schools affiliate scheme

news

Issue 36

Autumn Term 2010

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CONNECTING TEACHERS TO THE WORLD OF MATERIALS, MINERALS AND MINING

HELLO AND WELCOME TO THE NEW IMPROVED SCHOOLS AFFILIATE SCHEME

Hello there, I hope that you and your colleagues enjoyed the summer break and are ready for the onslaught of the new term. July and August have been very busy for us trying to get all the new benefits in place for members.

You should have received a letter at the beginning of July outlining changes to your Schools Affiliate Scheme membership which took effect from the beginning of September. I know that some of you will be very disappointed that we are no longer able to provide a visit to your school free of charge. Making a visit an optional extra was a very difficult decision, but one that we felt had to be taken in order to avoid a huge increase in membership subscriptions for all. You can find out more about the improved membership package on page 4.

The newsletter has also undergone a few minor changes. You may notice that the minerals and mining page from the back has disappeared. There is now a separate Minerals and Mining supplement for all members teaching geology. If you are not a geology teacher and would like to receive this supplement in addition to the main newsletter please let me know.

In this issue you should find all the usual information. There are details of our upcoming conference on Nanotechnology and the Autumn Open Day Programme, a feature on the newly launched 2011 Starpack Schools competition and plenty of technical stuff too!

Finally, I cannot say this often enough: this is your Schools Affiliate Scheme and your comments, good or bad, are very welcome. I look forward to hearing from you!

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

NANOTECHNOLOGY

Small world, big ideas

A conference for teachers on 13 October 2010

This is your final reminder about our upcoming Nanotechnology conference. There are still places available for the event in Grantham on Wednesday 13 October and it is **free of charge** for any teacher from a member school to attend. 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.

You can get full details and a registration form from http://www.iom3.org/events/nanotechnology-small-world-big-ideas.

Hope to see you there!

AUTUMN OPEN DAY PROGRAMME 2010

A final reminder about the Autumn Open Day Programme too! These events have been designed to support the teaching of the materials topics in the A-level (or equivalent) physics, chemistry, design technology and engineering 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	03/11, 10/11, 17/11, 24/11 Any 3hrs between 1300 & 1700
Cambridge University	32	14/12 or 15/12 Any 2.5 hrs in the afternoon
Edinburgh Napier University	40	03/11, 24/11 1230 to 1530
University of Exeter	40	03/11, 10/11, 17/11 Afternoon tba with school
Imperial College	**FULLY BOOKED**	
University of Leeds	40	03/11, 10/11, 17/11, 24/11 1230 to 1600
University of Liverpool	30	03/11 Afternoon tba with school
Loughborough University	**FULLY BOOKED**	
University of Manchester	30	03/11, 17/11, 24/11 1400 to 1600
University of Oxford	20	18/11, 25/11 1000 to 1230
Queen Mary (University of London)	**FULLY BOOKED**	
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

These events are **free of charge** to attend; you just need to get you and your students to and from the venue. For more information and the latest list of available dates please contact diane.aston@iom3.org

Alternatively you can find out more and download a registration form from www/iom3.org/content/autumn-open-day-programme.

Bookings for these events have been pretty slow coming in this year, despite giving you lots of notice. Is there a reason for this? Are you finding it harder to get students out of school? Are these events not what you need anymore? Please let me have your feedback!

SCHOOLS STARPACK
PACKAGING DESIGN AWARDS 2011

- *Gain recognition for your school*
- *Prizes of up to £500*
- *Certificates for all winning students*

The Schools Starpack Packaging Design Awards, now in their 12th year, form part of the Institute's Annual Awards programme. The briefs provide excellent opportunities for Key Stage 3, 4 and AS level, individual or joint activity (Brief D only) and extension activities for after school clubs.

The winners of this year's Schools Starpack Awards were presented with their awards at the Institute's conference facilty in Grantham. From over 200 entries 8 gold, 20 silver, 18 bronze and 18 Highly Commended Stars were awarded, along with sponsored prizes for the best school in each of the four categories. Students' work was on display and the day also saw a presentation on interview techniques and CV writing.

Bungay High School (top right) took the Logoplaste-Sponsored Award for the best overall entries into the New Ribena Drink Bottle Brief.

Laura Collins from Derby High School took a Gold Star in the Themed Chocolate Gift Brief (bottom right)

Snapshot of the 2011 Briefs

Brief A - New Children's Toy Pack/Product
Key Stage 3, 4 and AS level.

Sponsored by British Polythene Industries PLC (BPI)

Using Plaswood design a new and innovative toy container/package or design a play product whereby the product is also the package. Material provided on request.

Brief B - Cravendale Milk Container
Key Stage 4 & AS level

Sponsored by Logoplaste UK Limited

Design a new and innovative concept for the Cravendale brand that could allow a new design to be used across a range of sizes, from 500ml to 1 litre and 3 litre.

Brief C - Celebration Cake Box
Key Stage 3 & 4

Sponsored by the Benson Group

Design a new and effective package for a celebration cake that uses cartonboard. Material provided on request.

Brief D - Materials Research Brief
Key Stage 4

Sponsored by the Institute of Materials, Minerals & Mining

Research the materials used to design a particular product and then design alternative packaging using natural materials detailing the advantages and disadvantages of your chosen material.

For full details of the briefs, guidelines and advice for teachers please visit www.starpack.uk.com/schools.

Alternatively contact Rachel Brooks by 'phoning 01476 513885 or emailing Rachel.Brooks@iom3.org.

The closing date for entries is 25 February 2011.

