and Design Exchange was set up a few years ago to bring together materials scientists and engineers and designers. Its partners are IOM3, the Royal College of Art, the Design Council, the Institute of Engineering Designers and the Engineering Employers Federation and it is just one node of the Materials Knowledge Transfer Network.

In addition to producing a fascinating magazine three times a year MADE also organises conferences on a range of topics which would be of particular interest to Design and Technology teachers. Previous events include Recycling Christmas and Biomimetics – nature did it first.

An event entitled 'Design Bugs Out' was held here last week and I have about 20 copies of the conference literature to give away. This features some really neat design ideas and shows how materials and design have been used to solve issues in the medical industry. If you would like to receive your free copy please email diane.aston@iom3,org with **Design Bugs Out** in the subject line. There are only a limited number of copies and these will be allocated on a first come first served basis!

Registering to become part of MADE is free of charge and you can sign up at www.made.uk.net.

Materials Master Class for Teachers

Once again this year Rolls-Royce, in conjunction with the University of Birmingham and sponsored by the Armourers and Brasiers Company, will be running a Materials Masterclass for teachers.

The course is run in two parts: the first takes place in the Materials department at the University of Birmingham will be on 15 and 16 July and the second at Rolls-Royce in Derby on 06 October.

The Master Class is designed to support curriculum delivery in science and technology but may also be relevant to those teaching engineering courses. It draws on the areas of materials science in which Rolls-Royce has experience and can demonstrate examples of applications. It offers an extension to your personal knowledge in the field as well as resources and ideas to take back to the classroom.

An outline of the activities on each part of the course is given below:

15 July	16 July	06 October
Structure of crystalline materials	Materials in aerospace	Technology exhibition
Structure of polymers	Magnetic materials	Tour of production build line
Impact testing	Shape memory alloys	Heritage exhibition
Sports materials	Electron microscopy	Non-destructive testing
Piezoelectric materials		Materials testing
Courses and careers in materials		Failure investigation

Previous delegates said:

"An excellent course" "Excellent, very enjoyable and worthwhile"

"A relaxed, friendly and informative course and one which I shall remember"

"Friendly staff who gave good answers to any questions"

Places on this course are limited and there is a small delegate fee of £30 to contribute towards the cost of all meals and accommodation. For more information or to book a place please contact Erica Tyson by emailing Erica.tyson@rolls-royce.com.

The Science of Materials Summer School

This popular residential summer school, run in conjunction between the Institute of Materials, Minerals and Mining, the Royal Society of Chemistry and the Worshipful Company of Armourers and Brasiers will be running again this year from 04 to 07 July.

The course will be based at Imperial College but will also feature sessions at London Metropolitan University and Queen Mary, University of London and special visits to a number of museums. It will enable teachers to provide support, help and advice to students on all aspects of Materials Science through lectures and seminars, practical experiments, discussions and visits. Themes on the course include biomaterials, fuel cells and polymers. On the Wednesday evening there will be a formal course dinner at the spectacular Armourers Hall. Attendance on this excellent course costs £125 for IOM3 or RSC members and £250 for non- members, and this is heavily subsidised (prices quoted are excluding VAT). This fee includes all meals and accommodation during the course.

For more information please contact Joanne O'Meara at the Royal Society of Chemistry by emailing OMearaj@rsc.org or telephoning 01223 432221.

SAS page

Visit diary

Following a very hectic spring term for both Toby and myself, the summer term is a bit quieter. Owing to the fact that I will have just returned to work after having a baby, I will not be doing any visits during the summer term, but Toby will be out on the road and visiting the following:

April		June	
21-22	East Midlands UCAS convention	25	All Hallows Catholic High School
27	Plymouth High School for Girls	29	Stockton Sixth Form College
May		**July**	
05	Chantry High School	07	Altrincham Grammar School for Boys
06	Hagley Catholic School	19-20	Smallpeice Mining course – Camborne School of Mines
28	St Andrews Chemistry teachers meeting	21	Salters Chemistry Camp, Manchester
Visit by Toby White			

There are a limited number of dates remaining for the summer term. To obtain these or book for the Autumn Term please contact Sarah Harrison by emailing sarah.harrison@iom3.org.

Schools and Colleges Ambassadors Scheme

Over the past few years we have been acutely aware that as the number of SAS members has grown it has become increasingly difficult to fulfil all the requests for visits that come in. I know this has caused some of you great disappointment, but hopefully from now on you will find it much easier to get in the diary and have someone visit your school.

