CSEM's

Materials Monthly

September 2004 Making materials matter

Picking the glue from the wood

Distinguishing resin in wood composites

Wood composites are mixes of wood particles glued together with resin. While only constituting 4-6% of the final product, resin make up around 20% of its total cost making it the most expensive component of particle board.

▲▲ Olivia holds up a sample of 'industry-quality' particle board that she produced to test a new technique for making resins in the composite opaque to X-rays.

Around a million cubic metres of wood composite products is produced each year in Australia, so this is big business. Surprisingly, given the expense of the resin, we don't know a lot about where the glue goes and how it works in binding together the wood particles. We know it works but we haven't got a good model for why it works. Without this understanding, it's difficult to improve the process and explore techniques for reducing the amount of resin being used.

Traditional forms of analysis have involved taking multiple thin sections of the finished particle board product. Besides being time consuming and labour-intensive, it's difficult to capture the three dimensional nature of the particle/resin matrix using this technique. Could X-ray tomography be a more effective technique for understanding this system?

X-ray CT

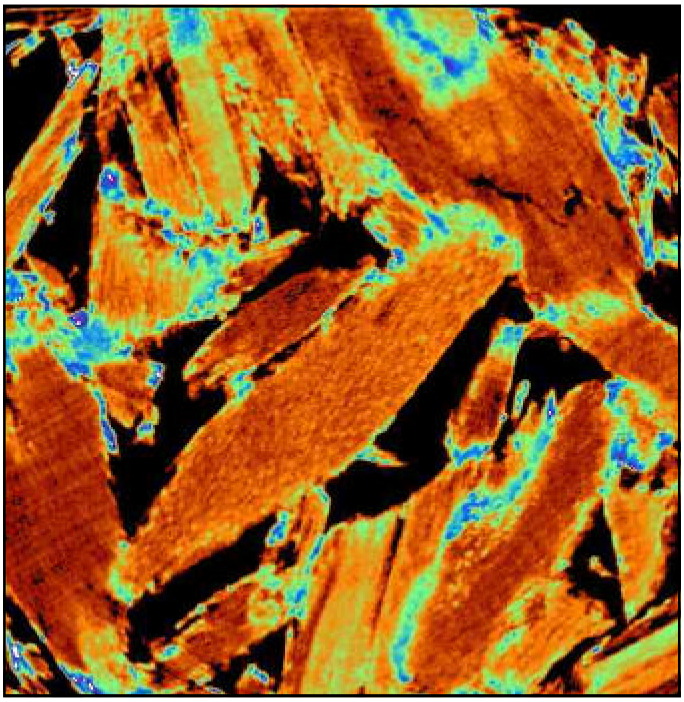
X-ray CT (CT stands for computed tomography) is a process in which an object is scanned with X-rays to create a 3D image of the object.

Medical CT does this by taking thin slices through the object. Another approach is to take radiographs of the sample from different angles, which are then reconstructed to form a tomogram (a 3D density map of the sample). This can be viewed from different angles, and at different depths through the sample.

It's this second approach that is being used by the Department of Applied Maths in the Research School of Physical Sciences and Engineering. The researchers there have built one of the most advanced X-ray CT facilities in the world in that it can measure structures over three scales of magnitude simultaneously – from microns to millimetres. (For a more detailed explanation of the process and the facility in the Department of Applied Maths, see the feature story in April 2002 issue of *Materials Monthly*.)

The facility in Applied Maths has now been running for a few years. Most of the operating bugs have been ironed out, and it's a relatively straight forward process to use it to delve into the structure of many materials. Olivia Morrison, an Honours student studying for your Bachelor of Engineering, wondered if it might assist in throwing more light on resins in particle

(Continued on page 2)



▲▲ The resin (blue) is now easily distinguishable from the wood particles (brown).

Inside this MM

Volume V, Issue 8

Materials Monthly is produced by the ANU Centre for Science & Engineering of Materials

THE AUSTRALIAN NATIONAL UNIVERSITY

the glue from the wood

(Continued from page 1)

board. At first glance it appeared a relatively straight-forward investigation, a good choice for an Honours project. As is often the case, it quickly became more complicated.

Can't see the resin

Olivia set about scanning samples of commercial particle board but a major obstacle was immediately thrown in her path. The X-rays could not distinguish the wood particles from the urea formaldehyde resin that bound them together. Now if this was the centre of a major research effort you'd start figuring how you might get around the obstacle. However, when it's the subject of an Honours project in which you have extremely limited time to carry out the research, this initial result would be a strong signal to find a new project.