Starpack is organised by IOM Communications Ltd and endorsed by the Packaging Society, a division of the Institute of Materials, Minerals & Mining

WELCOME TO THE NEW IMPROVED SCHOOLS AFFILIATE SCHEME

At the end of the summer term you should have received a letter from us detailing changes to the Schools Affiliate Scheme which took effect at the beginning of September. In reviewing the benefits of membership we have tried to put together a package which all members can easily access. We think that the Scheme still offers excellent value for money and hope that you continue to find the information and resources that we provide valuable and useful.

Resource box

We have been working hard over the summer trying to source examples of materials for our new resource box loan initiative and envisage that the first boxes will be available shortly after half term. As much as possible the contents of the box will mirror the samples taken into school on a visit and the artefacts have been chosen to bring the materials topics in the curriculum to life. The box contains an information card about each of the artefacts along with curriculum links and power point presentations.

It is very important that these boxes are trialled by schools to ensure that the contents, both in terms of samples and supporting literature, are appropriate. We are looking for twenty schools to be involved in piloting the boxes and giving detailed feedback and potentially assistance in writing activities relevant to all key stages and subjects. If you are interested in taking part in the pilot please get in touch by emailing diane.astion@iom3.org. You will be able to borrow the box for a period of one week so that you and your colleagues can use it with as many different groups as possible.

SAS website

A new SAS micro-site has been created within the main IOM3 site, containing details about the Scheme, resources, conferences and events and links to other organisations. There is also a members' only area containing previous resources in a downloadable format, back issues of the newsletter and dates available for visits.

You will need a login and PIN to access this are and we will be writing to you shortly with these details. Please keep this information in a safe place as you will need to use it whenever you want to access the members' area.

The new site is located at www.iom3.org/SAS.

Materials World and online journals

Materials World has been part of the SAS membership package since it began in 1999. However, we are now living in the electronic age so we are pleased to now give members on-line access to Materials World through the IOM3 website. Not only that but you will also be able to access the Institute's other magazines (Clay Technology, Packaging Professional and Wood Focus) and all of our refereed journals.

To access these resources you will first need to login and then navigate to www.iom3.org/content/publications

School visits

Unfortunately we are no longer able to provide a visit to your school free of charge. However, this is an optional extra available at an additional charge of £150 for one session of up to an hour and a half or £200 for two sessions of up to an hour and a half each.

A limited number of days are available for visits and the autumn term is already pretty full. The dates for the upcoming academic year are:

Oct:	20	Dec:	15
Jan:	12, 19, 26		
Feb:	02, 09, 16		
Mar:	02, 16, 23, 30		
Apr:	06, 13	May:	18, 25
Jun:	08, 22, 29		
Jul:	06, 20		

If you would like to book a visit please contact sarah.harrison@iom3.org

COPPER COMPETITION

The Copper Development Association (CDA) has just launched a competition for schools in which students (aged 11 to 16) must design a poster highlighting the vital role copper plays in our everyday lives. The posters should be designed to appeal to other students and may be in either portrait or landscape format.

The winning design will be printed (A2 size) and distributed to schools around the UK and the prizes for the school and individuals are not insignificant. The winning individual or team will receive £100 and their school equipment to the value of £500. There are prizes for second and third place too.

The posters may contain images and text, but your students must make sure that any images they use are either copyright free or that they get permission to use them as the CDA will own the copyright on all posters submitted.

The closing date for entries is 10 December 2010 and judging will take place on 15 December 2010.

For more information visit http://www.schoolscience.co.uk/competitions.cfm and click on Curious about Copper or alternatively, contact Bryony Samuels by emailing Bryony.Samuels@copperdev.co.uk.

To help your students on their way the pull-out article in this issue looks at copper!

FLYING HIGH WITH THE LONDON MATERIALS SOCIETY

The **London Materials Society** held its 8th annual Schools Event this June at the RAF Museum in Colindale. Both pupils and teachers from the Warren School in Barking & Dagenham began the day with a very popular rocket-building activity, designed to demonstrate the principles of aeronautics in a hands-on fashion. In a practical workshop that spoke directly to the National Curriculum in both Science and Design & Technology, we were encouraged to think about how the design of our rockets would affect forces of lift, drag and gravitational pull, and to weigh up the pros and cons of using strong or lightweight materials in the construction. Then came the most exciting bit: launching the rockets using an electrically-controlled compressed air launcher. Some of the most successful creations travelled an impressive 10 metres, hitting the back wall or getting lodged in the rafters!

After lunch, the students were able to explore the Aeronauts Interactive Centre, which has over 40 experiments to help visitors learn about flight, covering topics such as air resistance, friction, circuits, light and reflection, G-Forces and materials and structure in aircraft design. The pupils were also given the chance to explore the RAF Museum's vast collection of historic aircraft.

The next London Materials Society Schools Event will take place on the 7th July 2011 (venue to be confirmed). For more information please email Dr. Priya Pavan at priya.pavan@gmail.com.

Help from Local Societies

Don't forget that members of the Schools Affiliate Scheme have an open invitation to attend the meetings of the nearby local societies. The Institute has around 60 local groups focussing on all aspects of materials and their event programmes for the 2010 – 2011 year have just been published. You can find out what is going on in your area by visiting www.iom3.org.uk/content/local-societies and clicking on your region. The lectures are aimed at an adult audience and vary in technical content but they would be a good way for you to boost your knowledge (they may be able to count towards your CPD too!) and meet other Institute members in your area. Many groups are very keen to get more involved in education and I know that you would be very welcome!

