CSEM: ANU's Centre for Science and Engineering of Materials

Materials Monthly

Making materials matter June 2001

From thought to hard reality

Sitting next to the Canberra School of Arts is a small demountable building that contains a wonderful machine that can turn your thoughts into solid, 3D objects. It's not magic, it's the FDM8000, the largest rapid prototyping machine of its kind in Australia. And while it doesn't run on 'thought waves', it does allow you to convert your computer designs into working, plastic models at the touch of a button.

The FDM machine (FDM stands for Fusion Deposition Modelling) was only acquired last year by the School of Arts but it's already generating some exciting prototypes: for both art and science. As a result of an article appearing in the October issue of *Materials Monthly* several scientists have approached Gilbert Riedelbauch, Lecturer in charge of the Computer Art Studio and officer in charge of the FDM8000, to use the machine to turn their thoughts into objects.

Prof Stephen Hyde from Applied Mathematics, RSPhysSE, has long studied the role of curvature in a wide range of materials. He wanted to explore a complex mathematical shape he had created on the computer and had the FDM8000 build him a model.

Dr. Glen Johnson, Centre for Sustainable Energy Systems, ANU, heard about the machine and had a model of a lens concentrator system built.

"It's wonderful watching people hold up their 3D solid models for the first time," says Riedelbauch. "They are seeing and touching what has been up till then abstract thoughts existing only in virtual space. It's one thing

(Continued on page 2)

Left: Gilbert Riedelbauch holds a 'twisted sphere', a 'hard copy' of Prof Stephen Hyde's complex mathematical shape. The rapid prototyper converted Hyde's idea from virtual space to real life.
Above: the 'twisted sphere' close up.

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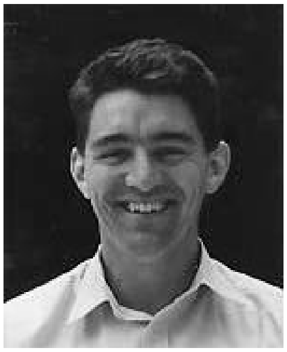

Direct from the Director

Phil Evans, Forestry Department

Until recently CSEM paid scant attention to materials science at the undergraduate level. After all, our mandate excludes specific mention of undergraduate education, and there is a school of thought that believes that the 'best' materials scientists train in the 'pure' sciences at the undergraduate level and then go on to specialise in one of the many parepistemes that constitute materials science.

Last year, however, CSEM decided to put a lot of the effort into developing coherent materials science streams within the framework of the B.Sc (see http://www.anu.edu.au/CSEM/newundergrad.html for further details of these streams). We started promoting these streams in September of last year and based on enrolment data gathered by Nick Welham it appears as though six undergraduate students were attracted to the ANU by our program. Not a bad effort considering that enrolment in some other B.Sc programs run by fully fledged departments were as low as 12!

This year we have been putting additional effort into developing the BSc (materials) focussing on forensics, which is particularly attractive to students at present.

What prompted CSEM to change tack and put its effort into developing an undergraduate program when one of its major aims is to increase postgraduate numbers in materials science? Last year, Jenny Edwards was able to obtain figures from the Graduate School which showed that around 40% of ANU's postgraduates are derived from its undergraduate population. Therefore, without a substantial element of materials science in the B.Sc or B.Eng, the chances of building a large, viable postgraduate program are severely diminished.

The numbers of postgraduate students affiliated with CSEM have remained stubbornly low. Our initiative at the undergraduate level is a step towards reversing the situation.

(From thought to hard reality, continued from page 1)

to see and build a design on the screen and quite another to touch it and study it from every angle. It gives you a whole new perspective on what you're attempting to create, and often provides the insight on where next to take the design."

The prototyper works by analysing a computer 3D design and then slicing it into hundreds of thin layers. These slices are then fused one by one in the form of a fast-setting, white, molten ABS plastic. As the layers build, the design takes form.

Where required support structures are added in by the machine. These are laid down as brittle grey plastic and serve as scaffolding to support the model as it grows. When the prototype is finished, the support plastic can be broken away leaving the model by itself. The ABS plastic can be tested, sanded, painted and drilled. There's even a 'medical grade' ABS for creating prototypes for clinical trials.

Riedelbauch says the machine can also be upgraded with 'waterworks'. In this system the plastic support structure is water soluble and is dissolved away when the model is complete. This allows models with working gears and moving parts to be created in one treatment – no assembly required.

