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

Materials Monthly

Making materials matter

October 2001

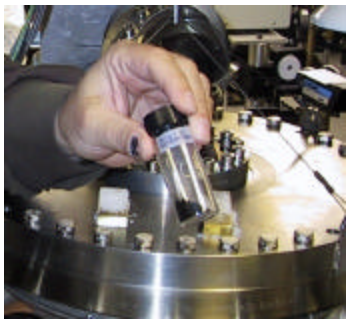
Laser-laid material

GETTING MORE FROM A PULSE OF LASER BEAM

Pulsed laser deposition (PLD) is not a new way of forming high-quality thin coatings but scientists from ANU's Laser Physics Centre have refined the technique to such an extent that they're now creating novel materials with extraordinary characteristics.

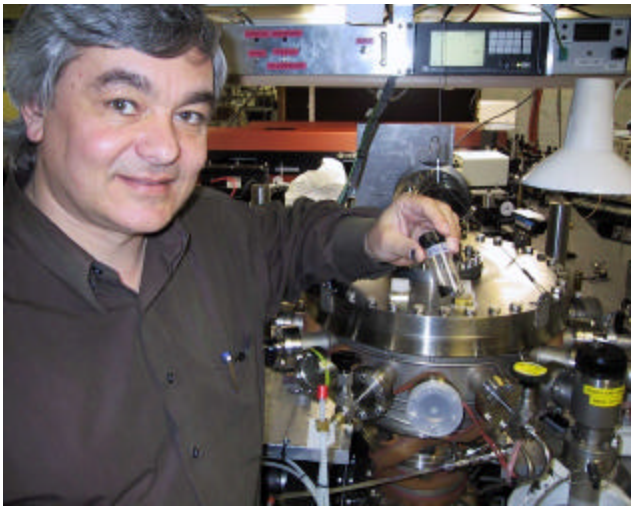
PLD is fairly straightforward. A high-intensity, pulsed laser beam is focussed on a target in a chamber that's either evacuated or filled with a specific gas such as argon, oxygen or nitrogen. The laser beam causes the target material to vaporise (or ablate) into the chamber. A substrate to be coated is placed in the path of the laser-produced plume, and the vapour clings to its surface, forming a thin layer of the ablated target material. It's possible to build films of specific thickness by using an appropriate number of laser pulses.

PLD can produce diamond-like coatings that make a surface nearly diamond hard, or high-temperature superconducting films that may pave the way for practical superconducting devices. It has the highest instantaneous deposition rate among all other known deposition methods (such as electron-beam deposition or magnetron sputtering).



However, for all it's advantages, there are several technical obstacles that stand in the way of its widespread commercial use. Its main drawback has been the deposition of particulates on the film resulting from inhomogeneities in the material being vaporised by the laser. These particles produce a lumpy film of uneven character.

After a detailed investigation of the problem, scientists at ANU's Laser Physics Centre have proposed a new approach in PLD which is producing some amazing results. Traditional approaches involve using a pulsed laser beam (the pulses last around 10 nanoseconds or 10 billionths of a second) and firing it repeatedly at the target at a rate of around 10-100 times per second. The ANU Laser Physicists, led by Dr Andrei Rodes, are using much shorter pulses (measured in million, billionths of a second) with a much higher repetition rate (a million times per second).



Dr Andrei Rode with a vial of carbon nanofoam in front of the equipment that produced it. (Vial seen in more detail in top right corner.)

The consequence of using shorter pulses

(continued on page 2)

Inside this MM

Volume II, Issue 8

Direct from the Director

Phil Evans
Centre for Science and Engineering of Materials

As the date for my departure from the ANU looms closer my time is increasingly being taken by the business of moving my family (and dog) to Canada, and my thoughts are being drawn towards my new job and the task of running Canada's national centre for wood products education. This, of course, will be my last editorial for Materials Monthly and there are many people I want to thank for their involvement in CSEM over the last couple of years.

Firstly to CSEM's staff: Jenny Edwards, Amanda Cook, and more recently David Salt and Sylvana Ransley, a big thanks for their ideas, hard work and patience.

Thanks to the members of the management committee (current: Karin Ahrling, John FitzGerald, Heather Kennett, Elmars Krausz, Marc Ridgway, John Thompson, and Zbigneiew Stachurski; and past: Ian Jackson, Rick Pashley, Ezio Rizzardo and Tim Senden), and in particular the chairs Erich Weigold, Darrell Williamson and Denis Evans for giving me the freedom to run the Centre autonomously and for securing our budget.