SCHOOLS INTO INDUSTRY PROGRAMME

Jo Chapman from Proskills outlines the Schools into Industry Programme. For further information, and to register for free schemes of work and teaching resources, please visit **www.theits.org.uk**

Schools into Industry is an award winning programme showing students that manufacturing is an exciting, dynamic industry and provides a good career choice. All activities are curriculum-mapped, there is a free interactive programme and prizes worth £2,500!

The first programme to be launched was PrintIT!. More than 100,000 students throughout England have been engaged in the programme over the past 5 years and twinning has been arranged with more than 500 printers.

Twinning aims to link schools with local employers to offer their support for the project through mentoring and advice, and helps to bring learning to life through site visits.

Programmes are mapped to relevant parts of the 14-19 curriculum, are flexible to fit in with school planning & are free to use.

DigIT! to BuildIT! Was launched earlier this year and is for Year 9 Geography students, GCSE Science & A-level Geology students and students studying the Diplomas in Construction & the Built Environment. DigIT! To BuildIT! aims to introduce students to the Extractives & Building Products industry through researching materials used in the construction process, identifying their origins, and recommending eco-friendly, sustainable alternatives.

PrintIT! is for students of GCSE Graphic Products or GCSE Product Design and the Diplomas in Creative & Media and Manufacturing & Product Design. PrintIT! comprises an exciting project where students design a print-centric campaign to promote Fairtrade products, whilst gaining an interest and understanding of careers in the modern, high-technology Print and Paper industry.

MakeIT! Furniture is for students studying GCSE & A-level Design Technology & Product Design and the Diplomas in Creative & Media and Manufacturing & Product Design. MakeIT! Furniture aims to familiarise students with the Furniture, Furnishings & Interiors industry from researching and designing products, identifying the raw materials used, and sustainable design through to the production of finished pieces of furniture and products.

MakeIT! Glass is for Year 9 Design Technology students, GCSE & A-level Product Design students, and students of the Diplomas in Construction & Built Environment and Manufacturing & Product Design. MakeIT! Glass aims to familiarise students with the Glass industry through researching and designing glass products, investigating the manufacture of different types of glass as well as its many and varied uses.

MakeIT! Ceramics is designed for students studying GCSE & A-level Art & Design and the Diplomas in Creative & Media and Manufacturing & Product Design. MakeIT! Ceramics aims to familiarise students with the Ceramics industry through designing products and investigating different aspects of the industry, from the sourcing of raw materials and exploring environmental issues, to the production of glazed ceramics.

COPPER

Introduction

Copper is an orange-ish metallic material that has been known since ancient times; this is probably due to the fact that it is one of only a small number of metals that can occur in their native form in nature (Figure 1).

The name copper comes from the Roman *cuprum* which is a simplified form of the phrase *aes Cyprium*, meaning copper from Cyprus. The Greek name for copper was *chalkos* and the prefix chalco- is still used in the name of a number of copper-containing minerals. The metal is associated with the Greek and Roman gods Aphrodite and Venus owing to its lustrous appearance and its symbol in alchemy is that of the planet Venus.

Copper has found widespread use since its discovery and the modern world we live in today could not function without this truly indispensable element!

History

There is evidence to suggest that copper has been used for over 10,000 years, giving rise to the *Copper Age*, a precursor to the *Bronze Age*. A copper pendant has been found in northern Iraq which has been dated to around 8,700 BC and it is likely that this was made from a piece of native copper. Copper smelting from simple minerals was first used around 5000 BC and it is thought that this skill developed independently in various regions around the globe. These early smelting operations probably used malachite or azurite as the ore. These are both copper carbonate compounds (Figure 2).

It did not take long for early metallurgists (whether they knew it or not!) to realise that the addition of small amounts of tin (to make bronze) or zinc (to make brass) improved the properties of copper. Bronze artefacts (Figure 3) dating back to 3000BC have been identified and it is generally accepted that in Europe the Bronze Age is defined as the period between 2500BC and 600BC.

Copper mining in the UK dates back several thousand years. The copper mine on the Great Orme in North Wales is thought to have been abandoned around 600BC but it was worked again between the seventeenth and nineteenth centuries. Copper mines in Cornwall were of international importance around 200 years ago and fortunes were built on the proceeds of copper mining in Derbyshire and Cheshire.

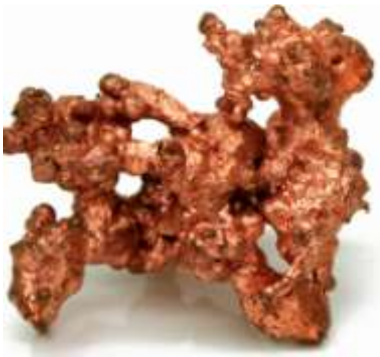


Figure 1 – A small piece of native copper (about 4cm across). http://upload.wikimedia.org/wikipedia/commons/f/f0/NatCopper.jpg

Figure 2 – Rock sample consisting of green malachite ($Cu_2CO_3(OH)_2$) and blue azurite ($Cu_3(CO_3)_2(OH)_2$). http://upload.wikimedia.org/wikipedia/commons/4/4e/Azurite-Malachite-220790.jpg

Figure 3 – The Gayer-Anderson Cat is an ancient Egyptian statue made from Bronze and dating to 664 to 332 BC. http://upload.wikimedia.org/wikipedia/commons/3/3f/Gayer-Anderson_Cat_01.jpg

Physics properties		
Density		8940kgm^{-3}
Melting point		1084°C
Boiling point		2562°C
Atomic properties		
Crystal structure at room temperature		Face-centred cubic
Electronegativity (Pauling scale)		1.90
Atomic radius		128pm
Mechanical properties		
Ultimate tensile strength		200-400MPa
Young's Modulus		110-128MPa
Hardness	Mohs	3.0
	Vickers	369MPa