While the FDM8000 is based at the Canberra School of Arts, Reidelbauch is pleased to see scientists using its potential. "We're delighted in the collaborations that have grown out of last year's story in *Materials Monthly*, and I'd be happy to discuss further work with any interested scientist," says Riedelbauch.

With an upgrade the FDM8000 can build models with moving parts and cogs that don't need assembly.

For more information
contact

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For background on the FDM8000 see www.stratasys.com

Materials on Campus

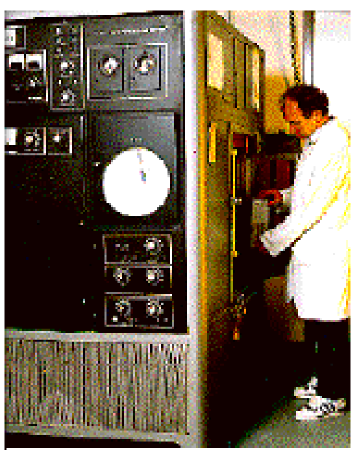
Forest Products Technology

The Forest Products Technology group sits within the Forestry Department, which was recently dissolved and now forms part of the School of Resource, Environment and Society. Research being carried out by FTP revolves around better understanding wood and improving its suitability for use outdoors.

Photodegradation and Stabilisation of Wood

A major area of study for the FPT group is the photodegradation and protection of wood. Wood is highly susceptible to photodegradation by UV and visible light.

The transmission of visible light through clear finishes (varnishes) on wood and degradation of the underlying substrate explains why such finishes, even those based on highly durable fluorine resins, perform badly on wood. This observation provides a practical incentive in developing treatments that can photostabilise wood. The most successful way of photostabilising polymers is to graft photostabilising chemicals to the polymer chains. FPT has used this approach (amongst others) to photostabilise wood. A range of UV absorbers with reactive functional groups have been synthesised and 'grafted' to wood. Tests have shown that UVA grafted wood is highly resistant to photodegradation and accordingly the longevity of clear finishes applied to wood is considerably enhanced.



Testing the weather resistance of timbers

Wood Cement Composites

Wood cement composites consist of wood strands with particles or fibres imbedded in a mixture of Portland cement. They are highly resistant to weathering as well as decay, and are cheap and easy to manufacture in small, low-cost plants. One type of wood cement composite, wood-wool cement boards (WWCBs), is manufactured in several plants in the Philippines and used in the construction of low-cost (affordable) housing.

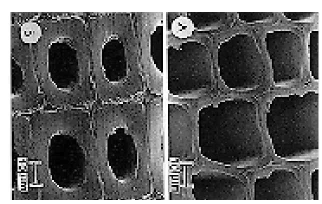
At present, WWCBs are mainly used as a sheathing material because they lack sufficient strength for structural applications. Research undertaken by a postgraduate student, Rico Cabangnon, in FPT has led to the development of a solution to the problem of the poor strength of WWCBs. The solution revolves around changing the structure of the boards, specifically achieving a 3-layer cross-ply structure in which wood strands in the centre of the boards are orientated perpendicularly to those in the core.

This technique for improving the strength of composites is well known and accounts for the impressive strength of plywood. However, it is rarely used in practise to improve the properties of particulate composites because of the difficulties of orientating fibrous elements.

A variety of wood composites

In the Philippines, commercial WWCB factories produce composite mats by hand and thus there is the potential, as yet unrealised, of developing boards in which structure is altered to improve properties (the essence of materials science). Experimental research has shown that the bending strength of WWCB's can be doubled by changing board structure from a random to a cross-ply orientation. Research is underway to plan a trial of the technique in commercial plants in the Philippines.

As mentioned in a previous newsletter (Dec, 2000), Mr Cabangnon was given a special mention for his research by the Far Eastern Economic Review as part of their Young Inventors Award.



EM images of wood

Other areas of research

FPT is also active in the areas of wood anatomy and relationships between structure and function (R Heady), quantification of surface checking of wood (Chrishy, Senden and Evans) and resin-paper composites (Roberts, Senden, Knackstedt).