Peter Beutel of the Department of Forestry, before he moved on to ACT Forests, was always willing to help Centre staff negotiate their way through ANU's complex financial and purchasing system, and he deserves a big vote of thanks.

Thanks also to Andrew Cockburn (Dean of the Faculty of Science), Jan OConnor, Simon Gilmore and staff at the Canberra Institute of Technology for supporting our undergraduate program.

To CSEM's Seminar speakers (see http://www.anu.edu.au/CSEM/seminars.html for a full list of seminars we've run over the last two years), many thanks for entertaining, perplexing and giving us insights into different facets of materials science and engineering. Andy Christy and Nick Welham always stayed on late into the evening after each of CSEM's seminars to help me with the catering arrangements which was much appreciated. Nick also did sterling work in manning CSEM's desk or stand at various open days and during Science Week.

Finally, I would like to thank all those who supported CSEM in other ways by attending the seminars, providing feedback on articles for Materials Monthly and curriculum descriptions for various handbooks.

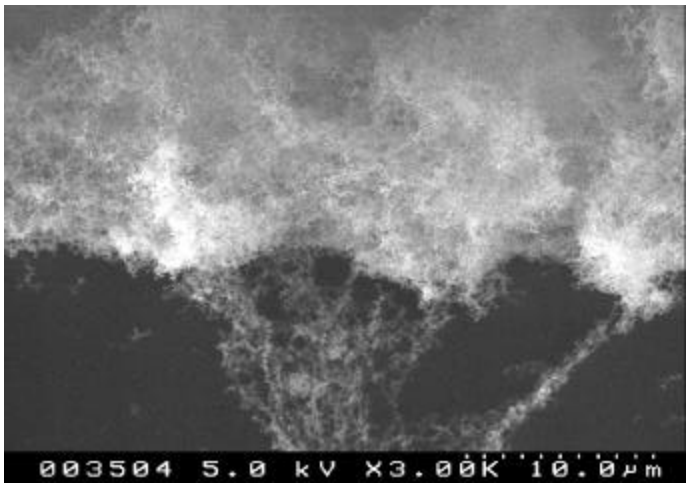
I hope you will continue to support CSEM, and give your full backing to the next Director.

Living in a materials world

As part of CSEM's efforts to promote materials science and engineering to the broader community (and in particular to high school students) we've recently sponsored a special feature on MSE at ANU in *The Helix* magazine. *The Helix* is CSIRO's magazine for science students. It goes to 15,000 students around the country. As well as appearing in the magazine, CSEM has several thousand run-ons of the four page feature. A copy of the special feature is enclosed with this newsletter. If you'd like multiple copies for a promotion please contact CSEM.

(Continued from page 1)

fired more frequently is that fewer atoms are vaporised per pulse but more target material is vaporised overall because the pulsed beam hits the target more often. The result is a faster deposition rate with a much more even film. Known as ultra-fast PLD, the technique is up to 100 times faster than conventional PLD and produces a film that is of a higher quality. And, because the vaporisation can be easily controlled, the nature of resultant film can be easily modified.



Scanning electron micrograph of the carbon nano foam, a novel material built using ultra-fast pulsed laser deposition.

Not only is the technique promising a revolution in thin layer deposition, the laser scientists are producing some amazing materials with the technique. Among several novel materials that have been produced is carbon nanofoam. It's formed when Ultra-fast PLD is used to evaporate graphite in an inert atmosphere of argon. The result is a diamond-like carbon foam that is possibly the lowest density solid substance ever produced (under 3 milligrams per cubic centimetre) with an enormous surface area (300-400 square metres per gram) that's an excellent conductor of heat while possessing extremely low electrical conductivity. What's it good for? Carbon nanofoam is so new that it's still being characterised but with what's known about it already, you can be sure you'll be hearing a lot more about it in the near future.

More information: Andrei Rode at avr111@rsphy1.anu.edu.au

ARC-charged technology

ANU did particularly well in the Australian Research Council grants (announced last month) scoring $24.13 million in new research grants. The funds will be paid over the next five years, with $8.30 million awarded for 2002.

The University was the lead (administering) institution of five successful Linkage: Infrastructure, Equipment and Facilities Scheme grants valued at $1.79 million for 2002. Several of these grants will directly boost ANU's already strong capacity in materials science and engineering. Here are details of the winning infrastructure grants with an MSE connection.