Figure 4– Selected properties of copper. http://www.copper.org/resources/properties/atomic/homepage.html and http://www.roymech.co.uk/Useful_Tables/Matter/Copper_Alloys.html

Figure 5 – Pure copper takes on a peachy colour (top left), but this soon dulls on expose to air as a black oxide layer forms (top right). If corrosion is allowed to continue the green-coloured patina known as verdigris forms. This gives the Statue of Liberty her characteristic colour. http://en.wikipedia.org/wiki/File:Copper_wire_comparison.JPG and http://upload.wikimedia.org/wikipedia/commons/6/6e/Statue_of_Liberty_frontal_2.jpg

The use of copper and its alloys has steadily increased since Roman times, though it is estimated that over 95% of all the copper ever mined and smelted has been extracted since 1900.

Structure and properties

Copper sits in the first transition series of the Periodic Table between nickel and zinc and is at the top of group 11 (which also contains silver and gold); it has atomic number 29 and atomic mass 63.55. Some of the key physical, atomic and mechanical properties of copper are given in Figure 4.

Copper is metallic solid at room temperature and it is both ductile and malleable owing to its close-packed, face-centred cubic crystal structure. It can be easily worked and drawn into fine wires but in order to do this is needs regular annealing to remove dislocations built up during deformation. Copper can be joined relatively easily by brazing, soldering or welding and it has excellent thermal conductivity.

The electrical conductivity of copper ($59.6 \times 10^6 S.m^{-1}$) is second only to that of silver ($63.0 \times 10^6 S.m^{-1}$), and for the obvious reason of cost silver is not a commercially viable choice! This exceptionally high value is because virtually all of the valence electrons in copper are free to take part in conduction.

The colour of copper depends on the level of oxidation. Pure copper has a pink-orange colour, however, when exposed to air a thin oxide coating forms and the colour dulls to an orangey-brown; if corrosion is allowed to continue the characteristic green-coloured verdigris appears (Figure 5). Verdigris is a complex mixture of carbonates, acetates, chlorides, sulphides and hydroxides.

As discussed above, copper will oxidise in air resulting in the formation of copper oxide. However, further reaction is prevented as the oxide layer protects the underlying material. Copper does not react in water making it perfect for marine applications, but it does react in sulphide-containing solutions.

The biggest issue with copper is galvanic corrosion. This is an electrochemical process arising when two metals with differing electrode potentials are in contact with each other in the presence of an electrolyte. The more reactive metal will corrode preferentially. This phenomenon is particularly important in marine environments as the salt water behaves as an excellent electrolyte and copper is often used alongside other metals.

The excellent all round properties of copper have led to its use in a vast number of applications.

Occurrence and extraction

Copper occurs in the Earth's crust at a concentration of around 68 parts per million which corresponds to about 1000×10^{12} tonnes in the top kilometre of crust or roughly enough to last 5 million years at the current rate of extraction!! However, it is not economically viable to extract most of this; most copper mines require a yield of at least 0.4%. There has been a steady increase in global copper production and in 2009 15.8 million tonnes were produced. Mines in Chile produced roughly 34% of this, with the next largest suppliers being Peru and the US each producing 8%. World copper output in 2005 is shown in Figure 6.

Figure 6 – Copper output in 2005 as a percentage of the top producer (Chile: 5.32 million tonnes). Green denotes 100%, yellow 19% and red 1%. http://upload.wikimedia.org/wikipedia/commons/2/2d/2005copper_%28mined%29.PNG

The main copper ores are the sulphides chalcopyrite, bornite, covellite and chalocoite, the carbonates malachite and azurite and the oxide cuprite (Figure 7), though chalcopyrite accounts for 50 percent of the ore extracted. These ores are typically extracted from large open-cast mines, the largest of which is Chuquicamata in northern Chile (Figure 8). The hole in the ground here is 4.3 kilometres long, 3 kilometres wide and 850 metres deep and in the ninety years that it has been operational it has produced over 29 million tonnes of copper!

Figure 7 – Copper containing minerals chalcopyrite, $CuFeS_2$ (left) and cuprite Cu_2O (Right). http://commons.wikimedia.org/wiki/File:Chalcopyrite-210594.jpg and http://upload.wikimedia.org/wikipedia/commons/1/1a/Cuprite-Copper-225060.jpg

Processing

Once the ore is at the surface the difficult task of getting the copper out begins. The processing route has a number of stages and in some cases the method employed depends on the nature of the ore:

Crushing and grinding. The copper-containing rock is initially crushed to walnut-sized pieces and then is ground into a fine powder. This stage is common for all ores.

Sulphide ores. Sulphide ores are concentrated, i.e. separated from the waste material by froth flotation, and the resulting slurry contains 15-40% copper depending on the mineral. The slurry is then smelted by heating to 1200°C with limestone and silica (these two additions aid slag formation) to produce a liquid known as *copper matte* which is essentially copper sulphide. The matte is converted to *blister copper* by blowing oxygen through the liquid. Blister copper is around 98% pure. The blister copper is formed into ingots which form the anodes in an electrolytic cell. When a current is passed through the cell the copper ions migrate from the anode into solution and are then deposited as pure copper on the anode. Impurities remain in solution or collect in the bottom of the cell as 'anode slime'

Figure 8 – The largest copper mine in the world at Chuquicamata in Chile. http://upload.wikimedia.org/wikipedia/commons/6/69/Chuquicamata-002.jpg

Oxide ores. The copper is leached out of the ore by immersion

Brass	< 45% zinc
Bronze	7-18% tin
Al bronze	5-11% aluminium
Si bronze	5-34% silicon
Cupronickel	10-30% nickel
Nickel silver	17% zinc, 18% nickel
Gunmetal	10% tin, 5% zinc

Figure 9 – Names and principle alloying elements of some common copper alloys.