But Olivia took the riskier course of exploring how you might distinguish the resin from the wood particles because it was an important challenge with widespread applications. There were two solutions that warranted further investigation. One was to increase the opacity of the wood particles to X-rays. The other was to increase the opacity of the resin to X-rays.

The wood particles could be made more opaque if they were labeled with potassium bromide. The urea formaldehyde resin might be made more opaque to X-rays if it had copper sulfate mixed in with it.

This second possibility arose as a suggestion from Professor Phil Evans, Director of the Canadian Centre for Advanced Wood Projects (and former Director of CSEM). Phil is a regular visitor to ANU and on one recent visit he was discussing the challenge of distinguishing resin in wood composites with Olivia and cited a recent study where copper sulfate was mixed with urea formaldehyde in MDF (medium density fibre) board. This study showed that the copper stays with the resin even under high temperatures, such as those experienced during pressing. No study, however, had tested whether this method would work for X-ray CT.

Do-it-yourself particle board

The problem with these possible solutions is that you have make up new samples of particle board from scratch, and to be meaningful they have to be made to industry standards. Industry, fortunately, were more than happy to lend a hand. (Not surprising when you consider what they stand to gain.)

Using contacts provided by Ray Roberts*, Olivia was provided samples of wood particle from Carter Holt Harvey and the use of Orica's resin facilities in Melbourne. (*Ray, who originally worked at Carter Holt Harvey, has recently completed cutting edge studies at ANU on how fluids penetrate paper, see *Materials Monthly*, November 2003.)

So Olivia was able to produce her own particle boards. Some samples had fibres labeled with potassium bromide. Others were made with resin labeled with copper-sulfate.

While she had limited success with the potassium bromide, the samples with copper-labelled resin worked a treat. The resin could now be clearly distinguished from the surrounding wood particles.

Despite only being an Honours research project, Olivia has developed a new way of imaging wood composites using X-ray tomography. It's an application that promises to revolutionise our studies of wood/resin systems.

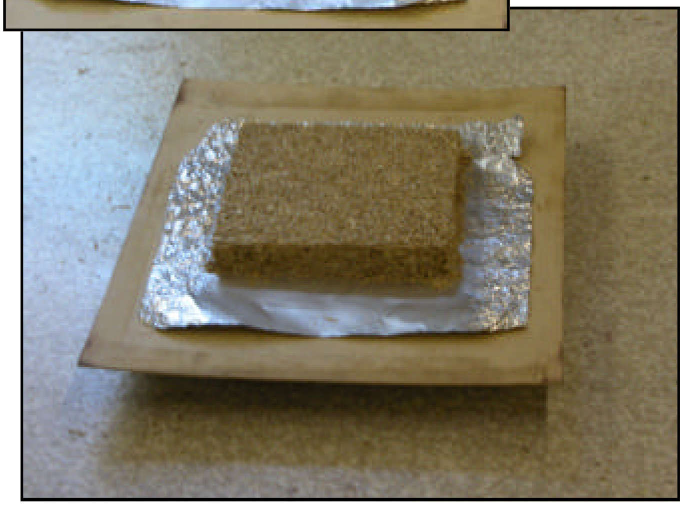
And what were the first results of this process? It seems that when the wood particles are squashed together under pressure that the resin clumps together where the chips are touching. The resin does not form a uniform thin layer over the entire wood particle. This has implications for how other ingredients in the composite mix such as wax and hardener are behaving. What it all adds up to is the topic of whole new research program. Maybe something that Olivia can come back to in the years ahead.

Olivia's supervisors for this project are Dr Tim Senden (Applied Maths) and Dr Adrian Lowe (Department of Engineering, Faculty of Engineering and Information Technology). For more information, please contact Tim Senden (Tim.Senden@anu.edu.au)

Olivia adds resin blended flakes into a wooden frame. This produced a mattress, suitable for pressing. ►►

◄◄ A mattress of unpressed wood particles

A pressed board ▼▼



The quiet room

Up above the lecture theatre in the Engineering Building is a large room with walls covered in thick, dark, polyurethane foam. As soon as you enter the room you're aware something weird is happening, though it's difficult to pin down exactly what it is. The difference is an un-natural quiet. Indeed, the quiet is so potent it seems to suck the strength from any noise made in the room, including the character of your own voice.

What you're experiencing is the Engineering Department's anechoic chamber. 'Anechoic' literally means 'without echo', and that's what you're experiencing. The thick foam acoustically isolates the room from the outside and dampens any noise (and a wide range of radio frequencies) being produced by any object operating inside thereby preventing any echo. The feeling produced is one of utter isolation.