Over the next few months we will be recruiting and training a group of Schools and Colleges Ambassadors. They will be located regionally and there will be initially be up to three Ambassadors per region, making it much easier for you to get a date. The Ambassadors will be enthusiastic communicators with an extensive understanding of the fields of materials engineering or minerals and mining engineering/geology so you will still have the expertise to draw on. We also hope that many of these Ambassadors will be in the early stages of their careers so they will be good role models for your students too.

A bonus to this Scheme is that you will also have the opportunity to build better links with the universities and companies where the Ambassadors are based and our network of local societies, as members of these will act as mentors to the Ambassadors.

The booking diary for the 2010-2011 year is now open, so if you would like to book a visit I would strongly suggest that you book as soon as you have your new timetable to secure your slot. This will also make it easier for us to identify where geographically visits are required.

New for 2010-2011

To coincide with our Autumn Term conference on Nanotechnology I have written a new presentation on this subject which our new Ambassadors will be trained to deliver. This talk will be available from September and links in nicely with the science curriculum, but will also be of more general interest too.

The presentation introduces the concept of nanotechnology and how the properties of materials are different on this very small scale. It covers nanomaterials that have evolved in nature over many millions of year and also some of the applications of this field that have been around for some time, such as nanoparticles in cosmetics to reduce the appearance of wrinkles.

It also features some newer uses in the fields of automotive design, medicine, sports equipment manufacture, construction and energy generation.

I hope that you enjoy this new resource!

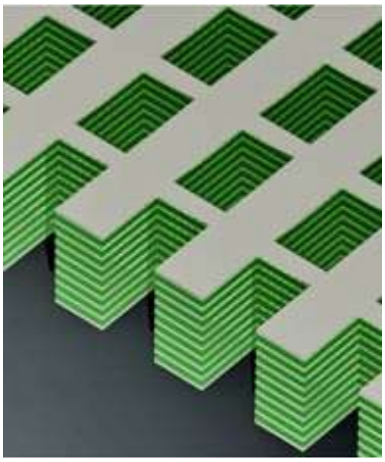
AUXETIC MATERIALS

Just over a year ago we held a conference on smart materials at the University of Exeter. One of the speakers, Professor Chris Smith, gave a fascinating presentation on a group of materials that he described as ***meta-materials***. In this article we shall explore this unusual group of materials which have some unique and very interesting properties... temperatures.

What is a meta-material?

Meta-materials are a class of man-made materials that have been specially designed to have properties that are not available in nature.

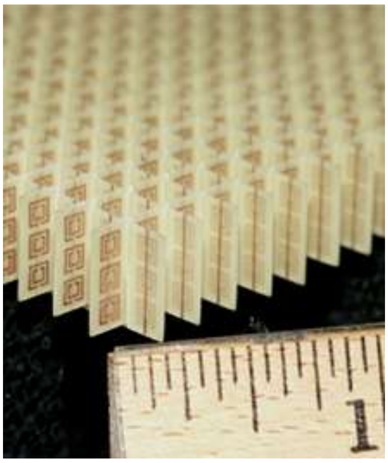
In most materials the properties are largely a result of crystal structure and microstructure and by modifying these the desired properties can be achieved. For example, the low temperature strength and toughness of a high strength low alloy steel can be controlled by the addition of elements such as titanium and niobium. These elements form tiny precipitates at high temperatures that control how the microstructure develops during processing. The resulting fine grain size produces a steel that has good strength and good toughness at low



This engineered meta-material has been designed to reverse the direction of visible and near infrared light. It could be used in the development of imaging devices with higher resolution and nanocircuits.

In meta-materials the properties are often controlled by structure on a larger scale and the structure is artificially engineered to contain small inhomogeneities which alter the properties on a macroscopic level.

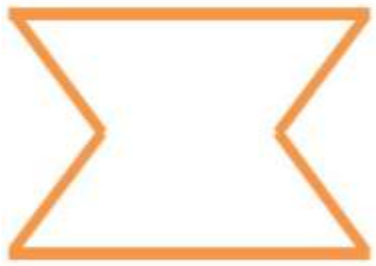
Auxetic materials are just one class of meta-materials; electromagnetic meta-materials are engineered to contain structural features which are smaller than the wavelength of the electromagnetic radiation they are designed to interact with. At present they have been successfully used with microwave radiation with a wavelength of a few centimetres and they have the potential to be used as beam steerers, lenses and antenna radomes.