Following that is a list of the project grants awarded in the area of MSE. Full details on all the grants can be found at:<http://www.arc.gov.au/ncgp/outcomes/default.htm>

Congratulations to all grant winners.

♦Infrastructure Grants

High Resolution Mass Spectrometer for (MS)n Chemical Characterisation

($900,000)

Partners: ANU, Uni of Syd, UNSW

Proposal by: Prof Lewis Mander, Prof MJ Crossley, Prof LD Field, Prof CJ Easton, Prof L Radom, Dr SB Wild, Prof LF Lindoy, Prof PA Lay, Dr JG Collins, Prof BG Rolfe

A Fourier transform ion cyclotron resonance ("FT-ICR") mass spectrometer equipped with electrospray ionisation (ESI) plus a "benchtop" matrix assisted laser desorption ionisation time of flight (MALDI-TOF) mass spectrometer are required to support the research of ca 28 research groups, including 44 post-doctoral fellows, and 138 honours and postgraduate students. By means of its high resolution and (MS)n capabilities, the FT-ICR-MS will provide key structural information on a wide range of synthetic and natural chemical substances, including sequence (e.g. peptides) and fragmentation patterns, while the MALDI-TOF instrument will be used primarily for high through-put proteomic analyses.

More information: lewis.mander@anu.edu.au

Bioscope IV: Advanced Scanned Probe Microscopy

($170,000)

Partners: ANU, Monash Uni

Proposal by: Dr Timothy Senden, Dr VS Craig, A/Prof IH Parker, Mr S Ramsden

The Atomic Force Microscope presents a unique view of the microscopic and molecular world, for it is sensitive to force alone. This instrument can accurately map force over a surface at the molecular scale; picoNewtons at nanometre resolution. The host of intermolecular forces which cause phenomena such as self-assembly, colloid stability, cell interactions and friction are only directly measurable with this technique. In this field of force measurement Australian researchers are leaders. The proposed instrument expands the capabilities of this effort, and develops exciting new directions including the direct manipulation of molecules through a novel feedback and control (haptic) interface.

More information: tim.senden@anu.edu.au

Focused Ion Beam System for multidisciplinary applications

($320,000)

Partners: ANU, UNSW

Proposal by: Dr Sally Stowe, A/Prof PR Munroe, Dr TJ Senden

A Focused Ion Beam (FIB) system to be housed in a central facility and configured for maximum flexibility and utility over a very wide range of disciplines and applications. It will be used for micromachining and nanoscale fabrication, as an imaging device sensitive to crystal orientation and as a preparation device for scanning and transmission electron microscopy. It will support research including electronic and opto-electronic materials, nanotechnology, complex mesoscale structures, earth sciences, small system optics, fracture behaviour of polymers and biocomposites.

More information: sally.stowe@anu.edu.au

♦Project Grants

♦**Hydrogen abstraction in chemical, biochemical and polymerization processes** (Michelle Coote)

♦**Surface adsorption, repulsion and attraction: A new experimental approach to surface forces** (Vincent Craig)

♦**Advanced physics and characterisation of silicon materials and devices** (Andres Cuevas)

♦**Organometallic materials** (M Humphrey, MP Cifuentes)

♦**Argon thermochronometers** (Sandra McLaren)

♦**Correlating U-Pb ages with the pressure-temperature conditions of mineral growth** (Daniela Rubatto)

♦**Dynamic force microscopy** (T Senden)

♦**The hydrothermal solubility of molybdenum: A LA-ICPMS study of synthetic and natural fluid inclusions** (T Ulrich)

♦**Ion implantation processing in silicon carbide for microelectronic applications** (Yin-Yin Wong-Leung, BG Svensson)

♦**Seismic wavespeeds and attenuation in upper-mantle rocks: a laboratory study of the effect of partial melting** (Ian Jackson)

♦**Nonlinear photonic crystals** (Yuri Kivshar)

♦**Surface forces in aqueous electrolytes** (Stjepan Marcelja)

♦**Nanocavities in Si** (Mark Ridgway, H Bernas)

♦**The shape of plants; discovering factors that control morphology**(Geoffrey Wasteneys, T Hashimoto)

♦**CesA (cellulose synthase) genes of *Arabidopsis***(R Williamson)