Further information

see: www.anu.edu.au/Forestry/wood/wood.html

ANU Forestry

Jobs & Scholarships

Computational Chemistry and Biology Postdoctoral Fellows and Postgraduate scholarships (closes 30/6/01)
Research School of Chemistry
http://www.anu.edu.au/hr/jobs/academic.html#rsc330

Argon Research Scientist (closes 29/6/01)
Research School of Earth Sciences
http://rses.anu.edu.au/prise/Prise.html

Associate Professor, Biomaterials (closes 1/7/01)
University of Connecticut
http://jobs.ac.uk/jobfiles/CD877.html

Research Posts in Metals, 2 positions (closes 22/6/01)
Queens University of Belfast
http://jobs.ac.uk/jobfiles/TA504.html

Research Associate, Processing Aluminium (closes 5/7/01)
Manchester Materials Science Centre
http://jobs.ac.uk/jobfiles/HJ216.html

Post-Doctoral Research Associates, Glass Optics (closes 22/6/01)
University of Southampton
http://jobs.ac.uk/jobfiles/LE164.html

Post-doctoral Research Associate, Iron and Nickel Base Alloys (closes 15/7/01)
University of Manchester Institute of Science and Technology
http://jobs.ac.uk/jobfiles/NA926.html

EEC: Research Fellowship, Nano-structured Anodes for On-chip Battery Applications (closes 13/7/01)
Imperial College, London
http://jobs.ac.uk/jobfiles/HJ010.html

Postdoctoral Research Fellowship (and Studentship), Nanocomposite Synthesis (closes 22/6/01)
Queen Mary, University of London,
http://jobs.ac.uk/jobfiles/BC949.html

Thesis Opening, Aluminium Composites (closes 8/7/01), Swiss Federal Institute of Technology
http://jobs.ac.uk/jobfiles/BC942.html

Post-doctoral Research Associate, Surface Science (closes 30/6/01)
University of Cambridge
http://jobs.ac.uk/jobfiles/HI972.html

For Your Diary

- **IOOC & OECC / ACOFT** — **28-30 June**
  Integrated Optics and Optical Communications & OptoElectronics Communications Conference / Australian Conference on Optical Fibre Technology see www.tourhosts.com.au/oecciooc/invitation.html

- **Advanced Engineered Wood Composites (AEWC)** — **14-16 August**
  2nd International Conference, Bethel, Maine, USA
  see www.materials.qmw.ac.uk/ecocomp/

- **Eco-Composites (EcoComp)** — **3-5 September**
  International Conference, Queen Mary, University of London, London, UK
  see www.aewc.umaine.edu/conferences/default.htm

- **Stellarator Workshop** — **24-28 September**
  13th International Workshop, ANU, RSPhysSE
  see www.rsphysse.anu.edu.au/admin/stellarator/

- **International Proteomics Conference (IPC 2001)** — **30 Sept - 4 October**
  International Conference, Nat Convention Centre, ACT, Australia
  see www.ludwig.edu.au/jpsl/news/ipc2001/ipc2001.html

The Big Chill

It's one of the rarest, coldest and most exotic materials in the Universe – a Bose Einstein condensate – and it's been created for the first time in Australia by a team of scientists from ANU's Department of Physics.

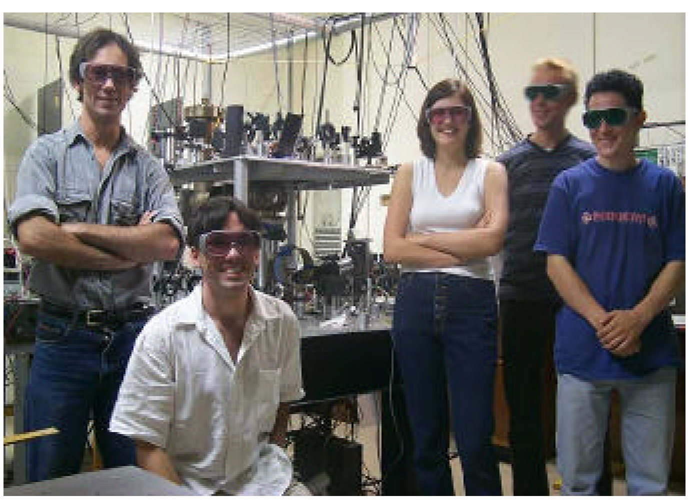
A Bose Einstein condensate, or BEC for short, is formed when atoms are cooled down to almost absolute zero (-273°C) and they are incredibly difficult to create. Only a handful of scientists in the world have been successful.

The ANU team consists of Dr John Close (group leader), PhD students Jessica Lye and Cameron Fletcher, and Visiting Fellow Dr Ulrich Kallmann. They created a BEC by cooling approximately a million rubidium atoms down to 100 billionths of a degree above absolute zero.

The atoms were first cooled in laser beams to 20 millionths of a degree above zero. The cloud of atoms was then held in a magnetic trap that allowed hotter, more energetic atoms to escape. Eventually the remaining atoms became cold enough to condense into a BEC – a state in which all the atoms in the condensate are the same.