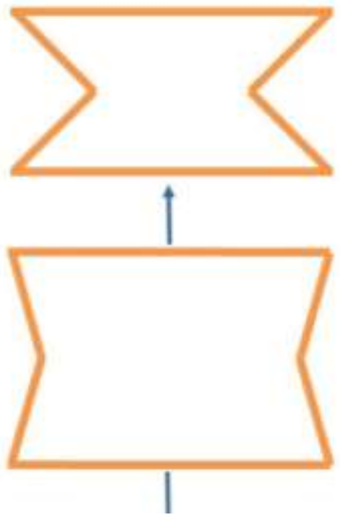
This array has been engineered by mounting an array of split-ring copper resonators on interlocking sheets of fibreglass circuit board. The array is 10x100x100mm in size and consists of three 20x20 unit cells. It has been designed to have a negative refractive index.

One feature of electromagnetic meta-materials that might prove particularly useful is that they can be engineering to have a negative refractive index. These are generally complex composite materials in which the various components are assembled in such a way to interact with the incident radiation in the desired way. In the photograph (right) copper split rings and wires have been mounted on a fibreglass circuit board.

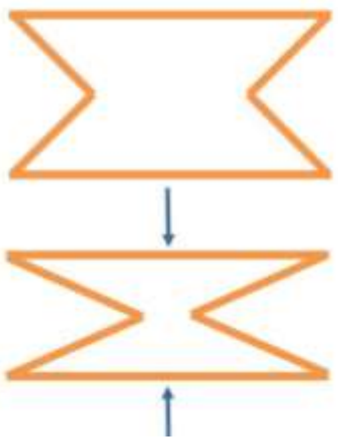
One of the most fascinating potential uses of meta-materials is for the development of cloaking devices and the first possible such device was demonstrated in 2006. The 'invisibility cloak' deflects microwaves so that they flow around the 'hidden' object



Auxetic hexagon containing hinge-like features.



When a tensile force is applied to an auxetic hexagon it experiences extension parallel to the applied force, but also expands perpendicular to the force as the hinge structure un folds.



When a compressive force is applied to an auxetic hexagon it experiences a contraction parallel to the applied force, but also contracts perpendicular to the force as the hinge structure folds.

making it appear as if there were nothing there at all. For the time being cloaking devices which operate in the visible spectrum are not available, so the Harry Potter Invisibility Cloak will have to remain a thing of science fiction for the foreseeable future.

What are auxetic materials?

Auxetic materials are a class of meta-materials which exhibit negative Poisson's Ratio. They have been known for over a hundred years but have only gained attention in recent decades. They can be single molecules, but more often they consist of an engineered material with a particular structure on the macroscopic level. Auxetic materials can occur in nature, but they are very rare. For example some rocks and minerals demonstrate auxetic properties as does the skin on a cow's teats.

Auxetics are created by modifying the macrostructure of the material so that it contains hinge-like features which change shape when a force is applied. If a tensile force is applied the hinge-like structures extend, thus causing lateral expansion. If a compressive force is applied the hinge-like structures fold even further causing lateral contraction.

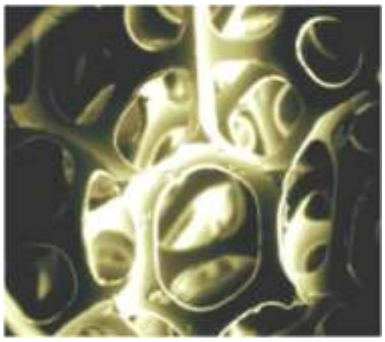
A common analogy used to describe the behaviour of auxetic materials is to consider an elastic cord with an inelastic string wrapped around it. When a tensile force is applied the inelastic material straightens at the same time as the elastic cord stretches, thus effectively increasing the volume of the structure.

Auxetic materials are often based on foam structures and as such they have a relatively low density. It is this open cell structure which can be modified to give the desired properties.

The unusual properties of auxetic materials mean that they are relatively resistant to denting. When an auxetic is hit the compression caused by the impact results in the material compressing towards the point of the impact, thus becoming much denser and resisting the force. Auxetic materials are also more resistant to fracture; they expand as they are pulled apart and this closes up and potential cracks in the material before they start to grow. The main drawback of these materials is that they are often too porous, not dense enough or not stiff enough for load bearing applications and when these properties are adjusted the auxetic behaviour tends to be reduced. Applications of these materials therefore often rely on a compromise of properties.