♦**Development and application of stress transfer modelling for area selection in mesothermal gold systems** (Stephen Cox)

♦**High internal phase emulsions - structure and rheology control**
(John White, PA Reynolds, MJ Henderson, RJ Goodridge, DE Yates)

♦**Discovery of new genes for plant cellulose biosynthesis and improved fibre production** (Richard Williamson, T Arioli, CH Hocart)

Positions vacant

Australia

Senior Fellow/Accelerator, Thermal Ionisation & ICP Mass Spectrometry (closes 30/11/01)
RSPhySE/RSES, ANU
http://www.anu.edu.au/hr/jobs/academic.html#PSE560/01

Director/RSPhySE (closes 19/10/01)
RSPhySE/RSES, ANU
http://www.anu.edu.au/hr/jobs/academic.html#RSPhysSE

Postdoc Fellow/Protein Crystallography (closes 26/10/01)
CSIRO Health Sciences and Nutrition, Parkville, Vic
More info: (03) 9662 7100

Scientist/Secondary Ion Mass Spectrometry (closes 19/10/01)
ANSTO, Sydney
http://www.ansto.gov.au/info/vac/vac2001/v87.html

Scientist/Ion Beam Applications (closes 26/10/01)
ANSTO, Sydney
http://www.ansto.gov.au/info/vac/vac2001/v86.html

Petroleum Geoscientist (closes 25/10/01)
AGSO, Canberra
http://www.agso.gov.au/aboutagso/recruitment/agso_vacancies.html#senres

Overseas

Faculty Position/Nanoscale Applied Physics (closes 7/1/02)
Boise State Uni, Biose, USA
http://www.mrs.org/career_services/classified/ads/boise.html

Assistant Professor/Physics, Materials Science (closes 31/12/01)
City University of Hong Kong
http://www.mrs.org/career_services/classified/ads/hongkong.html

Professorship, Center for Electronic Packaging Materials, (closes 30/11/01)
Korea Advanced Institute of Science & Technology, Korea
http://www.mrs.org/career_services/classified/ads/korea.html

Postdoc Fellowships/Nanoscale science (closes 9/11/01), University of Birmingham, UK
http://jobs.ac.uk/jobfiles/RA604.html

Research Fellowship/Nanotechnology(closes 31/1/02)
Toshiba Research & Development Centre, Japan
http://jobs.ac.uk/jobfiles/RA558.html

Research Fellowship/hydrophobicity of surfaces (closes 30/11/01)
Nottingham Trent University, UK
http://jobs.ac.uk/jobfiles/LF103.html

For the Diary

▶▶ Technology Convergence in Composites Applications — **6-9 February, 2002**
ACUN-3 International Composites Conference, Uni of NSW, Sydney
see http://www.materials.unsw.edu.au/events/acun3cover.html

▶▶ Biomaterials 2002 Annual Conference — **19-21 March, 2002**
Annual conference of the Australian Society for Biomaterials, ANU
see <http://www.biomaterials.org.au/

▶▶ Forensic Sciences - Outcomes for Society — **13-17 May, 2002**
16th International Symposium on Forensic Sciences, Nat. Convention Centre, Canberra
see http://www.nifs.com.au/ANZFSS/ANZFSS.html?International_Symposium.asp&1

▶▶ ICPP 2002 — **15-19 July, 2002**
11the International Congress on Plasma Physics, Sydney
see http://www.ise.canberra.edu.au/ICPP2002/

▶▶ World Congress on Particle Technology — **21-25 July, 2002**
4th World Conference, Sydney
see http://www.wcpt4.com/

New Photonic Degrees

Thursday, 20 September saw ANU launch two new exciting degrees: a Bachelor of Photonics and a Bachelor of Engineering (Photonics Systems).

Photonics is the science and technology of generating and using light for a range of applications. These include fibre optic communication, measurement, sensing, information processing and storage. Where electricity was the driving energy of the 20th Century, light looks set to take its place in the 21st Century. Photonics, consequently, is at the centre of this scientific revolution, and the challenge is prepare a workforce that is equipped to make the most of emerging opportunities. The three-year Bachelor of Photonics (BPh) is designed specifically to meet this challenge.

The BPh is offered in collaboration between the Department of Physics (Faculty of Science), the Department of Engineering (Faculty of Engineering & Information Technology) and the Research School of Physical Sciences and Engineering. Designed in close consultation with the photonics industry and the CRC for Photonics, the degree combines a sound science education in years one and two, with specialised training in 'state-of-the-art' photonics technology in year three.