Anechoic chambers are widely used for measuring the acoustic properties of acoustic instruments, measuring the transfer functions of electro-acoustic devices, testing microphones and performing psychoacoustic experiments.

As an example of its application for testing materials, Engineering student Matt Curtis has used this anechoic chamber to test the insulating properties of aluminium sandwich composites for cars. Aluminium sandwich composites are thin layers of aluminium with a polymer resin sandwiched in between. It's believed that these sandwich composites might provide excellent sound proofing in cars. It's thought they might be particularly effective at keeping out low frequency noises generated by the motor. To test how they might perform Matt built a foam box and placed a microphone inside (he created a mini-anechoic chamber). He then placed a sheet of aluminium composite over a hole into the box and exposed the box to range of sounds to test what was being picked up inside the box. To ensure the sounds he was using were pure he carried out the test inside the anechoic chamber.

▲▲ Matt Curtis prepares to take his mini anechoic chamber into the quiet room. Note how thick the foam is on the door into the chamber.

The chamber has also been used to test the propagation characteristics of the wireless network in the engineering building. The aim is to determine whether introducing material enhancers (similarly to acoustic enhancers in lecture theatres) will improve the performance of the network. This could be either with materials that absorb the signals or reflect them better than the walls.

The chamber was originally constructed by Professor Bob Williamson (who is now Director of the NICTA Canberra Research Laboratory).

More information on the chamber: Dr Haley Jones <Haley.Jones@anu.edu.au>

▲▲ Matt with Haley in the Engineering Departments anechoic chamber.

The sounds of silence

In the 1940s, John Cage, a famous experimental musician sat for while in an anechoic chamber at Harvard University. He expected to hear nothing, but as he wrote later, he "heard two sounds, one high and one low. When I described them to the engineer in charge, he informed me that the high one was my nervous system in operation, the low one my blood in circulation." Whatever the truth of these explanations, Cage had gone to a place where he expected there to be no sound, and yet found some. "Until I die there will be sounds. And they will continue following my death. One need not fear about the future of music." His realisation of the impossibility of silence led to the composition of his most notorious piece, *4' 33?*, a musical score with no sound.

Words of substance

"Scientists do not believe; they check. I am not asking you to believe anything I say on a scientific matter; only that there is tested evidence for all of it, and that I know the nature of that evidence and can make a judgement of its worth."

John Cornforth

Materials World Network

The Australian Research Council (ARC) has entered into a cooperative agreement with the US National Science Foundation (NSF) to stimulate enhanced collaborations among materials science researchers and create networks linking individuals and centres in Australia and the USA.

The ARC is providing funding under the Linkage-International program for researchers to participate in the NSF Program Materials World Network (MWN). The MWN includes joint activities between NSF and funding organizations in the Americas, through the Inter-American Materials Collaboration; Europe, including national European funding organisations, the European Science Foundation, and the European Commission; and other funding organisations.

The ARC is holding discussions with funding agencies in the Asia-Pacific region with the view of expanding the initial collaboration into an Asia-Pacific Materials Science collaboration.

More info: **www.nsf.gov/pubs/2004/nsf04599/nsf04599.htm**

Alert to science

ScienceAlert is a new Australian website that carries topical news items and feature articles from leading scientific research organisations as an information service to science, industry, the media, government and the community. There is no charge for its use, reproduction or linking. No registration is required.

It's a brilliant site that delivers quality science stories without all the bells and whistles that dog you on most science news sites. It also carries an extensive list of science events and jobs. The site has been set up by Julian Cribb, one of Australia's foremost science journalists (and former Director of CSIRO media).

Check it out at: www.sciencealert.com.au

For an article with specific interest to materials scientists, have a look at the feature story on the famous Australian chemist John Cornforth (see http://www.sciencealert.com.au/features/cornforth.htm)

"The chemists who create new compositions of matter have transformed, to an even greater extent, the modern world. They began to do this not much more than a century ago, starting with things like dyestuffs and medicines that are valuable but not needed in very large quantity. Sometimes, the things that they learned to produce were already known in nature; now, most products have no natural equivalent, they were created to satisfy the wants of an ever more complex society. New metals, plastics, composites, textiles, adhesives, coatings, rubbers, insulators, conductors, semiconductors, superconductors, optical fibres, detergents, ceramics .... the list is much longer than this, and chemists created the material for them all."

an extract from a speech delivered to the RACI by John Cornforth in 1992. (also, see quote on p3)

Science in motion

Velocity: Science in Motion is a free, quarterly e-newsletter that has just been launched highlighting breakthrough Australian science from a range of agencies and individuals. Published by ANSTO - the Australian Nuclear Science and Technology Organisation.