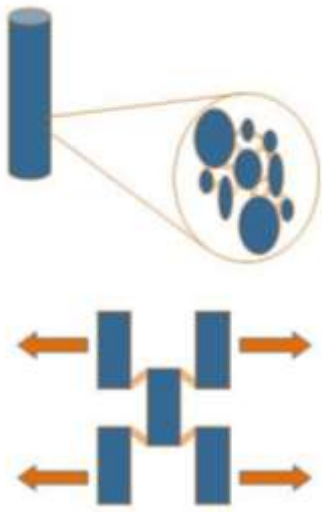
How are auxetic materials made?

Auxetic materials can essentially be made in two different ways. In the top-down approach everyday polymers are manipulated to give the desired structure and properties. In the bottom-up approach the material is built up from scratch, molecule by molecule, allowing them to be engineered on a very small scale. In both cases the objective is to create a repeating pattern of building blocks or cells which contain the necessary hinge-like features.



The first synthesised polymer-based auxetic material was created in 1987 using the top-down approach. Rod Lakes of the University of Iowa started out with an ordinary polyurethane foam which consisted of a honeycomb of hexagonal cells. When he applied heat and pressure to this cell structure it caused the side walls of the cells to buckle resulting in the auxetic hexagon shown earlier. A typical auxetic foam microstructure is shown right

The following year Ken Evans from the University of Exeter created another auxetic structure in PTFE. This structure consisted of oval nodules connected at their tips by long strands or fibrils. Under normal circumstances the nodules overlap with the fibrils wound round them. When the material is stretched in the direction of the fibrils they pull taut and this causes the nodules to rotate and snap into a rigid grid-like arrangement (see right). Liquid crystal materials can be engineering to have auxetic properties by building up a structure consisting of alternating rigid and flexible units molecule by molecule.



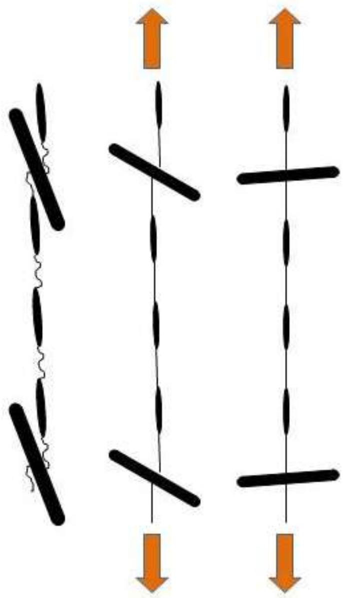
Schematic diagram of nodule and fibril auxetic material (top) showing idealised structure (bottom).

Where are auxetic materials used?

There have been many suggested uses for auxetic materials, but most of these have yet to come to fruition commercially. These materials can be difficult to process on a large scale, making industrial manufacture difficult. Some potential areas for use are described below.

Biomedical applications

Many of the materials that are currently used in medical applications can be processed to exhibit auxetic properties. It has been suggested that auxetic materials could be used to dilate blood vessels during heart surgery. A piece of auxetic foam, possibly made from PTFE would be inserted into the blood vessel and then tension applied to this to cause lateral expansion and open out the vessel. Auxetics could also be used in surgical implants and prosthesis and for the anchors used to hold sutures, muscles and ligaments in place.

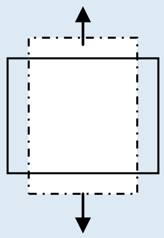


Schematic diagram showing how lateral expansion occurs under tension in a nodule and fibril auxetic material.

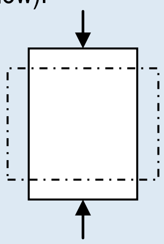
Poisson's Ratio

Poisson's Ratio, defined by Siméon Denis Poisson a French Mathematician in 1829, describes the behaviour of materials when they are deformed.

When a tensile load is applied to a cube of material it will tend to extend in the direction parallel to the load (axial direction) and contract in the two directions transverse or perpendicular to the load (see below).



When a compressive load is applied to a cube of material it will tend to contract in the direction parallel to the load (axial direction) and expand in the two directions transverse or perpendicular to the load (see below).