Where can I find out more?

www.copper.org/ This is your one-stop shop to find out everything about copper. N.B. this is the American Copper Development Association website. The UK CDA website is www.copperinfo.co.uk and also contains some useful stuff!

www.schoolscience.co.uk If you search for copper the site shows a wide range of resources to help you teach about copper in science, but some of these are relevant to technology too. The site has many activities that pupils can work through by themselves with regular questions so that they can check their understanding. The activities are suitable for students aged 11 to 18.

www.ectonhillfsa.org.uk The Ecton Hill Field Studies Association run school visits to a disused copper mine in Manifold Valley in the Peak District. Students have the opportunity to see how copper ore was mined 200 years ago and carry out a range of activities relating to the chemistry and geology curriculum.

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

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

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

in sulphuric acid resulting in a solution of copper sulphate. The copper is liberated using an electrolytic process. The copper sulphate solution is used as the electrolyte in a cell and when a current is passed through the cell copper comes out of solution and is deposited on a pure copper cathode.

Further processing. The 99.9% pure copper cathodes produced by these techniques are then processed into a variety of shapes for immediate use or alloying.

Copper alloys

Copper alloys are used in a huge range of different applications and they are generally classed as brasses or bronzes. The main alloying additions associated with these alloys are shown in Figure 9.

Brasses are used in many applications ranging from musical instruments to electrical connectors. They offer excellent electrical conductivity and workability but are harder and stronger than pure copper. These materials also exhibit good corrosion resistance. In addition to zinc, some grades also have small additions of lead, tin, arsenic, aluminium, manganese and iron. Lead improves the machining properties of the brass; tin and aluminium improve corrosion resistance and arsenic inhibits dezincification.

Tin bronze was probably the first copper alloy to be made. The addition of 10% tin by weight produces a material which is much harder than pure copper. Tin bronzes are used in coinage and marine applications because of their excellent corrosion resistance. They are also have excellent casting properties and are used for making statues. Small additions of zinc, phosphorus and lead may be used to further improve properties.

Aluminium bronzes typically contain up to 11% aluminium and in some cases small additions of iron, manganese, silicon or nickel. The alloys are designed to be either hot worked or cold worked and can be used for decorative purposes amongst other things.

Copper-nickel alloys are very ductile materials and can be formed using a wide variety of techniques. They offer excellent corrosion resistance and are idea for marine applications and coinage.

One final copper-containing material worth noting is **yttrium-barium-copper-oxide** (YBCO or $YBa_2Cu_3O_7$). This was the first material to become superconducting at liquid nitrogen temperatures, in 1986.

UNIVERSITY PAGE

Materials courses are run at a number of universities around the country. In the Autumn Issue last year there was an article covering what to look for in a materials course and details of the re-launched materials programme at Leeds.

In this issue the course at Queen Mary, University of London is highlighted by the Admissions Tutor, Dr Steve Dunn (s.c.dunn@qmul.ac.uk)...

Take the most exciting and revolutionary aspects of chemistry, physics, design, innovation and engineering, throw in a little biology and you have Materials Science the newest of the sciences, or is it?

The early pioneers and alchemists might well recognise Materials Science more easily than the subject disciplines we use today. They were dedicated to the control and understanding of matter to get improved performance or properties from the materials they found in the world around them. So take a moment to think about the Bronze Age, Iron Age, and perhaps even the Silicon Age. What is common to all of these? Put simply: materials. Each of these revolutionary periods in history used the clever modification and application of a material to change the shape of our world.

It is possible to be part of the revolution that is Materials Science. You can take the knowledge and skills learned in traditional disciplines and move towards the dynamic application of that knowledge. More recently the significant advances in design and technology have been made possible through materials science and the innovations it has brought – ever wondered how the iphone touch screen actually works, and why it doesn't get dirty? If these are questions you have asked then you are already considering the questions that lead you towards a career in Materials Science.

You can shape the world around you. By leading teams of chemists, physicists and engineers the materials scientist has an overarching understanding of the relationship between processing and performance, form and function and what can be achieved. Working in environments such as Airbus developing the largest non-metal wing structure ever produced, EADS-Astrium developing new materials for satellite systems, with clinicians and dentists in the healthcare industry developing next generation medical materials for treatment and diagnostics, cosmetic companies producing new products for the beauty market, or working with the growing number of companies developing technologies to help us face the threats and make the most of opportunities of the future, with Materials Science you can, literally, influence the shape of things to come.

At Queen Mary, University of London we mix the vibrant atmosphere of the Capital with innovative learning and teaching methods to produce highly skilled Materials graduates. In a survey for the Times Good University guide 2010 these graduates were placed 7th in the UK for graduate starting salaries (average £23,118), outperforming the likes of Cambridge and Oxford and were in the top 10 for employability. The range of courses and modules we provide cover the complete spectrum of materials science from renewable energy systems to dental materials and design and management. The experience at Queen Mary, University of London is carefully structured to enhance communication skills, use the latest industrial problems to give teaching a real feel and give access to the most relevant and up-to-date equipment. The overall result is a well grounded and highly skilled employable graduate.