The first issue features stories on: ANSTO research into crocodile blood - with the aim of creating a human blood replacement; CSIRO mineral sands research that has the potential to trap pollutants; an avalanche prediction device; ANSTO's replacement research reactor; an exhibition at one of Australia's premier science museums, Questacon; and radiopharmaceutical research.

It's free. Check it out at: http://velocity.ansto.gov.au

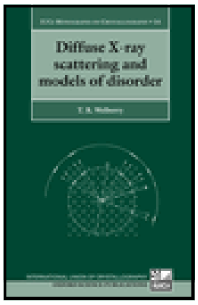
Digital theses

The Australian Digital Theses Program (ADT) is to be upgraded to enable the creation of an online directory of all research theses and dissertations from Australian universities. The ADT's current repository content will expand to provide an index to all Australian higher degree theses, whether in digital form or not, no matter when or where they were awarded.

The ADT Expansion and Redevelopment Project has been funded by the Department of Education, Science and Training (DEST) through the Australian Research Information Infrastructure Committee (ARIIC) program.

More info: http://adt.caul.edu.au/

Diffuse X-ray scattering text



Diffuse X-ray scattering is a rich (virtually untapped) source of local structural information over and above that obtained by conventional crystallography. Professor Thomas Welberry from the RSC has recently authored a major new textbook on the topic that has just been released by Oxford University Press.

The 288 page book aims to show how computer simulation of a model crystal provides a general method by which diffuse scattering of all kinds and from all types of materials can be interpreted and analysed.

Aimed at graduate students and research scientists working in solid state structural science in physics, chemistry, mineral sciences, materials sciences and engineering, you can read all about it (and order it) at: **http://www.oup.co.uk/isbn/0-19-852858-2**

Grab bag

World Year of Physics 2005

2005 has been recognised by the UN as the World Year of Physics. A variety of events are planned for the year that will bring the excitement of physics to the public and inspire a new generation of scientists. Timed to coincide with the centennial celebration of Albert Einstein's "miraculous year," the World Year of Physics will be coming to YOU before you know it.

The General Assembly of United Nations declaration statement reads as follows

- *Recognizing* that physics provides a significant basis for the development of the understanding of nature,
- *Noting* that physics and its applications are the basis of many of today's technological advances,
- *Convinced* that education in physics provides men and women with the tools to build the scientific infrastructure essential for development,
- *Being aware* that the year 2005 is the centenary of seminal scientific discoveries by Albert Einstein which are the basis of modern physics,
- 1. *Welcomes* the proclamation of 2005 as the International Year of Physics by the United Nations Educational, Scientific and Cultural Organization;
- 2. *Invites* the United Nations Educational, Scientific and Cultural Organization to organize activities celebrating 2005 as the International Year of Physics, collaborating with physics societies and groups throughout the world, including in the developing countries;

3. *Declares* the year 2005 the International Year of Physics.

The resolution was approved by acclamation the 10th of June, 2004 .

More info: http://www.physics2005.org/

And what better way to kick off the year in Australia than with 'Physics for the Nation', the 16th Biennial Congress of the Australian Institute of Physics being staged at ANU from 31 January till 4 February 2005 (see back page for more details)

Building vocal vowels

ANU has lent a hand to Questacon in building a precision set of plastic tubes for use in a new display it's developing on sound. Normally, these tubes would have been produced through a time-consuming and expensive process where their shapes are caste in solid resin blocks. ANU's School of Art, however, were able to produce them with a push of a button.

The new exhibition is called 'Strike a Chord- the Science of Music', and the plastic tubes will serve as 'vocal tracts'

"The vocal tracts demonstrate how different vocal vowel sounds are partly created by people constricting and relaxing parts of their vocal chords, throat and mouth," says Ms Ella Cameron, part of the Questacon team building the exhibit. "The exhibit consists of air bellows, a duck call reed and the 5 different tracts. Each of the tracts represents the throat making different sounds- AAAA, Ehhhh, EEE, Ohhh, and OOOO.

As the vibrations from the duck call pass through the different shaped tracts, certain vibration frequencies are favoured, thus creating the different vowel sounds."

Given the tricky nature of the tube shapes, the team at Questacon looked around for clever way to produce them and investigated the process of 'rapid prototyping'. In rapid prototyping, a computer design can be transformed in three dimensional solid plastic object. And, as it happened, the Computer Art Studio in the ANU School of Art owned and operated a Rapid Prototyper.