The ratio of the shape change in the transverse and axial directions is known as Poisson's Ratio and for most materials this value is between 0.0 and 0.5.

The Poisson Effect is caused by the stretching of bonds in the material lattice in order to accommodate the applied stress. When the bonds elongate along the stress direction they shorten in the other directions.

Filters

Traditional filters can be incredibly difficult to clean, leading to them being thrown away prematurely. A filter made from an auxetic foam could be cleaned much more easily by simply applying a tensile force to open up the pores. Once clean the force can be removed and the filter refitted.

Auxetic fibres

This is one are which does show real potential for exploitation. The key here is the development of a continuous process for developing auxetic materials in the form of fibres. The resulting fibres could be used in monofilament or multifilament form and could be knitted or woven together to make cloth. It has been suggested that these fabrics could be used in crash helmets, body armour and sports clothing where their dent and fracture resistance would be exploited.

It may also be possible to spin and auxetic fibre with another functional fibre and a more traditional textile to produce yarn with a range of useful properties for technical applications.

Auxetic fibre reinforced composites

There is no reason why woven fabric made from auxetic fibres cannot be used to reinforce a polymer in the same way that carbon or Kevlar cloth is used. However, the addition of an auxetic material could dramatically improve the fracture performance of the resulting composite. If the Poisson's ratio of the reinforcing fibres and matrix material are carefully matched the possibility of delamination at the matrix-fibre interface is reduced, thus making it more difficult for a crack to propagate and failure to occur. As the matrix contracts laterally when placed in tension, the auxetic fibre expands, allowing the interface to be maintained.

Auxetic materials could also be added to metallic materials such as steels to create composites with improved resistance to cracking under shear strain (twisting).

Where can I find out more?

You might like to have a look at the following websites:
http://en.wikipedia.org/wiki/Meta_materials
http://en.wikipedia.org/wiki/Auxetics
http://www.silver.neep.wisc.edu/~lakes/Poisson.html
http://research.dh.umu.se/dynamic/artiklar/shape/stretch.html
http://www.wisegeek.com/what-are-auxetic-materials.htm
http://www.azom.com/details.asp?ArticleID=167
http://www.azom.com/details.asp?ArticleID=168
http://data.bolton.ac.uk/auxnet//background/index.html
http://en.wikipedia.org/wiki/Poisson's_ratio

Resources etc..

Back in January at the ASE meeting in the snow I got to meet a whole host of people from other organisations that produce resources for schools. Some of these related to materials and I thought it might be useful to give you the lowdown on the ones that I found particularly interesting...

Teach Renewables and The Renewable World

(www.teachrenewables.co.uk and www.renewableworld.org.uk)

These two sites are both geared up to teaching about renewable materials and sustainable living. The first looks at how fuels and materials from sustainable sources can help to change the amount on non-renewable materials that we consume. It features case studies for KS1 to 4 and it nicely split into subject areas for easy navigation.

The second allows students to discover the diversity of renewable materials and their role in building a sustainable future. There are opportunities for individual study and group discussion and quizzes to test your knowledge. The site also has a selection of clips to give students a taste of the possible career opportunities relating to renewables.

The Element Collection (www.periodictable.com)

I think this was my favourite stand in the entire exhibition and every home should have its own periodic table with real samples! Although expensive, these collections could not fail to wow event the most disillusioned student! But if you cannot afford to buy one of the collections then I can strongly recommend the book 'The Elements'. I bought a copy and thought it was really well done with descriptions of all the elements along with some pretty impressive photos of them and their applications.

Earth Science Education Unit and Earth Science Teachers Association

(www.earthscienceeducation.com and www.esta-uk.net)

We have had links with ESEU and ESTA for some time and both organisations do a great job at supporting the teaching of earth science at all levels and in all subjects. The former provides CPD courses for teachers and the latter a wealth of resources for schools. If you have not come across either of these organisations before I would recommend making contact!

SEP and TEP (www.sep.org.uk, www.tep.org.uk and www.mutr.co.uk)

As usual the team from SEP and TEP were at the exhibition demonstrating the excellent resorces that they produce for science and technology teachers. If you have not already had a look at what they can offer I would strongly recommend visiting their website).

National STEM Centre

(www.nationalstemcentre.org.uk)

Based at the National Science Learning Centre in York this new facility will house the UK's largest collection of STEM teaching and learning resources, in order to provide teachers of STEM subjects with the ability to access a wide range of support materials.