For more information about the variety of materials courses offered, or how we can help support your learning environment please contact Elena di Mascio by telephoning 020 7882 8734 or email e.g.dimascio@qmul.ac.uk.

ULTIMATE GUIDE TO CERAMICS PART I

The Ultimate Guide for the next three issues will focus on ceramics. In this issue we will concentrate on the definition, structure and properties of ceramics, in the Spring issue processing will be explored and in the summer issue we will consider where ceramics are used.

Figure 1 – Flint arrow head dating to the late Stone Age. http://commons.wikimedia.org/wiki/File:Biface_Silex_Venerque_MHNT_PRE_.2009.0.194.1_Fond.jpg

Figure 2 – Bronze Age pottery vessel dating to about 2000 BC. The vessel is 28.5cm tall and the diameter at the rim is 21.5cm. http://upload.wikimedia.org/wikipedia/commons/2/2a/Vaso_tr%C3%ADpode_arg%C3%A1rico_%28M.A.N._1983-57-339%29_01.jpg

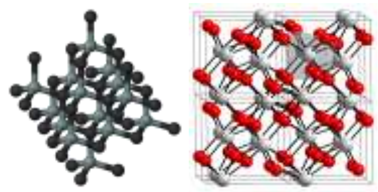


Figure 3 – Tetrahedral structure of covalently bonded silicon carbide (left) and cubic structure or ionically bonded zirconia (right). (http://commons.wikimedia.org/wiki/File:Silicon-carbide-3D-balls.png and http://commons.wikimedia.org/wiki/File:Kristallstruktur_Zirconium(IV)-oxid.png

Introduction

It is generally accepted that materials can grouped into one of three classes:
Metals
Polymers
Ceramics

The fourth group, composites, are made by mixing materials from two of the other groups together.

The strict, non-property based definition of a ceramic is an inorganic, non-metallic solid and this encompasses a very large number of different materials.

Ceramics are prepared by the action of heat and subsequent cooling. This definition includes rocks made by heating and cooling in the Earth's crust and indeed the Stone Age is defined as a time when early Man learnt to use stones as tools (Figure 1). Some of the first man-made ceramics to be used were pottery objects made from clay. In fact the word ceramic comes from the Greek word keramikos meaning pottery or burnt stuff. Today ceramics can be split into four categories which give an indication of their use:

Structural ceramics include bricks, pipes and tiles and are often clay-based materials.

Refractories are a group of ceramics used in high temperature applications such as furnace linings, fire retardant coatings and crucibles for containing molten glass or metal.

Whitewares include stoneware, earthenware, porcelain and bone china. They are used for tableware, sanitaryware, tiles and other pottery products.

Technical or engineering ceramics tend to be characterised on the basis of their chemistry, i.e. as oxides, non-oxides (carbides, nitrides) or composites. They have very specific properties, often developed for very specific applications and examples of their use include insulating space shuttle tiles, biomedical implants and jet engine component coatings.

Structure and properties of ceramics

As with all materials, the properties of ceramics depend very much on their structure, both in terms of the type of bonding and crystal structure. Ceramics may be covalently bonded, ionically bonded or a mixture of the two (Figure 3). Figure 4 shows the type of bonding in some common ceramics. Ceramics can be crystalline in nature or amorphous or glassy, but again there are instances where the material may contain both crystalline and non-crystalline areas.

The microstructure of ceramics is very much dependent on their processing. Crystalline ceramics tend to have a polycrystalline structure (Figure 5) which also contains voids and other defects. In an amorphous material defects will also be present.

In general ceramics are materials strong in compression but relatively weak in tension. They tend to be brittle materials and undergo very little plastic deformation before final fracture. This poor toughness owes itself to the few available slip systems in crystalline materials and the very slow plastic flow in amorphous ceramics. Fracture toughness is a particularly important property of ceramics. This describes the ability of a material containing a crack to resist its propagation to failure. Fracture toughness is a useful measure when the material contains existing defects. Defect or crack formation can require considerable energy, but much less energy is needed for the crack to grow through the material. Ceramics also tend to be hard and wear resistant.

Traditionally ceramics are thought of as good electrical and thermal insulators. However, by modifying the structure they can be designed to be good electrical or thermal conductors or both. Semiconducting ceramics such as zinc oxide are very important to our modern electronics industry. Some ceramics are also high temperature superconductors. Yttrium-barium-copper-oxide was the first material to superconduct at liquid nitrogen temperatures and it is a ceramic with a very complex Perovskite-based crystal structure.

Ceramics also have useful optical / electromagnetic properties. Glass is used for windows because it is optically transparent, but optical ceramics can be far more complex than this. Modification of the structure can produce a material which behaves as a frequency-selective filter or waveguide. There is a growing interest in ceramics which are transparent in the visible and mid-infrared regions of the electromagnetic spectrum particularly for military applications. In general glassy ceramics or those with a crystal size smaller than the wavelength of the incident radiation tend to be transparent. Opaque materials arise when incoherent scattering of the light occurs at the crystal boundaries.

Summary

Ceramics are often brushed off as being simple, old-fashioned materials; however, this could not be further from the truth. Our modern society could not function without these important and diverse materials.