BECs are a fifth state of matter that behaves quite differently to the other four (solid, liquid, gas and plasma). They straddle the boundary between the everyday world and the quantum world and are so exotic and new that scientists still aren't certain on how they can be applied. However, the strong belief is that BECs will be solving some fundamental questions in physics and could well underpin revolutions in atom lasers, atom interferometers and computer chips.

See **photonics.anu.edu.au/aoptics/** to learn about the ANU breakthrough. See **www.colorado.edu/physics/2000/bec/** for an excellent introduction to BECs.



The ANU-BEC group in front of the BEC machine. From left, John Close, Cameron Fletcher , Jessica Lye, Ulrich Kallman and Ben Sheard (a visiting vacation scholar).

Mother of computers

ANU is the host of one of the world's newest and most powerful supercomputers.

Established by the Australian Partnership for Advanced Computing (APAC), the Compaq computing system, known as the National Facility, is among the 60 most powerful computer systems in the world. By October it will have 120 Compaq alpha servers, 480 processors, 508 gigabytes of memory and 10 terabytes of storage.

APAC is a partnership between 29 universities and CSIRO. It established the National Facility to provide researchers with a computing capacity some 5-10 times larger than is currently available at Australian unis.

It began operation in April and is currently being used 24 hours a day by over 100 users from around Australia. Over 2/3 of its resources are available to researchers at universities on the basis of merit.

Users are producing designs, models and simulations that have not previously been possible. Projects include analysing proteins for designer drugs, modelling superconductor structure, simulating turbulent flow and understanding crystal structure to develop new plastic materials.

For more information, visit: www.apac.edu.au/

Material Grabs

Vibrations produce stronger plastics
A Lehigh University professor has developed a simple, software-directed device that vibrates molten plastic in an injection mold to produce stronger plastics. **(see www.globaltechnoscan.com/30May-5June01/plastics.htm)**

3D Photonic band gap crystals
Scientists from Toronto Uni have developed a blueprint for a 3D photonic band gap material that is suitable for large-scale microfabrication.
(see albatros.physics.utoronto.ca/PBG/SquareSpirals/index.html)

Molecular rulers measure nano-scale wires
Using organic molecules as "molecular rulers", scientists at Pennsylvania State Uni have demonstrated they can make wires from 15 to 70 nanometers wide and a few micrometers long that are spaced 10 to 40 nanometers apart.**(see pubs.acs.org/cen/topstory/7907/print/7907notw5.html)**

Twisted nanotubes
The electrical resistance of carbon nanotubes can be controlled by rotating them according to a researcher at NC State Uni. This may help designers of future nanoscale electronic devices and actuating systems. **(see nemo.physics.ncsu.edu/~nardelli/mylib/carbon.pdf)**

MM webspotting

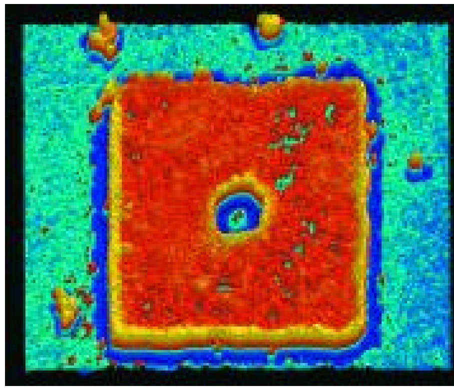
Global Techno Scan
www.globaltechnoscan.com/
A weekly news site showcasing new technology

NASA chemistry and materials
www.sti.nasa.gov/scan/chem-mat.html
Materials and space

Physics 2000
www.colorado.edu/physics/2000/cover.html
A fabulous interactive journey through modern physics with a fascinating tutorial on Bose Einstein condensates

NOVA Science
http://www.science.org.au/nova/index.htm
Good Ozzie science education from the AAS. See hydrogen

Picture this



To get a 30 nm gold dot in the centre of hole in a gold square you need a very steady hand or a molecular ruler (see Grabs, p5).

CSEM

Centre for Science & Engineering of Materials

Faculties
Department of Chemistry
Depart of Engineering
Department of Forestry
Department of Geology
Department of Physics

Institute of Advanced Studies
Research School of Biological Sciences
Research School of Chemistry
Research School of Earth Sciences

Institute of the Arts

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We welcome any feedback, enquiries or contributions.
Please let us know if you wish to be added to our electronic or postal mailing lists.
Electronic copies of *Materials Monthly* can be accessed at:

www.anu.edu.au/CSEM