The National STEM centre leads the government's STEM Programme, bringing together business, industry, charitable organisations, professional bodies and others with an interest in STEM education to facilitate closer collaboration and more effective support for schools and colleges. It also provides on-site facilities for STEM partners to support their work with schools and colleges

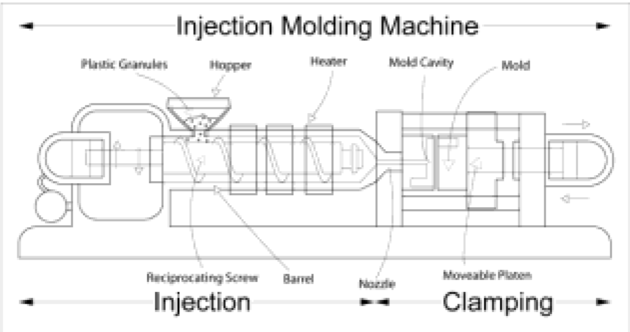
Ultimate Guide to Polymers Part II

Following on from the information on structure and properties in the last issue, this article primarily focuses on how polymers are processed.

Injection moulding

The first screw injection moulding machine was developed by James Watson Hendry, an American inventor, in 1946. Since then industry has evolved somewhat and modern machines are able to produce large numbers of identical components quickly and cheaply.

A schematic diagram of a typical injection moulding machine set up is shown below.



Granules of material are fed into the hopper which then loads the plastic in to the barrel which contains an Archimedes Screw. As the polymer travels along the screw it is gradually heated so that it is molten by the time it gets to the far end. The molten plastic is then injected under pressure into the mould cavity or die, where it cools and hardens before the two sides of the mould are opened and the component is released. Machines tend to be rated on the amount of clamping force needed to keep the two halves of the mould together. This varies between 5 and 6000 tonnes and stiffer materials tend to need to require a higher injection pressure and therefore more force to clamp the mould together. Care must be taken during moulding to ensure that the cooling rate is neither too fast (in which case the plastic solidifies before the mould is filled) or too slow (in which case the component has not solidified completely before being released). The cooling time is the dominant factor when calculating how long the process will take. This is reduced by cooling the metal mould with water during processing.

The geometry of the mould may be quite complex and in many cases multiple components are produced at the same time. Where large shapes are being moulded it is more common to produce just one on each closing of the mould. Mould design and mould material are key when setting up a new system as these will have implications on the economics of manufacture. Mould materials include hardened steel, aluminium or a beryllium-copper alloy. Although steel moulds are more expensive their longer lifespan offsets the high initial outlay.

The advantages of injection moulding include:

- High production rates
- Repeatable high tolerances
- Suited to a wide range of materials
- Low labour costs
- Little finishing is required to scrap production is minimal

However, there are disadvantages to injection moulding including:

- Upfront costs are high as machines are expensive
- Mould production is costly
- Running costs can be high
- Need to carefully design mouldable parts

Injection moulding can be used to process a wide range of different materials including both thermosoftening and thermosetting polymers. Generally speaking the mechanical properties of the material are unaffected by the moulding process, though some anisotropy may occur and internal stresses may be generated as the liquid shrinks on solidification.

Blow moulding

As a process blow moulding has been around for many hundreds of years; the Syrians used simple blow moulding to make glass objects. Today it is largely used to make hollow products from thermoplastics and in general there are three types of process: injection blow moulding, extrusion blow moulding and stretch blow moulding. These processes all start with a parison, a preform from which the final product can be produced.

The advantages of blow moulding include:

- Comparatively low tool and die costs
- Fast production rates
- Ability to produce complex shapes
- Uses less raw material than some other processes

Disadvantages to this process include:

- Limited to making hollow parts
- Wall thickness can be difficult to control

Extrusion blow moulding

This is the most popular variety of blow moulding and can be used to make bottles, hoses and drums for a wide variety of applications. The process starts by extruding molten plastic in to a hollow tube – the parison. The parison is then placed into the mould cavity whilst still soft and pressurised air is blow into it to inflate it to the desired shape. The plastic is allowed to cool and the product removed by opening the two sides of the mould.