Material	Bonding
Si	Covalent
SiC	Covalent
Si_3N_4	Covalent
NaCl	Ionic
MgO	Ionic
Mica	Ionic
Al_2O_3	Covalent-ionic
SiO_2 (quartz)	Covalent-ionic
Soda-lime glass	Covalent-ionic

Figure 4 – Bonding in ceramics ('Materials Science' by Anderson, Leaver, Rawlings and Alexander)

Figure 5 – Microstructure of an alumina ceramic composed of 96% Al_2O_3, with the remainder a mixture of MgO, CaO and SiO_2. The light coloured phase is angular particles of alumina and the dark coloured matrix is an aluminosilicate glass. (http://www.doitpoms.ac.uk/miclib/micrograph.php?id=198)

Where can I find out more?

http://en.wikipedia.org/wiki/Ceramics
http://en.wikipedia.org/wiki/Ceramic_engineering
http://en.wikipedia.org/wiki/Ceramic_materials
http://en.wikipedia.org/wiki/Fracture_toughness
http://en.wikipedia.org/wiki/Semiconductor
http://en.wikipedia.org/wiki/Yttrium_barium_copper_oxide

Photo 1 –Measuring the strip.

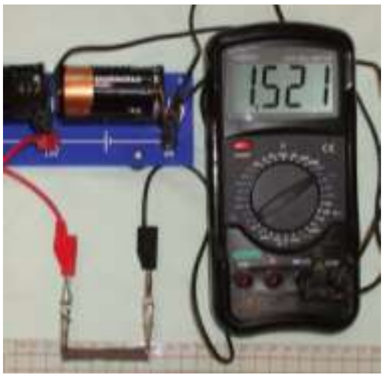
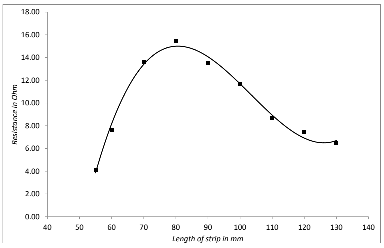


Photo 2 – Potential difference across the battery when strip is connected.

Photo 3 – Potential difference across the battery in open circuit.

Photo 4 - Current measured in circuit shown in Photo 2



Graph showing how resistance varies with length

ELECTROLYCRA: Stretch conductive fabric

By Francisca Wheeler

At the last ASE annual conference in January 2010 at Nottingham University, teachers were given short strips of what appeared just like any bit of lycra material. The samples, which look and feel like ordinary lycra, were distributed by SEP[1] and are in fact of a special type of fabric named ***electrolycra***. The fabric is silver plated and so it has very unusual properties. Like lycra, the material stretches under tension but, because it has been silver plated, it is highly conductive. The strange thing is that the resistance of the strip of fabric initially increases when a stretching force is applied to it but then decreases as the force continues to increase.

Since it is soft and a conductor it can be used as a substitute to metal sheet or foil in sensors where a compliant material is more appropriate than a stiff one, for example in certain medical applications. Also, because it warms up when a current passes through it, the material can be used in the lining of gloves, slippers or hats. Electrolycra is an interesting material with many applications making it worth investigating its electrical and mechanical properties.

A simple electrical circuit, with a rule, a 1.5V battery, a multimeter and connecting wires is sufficient to investigate the changing resistance of the strip of electrolycra. Although the conventional way to measure small changes in resistances is by using a bridge, in this case the use of a multimeter proves to be very satisfactory. The values for resistance are small but the changes to it are relatively large. The multimeter was used to measure potential difference and current instead of measuring resistance directly.

Photo 1 shows a strip of electrolycra 55mm x 8mm. The other photos show the method used to calculate its resistance. The internal resistance of the battery, r, was found to be 0.35 Ω. This was calculated by dividing the difference between the multimeter readings in photos 3 and 2 by the reading in photo 4.

The current in the circuit, I, as shown in photo 4, was recorded for different lengths of the strip. Taking the emf of the battery as 1.568V (see photo 3 which shows the potential difference across the battery in open circuit) and the value of the internal resistance of the battery as 0.35 Ω, the value for the resistance of the strip, R, was calculated as its length was increased:

$$R = \frac{emf}{I} - r$$

The graph shows the results obtained with a cubic line fitted to the data. The results are in almost perfect agreement with the information SEP supplies with the strip, which states that "its initial resistance is around 4 Ω rising to about 15 Ω before decreasing to about 6 Ω".

1. The Gatsby Science Enhancement Programme (SEP) sells the conductive fabric through Middlesex University Teaching Resources (http://www.mutr.co.uk/product_info.php?products_id=1009614)

ROLLS ROYCE MATERIALS MASTERCLASS July 2010

Stephen Burrowes, Associate Director, Science Learning Centre West Midlands.

Once again, Rolls Royce and the University of Birmingham Metallurgy and Materials Department were able to provide a wonderful opportunity for Science and Design & Technology teachers to find out more about the fascinating field of materials during this 2-day event. In addition to the experiences at the University of Birmingham, the teachers still have a visit to the Rolls Royce plant at Derby and affiliation to the Institute of Materials, Minerals and Mining to look forward to. Truly the gift that keeps on giving!

Participants hailed from as far afield as Qatar and Bexhill and all appreciated the expertise, commitment and approachability of the team of presenters led by Dr Hanshan Dong.

There was a wide range of experiences on offer. The "Crash helmets for eggs" activity became very competitive and rules were bent. In "Composites and sensors" with Professor Gerard Fernando we discovered that there is a bridge on the B4580 which is made solely from composites and has embedded sensors which can tell the difference between a car and a bike. Next it was out with polarizing microscopes to watch crystal growth in polymers and how speed of cooling affects structure. There was an amazing array of ceramic products on display during the "Piezoelectric Materials" session with Hanna Hughes – a real eye opener if you think that ceramics are confined to 'sanitary ware'. During "Impact Testing" with Dr Milorad Novovic it was fascinating to reflect that the same very basic but precise Charpy test has been used since 1905. The "Materials courses and careers" session usefully demonstrated the flexible range of options available at the University of Birmingham and the careers that these can lead into. In "Materials in Sport" with Dr Hanshan Dong we learned that modern vaulting poles consist of 3 layers, whilst in golf "wedges" generate backspin to stop the ball quickly on the green using a titanium/ diamond coating. Dinner was a sociable affair but surprisingly no one ventured out clubbing to Birmingham city centre. At least if they did, they didn't admit it the following morning.