"Once an object has been modelled using Computer Assisted Design software, the object is analysed and sliced into hundreds of thin layers (up to six layers per mm)," says Gilbert Riedelbauch, Lecturer in Charge of the Computer Art Studio. "These cross-sections are then laid down one by one in fast-setting, white, molten modelling plastic. Each layer fuses onto the layer underneath. As the layers build, the design takes form."

"We had never tried rapid prototyping before at Questacon, so it was a good excuse to try out the technology," says Ms Cameron. "I approached the School of Art to see if they could help us, and Gilbert was only too happy to give it a go. Next thing we know, the vocal tracts have materialised from nowhere."

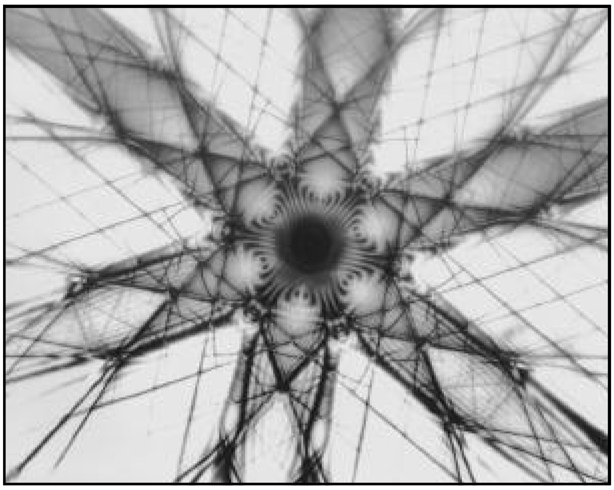
Strike a Chord will open in March 2005.

For more stories on the work of the rapid prototyper, see the March 2003 issue of Materials Monthly

More info on rapid prototyping: Gilbert.Riedelbauch@anu.edu.au

Gilbert and the tubes

Pick the pic



A crystal shining bright

The image shown here is a diffraction pattern from a thin and perfect silicon crystal using electrons accelerated through 300,000 volts potential. The crystal was aligned so that a <111> crystal axis was parallel to the illuminating electron beam. Using the lenses of the ANU's EM430 electron microscope (based at the Research School of Earth Sciences), the electron beam was converged near the crystal surface, so that the illumination angle was much larger than conventionally used.

This pattern, which consists of six equal 60-degree wedges around a centre, was captured by Dr John Fitzgerald, RSES. It is an example of a Large Angle Convergent Beam Electron Diffraction (or LACBED) pattern, and shows the symmetry of the silicon crystal structure viewed in this orientation, as well as its total lack of defects (as indicated by the mesh of background lines in the pattern being sharp, straight and regular). These patterns reveal a lot of information about the structure of a crystal.

More info: john.fitzgerald@anu.edu.au

Facets of international materials research

Do you have an interest in international materials science? The newsletter *Facets* is an excellent way of keeping in touch with international materials issues. It contains articles from all materials communities and is distributed widely. The current issue carries stories on chemistry in materials education, a new course on engineering nanoscience, biomimetic nanotechnology, fluid movement through paper (which is an ANU story), and materials research in microgravity.

Facets is produced by the International Union of Materials Research Societies. The Union was established in 1991 as an international association of technical groups or societies which have an interest in promoting interdisciplinary materials research.

The editors of Facets would be happy to receive articles of interest to the international advanced materials community on topics such as technology advances or development initiatives.

Contact CSEM if you would like to have a look at the current issue.

Physics for the nation

31 January—4 February 2005, ANU

The Organising Committee of the 16th Biennial Congress of the Australian Institute of Physics would like to invite you to participate in the largest gathering of physicists in Australia since the 1988 Bicentennial Congress, and perhaps the largest ever.

The timing of the Congress has been selected to coincide with the 2005 World Year of Physics (see page 5), which will celebrate 100 years since Einstein's famous discoveries in relativity, quantum theory and Brownian motion. The Congress will mark this international event and will highlight the important contribution that Physics has made to Australia. It's being staged right here in Canberra, the Nation's capital, and is running under the theme – "Physics for the Nation".

In addition to a dazzling array of presentations and discussions from a diverse range of physics disciplines, there will also be sessions on the wide-ranging benefits of physics to science, the economy, and the community. There will also be a "Physics in Industry" session in which problems requiring a physics solution posed by industry will be addressed at the Congress.

Don't miss it.

More info:
http://aipcongress2005.anu.edu.au/index.php

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