Injection blow moulding

The injection blow moulding process can be split into three phases: injection, blowing and ejection. It is used to make small medical bottles and other single serve containers. During the first stage the parison is made by injection moulding thermoplastic onto a core pin, thus producing the hollow preform. This generally consists of a fully formed bottle or jar neck and a thick tubular body. It is then moved to the blowing station where compressed air is used to inflate the parison to the desired size and shape. This is allowed to cool before being ejected from the mould.

Stretch blow moulding

During stretch blow moulding the parison is deformed both along its length (axial direction) and around its circumference (hoop direction) and it can be used to process a wide variety of common thermoplastics. An injection moulded perform, complete with bottle neck and screw thread is heated and a core inserted. The core is then expanded using compressed air to obtain the desired internal dimensions. The correct external dimensions are achieved by blowing the parison inside a mould. This process is particularly useful for making PET bottles for carbonated drinks as the process introduces residual stresses in the material which help it to resist deforming once filled.

Vacuum forming

Vacuum forming machines are common in school and college technology labs but are also used on a larger scale to produce a range of products including product packaging, speaker casings, blister packs for medication and even large objects like car dashboards.

It is a simple thermoforming process in which a sheet of thermoplastic is heated and then stretched and held on to a single surface mould by the application of a vacuum. Once the vacuum is released the part can be ejected.

Where can I find out more?

My best suggestion would be for you to go on a Polymer Study Tour as these residential courses are specifically designed to improve the polymer-related knowledge of teachers. You can find out more about these courses at www.horners.org.uk/pages/Education/pst.html

Other than that I found the following particularly useful when writing this article:

http://en.wikipedia.org/wiki/Injection_molding

http://en.wikipedia.org/wiki/Blow_moulding

http://en.wikipedia.org/wiki/Vacuum_forming

Smallpeice Course in Mining & Minerals

The Smallpeice Trust is once again running a course on mining and minerals for students in year 11 and 12. The course will take place at the Tremough Campus of the University of Exeter from 19 to 22 July and includes all meals and accommodation.

During the course delegates will:

- Learn about how minerals are found, mined and processed to their end use
- Find out more about minerals and their properties and what will eventually happen when they run out
- Understand how to survey minerals using the latest computerised techniques and equipment
- Visit local quarries and spend the day at the underground facilities of the Camborne School of Mines.

The course is heavily subsidised by Rio Tinto and Anglo American, two of the world's largest mining companies, however there is still a course fee of £145 per student.

For more information visit www.smallpeicetrust.org.

Minerals and Mining News

Having been supporting the teaching of materials, minerals and mining in schools and colleges for five years now (the last three with the Institute), the repeat visits are always great fun, as everyone knows what to expect. But I have also visited some new places recently, like Barrow Sixth Form College and Kings' School Macclesfield, and this is always exciting to see new opportunities open up. Thank you for making me feel so welcome and I hope that your students enjoyed the presentations

Occasionally I am asked to give a talk that draws together the materials and mining themes. This may be for a general interest science lesson, or for a teacher's event or a geological society meeting. One way of doing this is through a talk called "From Rocks to Rockets". Some of you may have seen an early version of this at the Smart Materials conferences we have run a couple of times. After a general introduction to Smart Materials, I focus on the shape memory alloy called Nitinol, which is made of nickel and titanium (hence its name). The story of how these elements are found, extracted, processed and alloyed is fascinating, and appeals to people interested in any of the physical sciences, including astronomy, as Nitinol has applications in space vehicles!

I strongly recommend you consider attending this year's Earth Science Teachers' Association conference in September. This year it is being hosted by the University of Leicester's Department of Geology. It's a great opportunity to develop your own knowledge and skills and to share some of the insights and experiences you have built up. Further details are available from the ESTA website (www.esta-uk.net) or from Leicester's website (www2.le.ac.uk/departments/geology/extranet/esta). I hope to see you there!

The spring term is proving to be a very busy time, with lots of schools requesting visits. So far none have succumbed to the weather, and as I write this the blue skies suggest spring may have arrived. Those of you with field trips coming up - I hope the weather is kind to you. I look forward to meeting up with many of you in the coming months.

Toby

Where does it come from – Potassium?

The link between this element and the mining industry is even stronger than the fact that the potassium bearing minerals need to be extracted from the ground. Potassium was actually discovered by Sir Humphrey Davy in 1807, who also invented the famous Davy lamp, which allowed miners to enter gassy workings without the danger of causing explosions.