An alternative is to enrol in the four-year degree of Bachelor of Engineering (Photonics Systems). This provides a complete and fully accredited Engineering course in combination with specialised training in Photonics.

For students interested in postgraduate degrees or a career in photonics research there's a BSc Honours in Physics with specialisation in Photonics.

For individual advice on enrolment in photonics, check out the website at http://photonics.anu.edu.au or contact the Department of Physics, Faculty of Science.

Above: **The Usual Suspects**: Dr David McClelland (at podium) introduces some of ANU's Photonics experts involved in the new ANU Photonics degree. From the left: Chennupati Jagadish, Barry Luther-Davies, John Love, Ping Koy Lam and Hans Bachor.
Right: Hans Bachor demonstrates a little photonic's for assembled guests at the launch.

Materials Grab Bag

Bye bye Darrell

Professor Darrell Williamson, former Dean of the Faculty of Engineering and IT, and past Chairman of CSEM's management committee, is leaving ANU and heading for the coast. Darrell has taken up the position of Director of Telecommunications and Information Technology Research with the University of Wollongong. CSEM wishes you all the best Darrell.

Darrell (left) at his farewell drinks with fellow CSEM members Hans Bachor (centre) and Adrian Lowe.

Tim goes fly fishing

When the Federal Government recently announced this year's Australian Research Council grants they asked a local ANU scientist who had benefited from an ARC Fellowship to speak about the value of ARC funding. That scientist was our own Dr Tim Senden from RSPhySE. Here's part of Tim's speech.

"This technique of Atomic Force Microscopy has changed many perspectives on how the molecular world works (for example, our understanding of adhesion and lubrication).

The possibility of manipulating a single molecule seems at first unreal, indeed 5 years ago it was pure science fiction. Our research group was amongst the first to perform stretching experiments on single molecules. It's a bit like fly fishing, but on the molecular scale. One casts an appropriately small rod and jiggles it on an molecular scale until a molecule grabs a hold, and then you pull it out. After a profitable time researching in France, the ARC provided me with the opportunity to continue my work back in Australia though a Post-doctoral fellowship, which I took up at the ANU. The tricks we've learnt have helped us to connect fields like nanotech and biotech. Apart from new materials, some exciting opportunities are a new range of diagnostic markers we call nano-phase composites (for diseases like DVT), and even a new method for sequencing a single strand of DNA.

What drives me is the chance to work across the conventional boundaries of physics, chemistry and biology. I believe that the ARC truly seeks to support novel science, and it is a great thrill for me to work as a recipient of an Australian Research Fellowship in a fertile research environment at the ANU."

MM webspotting

- **Science and Industry in Australia**
  http://www.science.gov.au/
  New Commonwealth Government science & industry web portal
- **Nanotechnology in Australia**
  http://www.nanotechnology.gov.au/
  A new single entry point for "Nanotech Capability" in Australia
- **Australian Proteome Analysis Facility**
  http://www.proteome.org.au/
- **ANSTO's Materials Division**
  http://www.ansto.gov.au/ansto/materil.html
- **Australian Institute of Nuclear Science and Engineering**
  http://www.ansto.gov.au/ainse/index.html
- **CSEM's fab *Links* Page** can have you at any of these sites with the click of a button: **http://www.anu.edu.au/CSEM/links.html**

Say Farewell to Phil

CSEM's Director, Phil Evans, is leaving for Canada. CSEM Members and Friends are encouraged to join us in a Farewell Drinks in the Forestry Bld Foyer.

venue: **Forestry Foyer, Bld 48,** ANU
date: **Wednesday, 17 October, 2001**
time: **5pm** (drinks/nibblies following lecture)

This will follow CSEM's October Seminar on 'limits to nanomachines' by Prof Denis Evans.

CSEM

Centre for Science & Engineering of Materials

Faculties
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Depart. of Engineering
Forestry ANU
Department of Geology
Department of Physics

Institute of the Arts

Institute of Advanced Studies
Research School of Biological Sciences
Research School of Chemistry
Research School of Earth Sciences
John Curtin School of Medical Research

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Materials Monthly comes out in the first half of each month. We welcome your feedback and contributions. Please send them to David Salt, Editor, *Materials Monthly,* care of CSEM. 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**