After a good breakfast, we were treated to an informative talk by Dr Paul Withey which detailed "Casting Technology" at Rolls Royce and this was illustrated by a wide range of pieces of turbine blades. Following this in the "Functional Materials – magnets" talk delivered by Dr Andy Williams we learned that magnets were referred to in a Chinese manuscript dating from 645 BC and that neodymium, iron and boron is the best material for a magnet. and We were treated to the sight of a beautiful shape memory alloy flower 'blooming' by Dr Dong before having the opportunity to find out for ourselves the transition temperature for a particular shape memory alloy spring. The Shakespearean adage "all the glistens is not gold" was put to the test using a scanning electron microscope to observe the surface and analyse the composition of a 24 carat gold ring. The results showed that significant amounts of copper and zinc were also present in the sample. I suspect that this result may have repercussions since it is not what might be expected for a 24-carat ring!

Participants went away extolling the virtues of Rolls Royce, the Metallurgy and Materials department and its staff at Birmingham University and still have the site visit to Rolls Royce to look forward to. All were even more enthusiastic about materials and their possibilities than when they arrived so it would be fair to say that this was another very successful Materials Masterclass. Particular thanks should go to Dr Hanshan Dong and Carolyn Green (University of Birmingham, Metallurgy and Materials), Erica Tyson (Rolls Royce) and Michelle Evans (Science Learning Centre West Midlands) for the part they played in organising this event. Thanks to Institute of Materials, Minerals and Mining and Dr Diane Aston, participants' schools will now benefit from the IOM3 affiliation scheme.

Subject to confirmation, the dates of the Rolls Royce Materials Master Class for next year are 12 and 13 July and accommodation will be available on the night of 11 July for those with some distance to travel. We look forward to seeing you there.

ARGON

- Argon has atomic number 18 and atomic mass 39.45. It is one of the of noble gases and sits in Group VIII of the Periodic Table to the right of chlorine and with neon above and krypton below.
- Argon is a gas with a density of 1.784g.l^{-1} at 0°C and a pressure of 101.325kPa; it melts at -189.35°C and boils at -185.85°C.
- Argon is colourless, odourless, tasteless and nontoxic in all states.
- It is about as soluble in water as oxygen.
- The name *argon* comes from the Greek word αργοζ (argos) meaning inactive in view of the fact that it undergoes very few chemical reactions.
- Henry Cavendish suspected that there may be an unknown gas present in air in 1785. In 1882 H.F. Newhall and W.N Hartley independently encountered argon by observing lines in the colour spectrum of air, but they could not identify the element producing them. Argon was finally isolated in 1894 by Lord Rayleigh and Sir William Ramsey. They removed all of the oxygen, nitrogen, carbon dioxide and water from a sample of clean air, leaving the new element argon. It was the first noble gas to be discovered.
- Argon is isolated on an industrial scale by cryogenic fractional distillation of air, in which it is present at a level of 0.934% by volume and 1.29% by weight. It is thought of as a byproduct in the manufacture of pure oxygen and nitrogen and is relatively cheap in price. Around 700,000 tonnes of argon are produced each year by this method.
- Argon is used industrially because of its inactive nature. It is used as the atmosphere in some high temperature processes where relatively non-reactive materials would react with air. For example, an argon atmosphere is used in graphite electric furnaces to prevent the graphite from burning and it is used as a shielding gas when processing titanium. It is also used in MIG (metal inert gas) and TIG (tungsten inert gas) welding processes and an argon atmosphere is used when growing silicon and germanium single crystals.
- Argon can be used as a fire extinguishing medium. This is particularly useful for electrical / computer equipment where traditional extinguishers would cause irreparable damage.
- Argon is used to fill incandescent lightbulbs to prevent the filament from oxidising at the high operating temperature. It is also used for the creation of blue laser light and argon gas discharge lamps produce a purple/blue colour.
- Argon can be used as a preservative in packaging to prevent reaction with oxygen and moisture-rich air. It is used for food, wine, paint and varnish, ancient documents, high purity chemicals and pharmaceuticals.
- Care must be taken when using argon in large quantities in confined spaces as it is very difficult to detect and can cause asphyxiation. Since it is 25% more dense than air it will also hug the ground. This dangerous property of the gas means that it can be used as an asphyxiant for the mass slaughter of poultry.

A piece of rapidly melting argon 'ice'. http://upload.wikimedia.org/wikipedia/commons/0/0d/Argon_ice_1.jpg

Characteristic purple glow of argon gas placed in a high voltage electric field. http://en.wikipedia.org/wiki/File:Argon-glow.jpg

Where can I find out more?

http://en.wikipedia.org/wiki/Argon
http://en.wikipedia.org/wiki/Noble_gas
http://en.wikipedia.org/wiki/Henry_Cavendish
http://en.wikipedia.org/wiki/William_Ramsay
http://en.wikipedia.org/wiki/Lord_Rayleigh
http://en.wikipedia.org/wiki/Air_separation
http://en.wikipedia.org/wiki/Gas-discharge_lamp
http://en.wikipedia.org/wiki/Isotopes_of_argon