There is a large number of potassium-bearing minerals, including the alkali feldspars and some of the micas, but these silicate minerals are not of commercial interest. Only those that are water soluble are used to extract potassium, using thermal methods with potassium chloride, or electrolysis of hydroxides of potassium. These water soluble potassium bearing minerals are found in evaporate deposits; formed by precipitation from brines resulting from the extreme evaporation of seawater.

Potash is a generic term for a variety of potassium-bearing minerals and products. The UK has two potash resources from the Permian period, the Sneaton Potash and the lower but more extensive Boulby Potash, located underground along the North Yorkshire coast. Syvine (KCl) is the main potassium mineral present, but it is mixed with halite (salt, NaCl) to form sylvinite. This resource is commercially exploited by Cleveland Potash Limited at their Boulby Mine north of Whitby, where the Boulby Potash averages seven metres in thickness, but ranges from nil to over twenty metres. Remotely controlled continuous mining machines are used to extract the material, which is then carried by shuttle car to feed an underground crusher. Conveyors then take the material to the shaft bottom, where it is raised over a kilometre to the surface.

The potassium chloride is then recovered from the salt and other material by froth flotation, after which it is dried, screened and further refined.

Some material goes off to be used for industrial processes in the manufacture of soaps, additives for drilling fluids, etc., but 90% is used in the manufacture of fertilisers.

The UK is fortunate to have these reserves, as Potash is only produced in a few countries (Canada, Russia, Belarus and Germany being the main producers). It contributes significantly to the UK economy, employing over 800 people at Boulby mine and generating total sales of £98 million in 2003.

Further information can be found at the following websites.

www.clevelandpotash.co.uk (you will be re-directed to their new site location)

www.bgs.ac.uk/mineralsuk/planning/mineralPlanningFactsheets.html

Sir Humphrey Davy, English chemist and inventor. Born in Penzance 1778, died 1829.

Underground conveyor at Boulby Potash Mine near Whitby

Boulby Mine on the North Yorkshire Coast

A continuous miner at Boulby Mine

Potassium

- Potassium has atomic number 19 and atomic mass 39.10. It is one of the of alkali metals and sits in Group I of the Periodic Table between sodium and rubidium and is in the same period as calcium.
- The symbol for potassium, K, arises from its Latin name *kalium* which is derived from the Arabic work meaning plant ashes. The name potassium is derived from the English word potash which originally meant an alkali extracted in a pot from the ash of burnt wood.
- At room temperature potassium is a silvery gray solid with a metallic appearance and a body centred cubic crystal structure. It is very soft, having a Mohs hardness value of just 0.4 (talc measures 1 on this scale and diamond 10) and can easily be cut with a knife. When cut the new surface appears bright and silvery but because it is very reactive the surface soon dulls and becomes tarnished. Potassium is generally stored under oil or kerosene to prevent reaction with the air.
- Potassium melts at 63.38°C and boils at 759°C and has a density at room temperature of 0.89gcm^{-3}. The only metal with a lower density than potassium is lithium (0.54gcm^{-3}).
- Potassium produces a pale violet coloured flame when burnt in a flame test and flame photometry is just one technique for determining the concentration of potassium in solution. It reacts vigorously in water producing a strongly alkali solution of potassium hydroxide and the reaction is so exothermic that the hydrogen gas produced ignites. The purple colour in the image opposite is produced by phenolphthalein indicator which shows the presence of potassium ions.
- Potassium has 24 known isotopes, three of which occur in nature. The decay of ^{40}K to ^{40}Ar is commonly used for dating rocks (assuming that no argon was present in the rock when it was formed).
- About 93% of the world's annual potassium production is used in the manufacture of fertilisers where it is used in the form of potassium nitrate. However, potassium chlorate is used agriculturally as a weed killer.
- Potassium ions are necessary for all living cells to function and as such it is found in all plant and animal tissues. They are important for neuron function and in influencing the fluid balance between the interior and exterior of cells. Good sources of dietary potassium include bananas, avocados and brown rice. Too much potassium can stop the heart and fatal doses of KCl are used in lethal injections for execution.
- Potassium salts are used in food production as baking powder, as flour improvers and as a beer and wine preservative.
- Potassium compounds are used industrially in photographic emulsions, in hydrolysis reactions, in explosives (gunpowder), precious metal extraction, glass and soap manufacture and in inks, dyes and stains where it gives a bright orange colour.