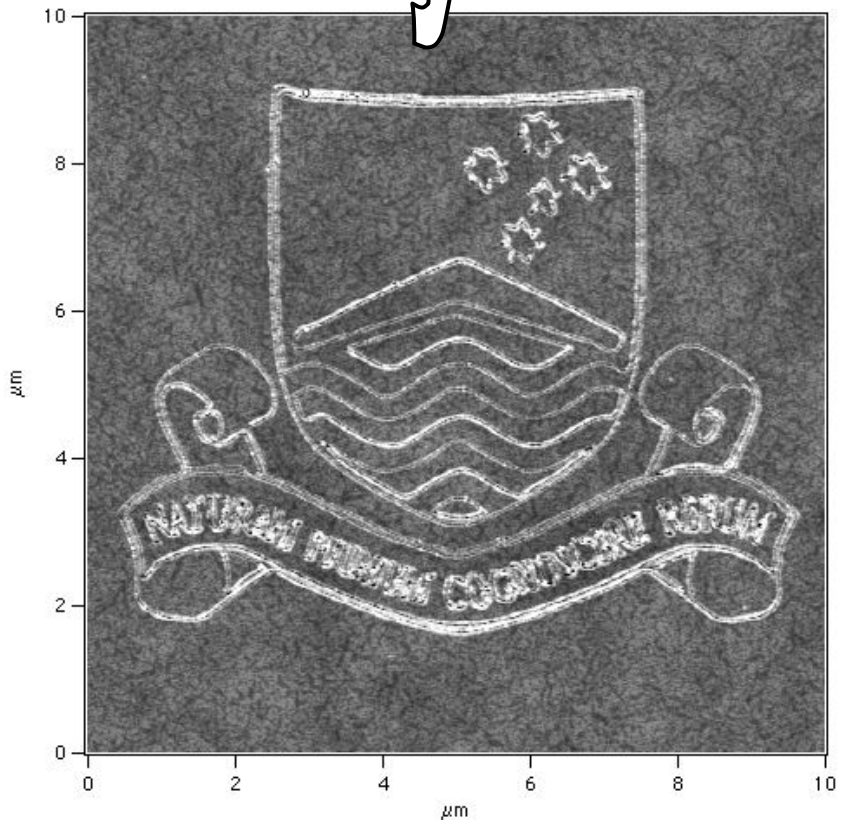
ANU Centre for Science and Engineering of Materials

Materials Monthly

Making materials matter *September 2002*

It's just a tiny scratch



It looks like a slightly blurry carving of the ANU crest into a block of sandstone. However, look at the scale and you'll see that this 'block of sandstone' is closer in size to a speck of dust. The square measures 10 microns across (one hundredth of a millimetre) and is actually made of plastic. The crest was scratched into its surface using the sharp tip of a newly acquired Multi-Force Probe (MFP) as a demonstration of its precision.

Although the instrument is capable of much smaller length scales, this image illustrates the precision with which the tip can be driven (the cut is approximately 5 nanometres deep), and its potential for microscopic materials testing. In typical operation the instrument is used to image surface topography at the nanometre scale, but the tip can also be used as a nanoscopic mechanical tool for picking up, translating and shearing objects at the molecular scale.

Given the probe's incredible potential for characterising materials, it was only appropriate that one of its first demonstrations was to carve out the University's motto: *'Naturam Primum Cognoscere Rerum'* (which translates to 'first to learn the nature of things'). And at this size the motto, indeed the whole crest, could comfortable sit on the side of a red blood cell.

The MFP has been designed by Asylum Research (Santa Barbara) and represents the leading edge in Scanned Probe Microscopy. Conventional instruments don't monitor the actual distance to the sample as it's scanned under the tip. The position of the tip is usually estimated at the time of scanning, which

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in combination with hysteresis, means the desired position could be many tens of microns from its actual position.

In the MFP a novel closed-loop monitoring system means that the position of the scanning tip is always known anywhere within a volume of (100 x 100 x 16) µm3 to within an accuracy of 0.4 nm. The distance calibration thus occurs at the time of scanning, and is NIST traceable.

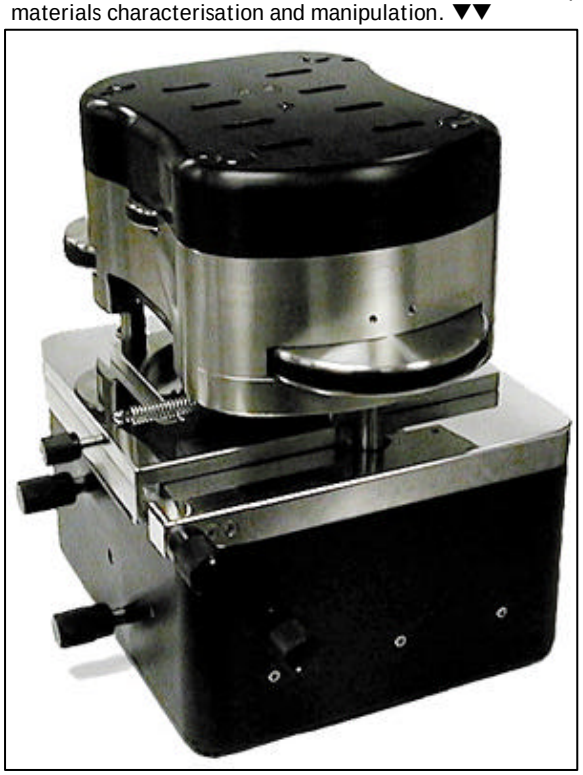
It is this incredible precision which allows it to continuously scribe lines which seamlessly join at their ends.

The instrument greatly extends an active research field in single molecular mechanics, nano-rheology and the biophysics of molecular assemblies.

The MFP was funded by a 2002 Linkage Infrastructure grant together with generous support from the Major Equipment Committee, the EMU Reserve and the CRC for Functional Communication Surfaces. Investigators on the grant were Vince Craig (Applied Maths, RSPhysSE, ANU), Ian Parker (Monash Uni) and Tim Senden (Applied Maths, RSPhysSE, ANU). The device is housed in Applied Maths (RSPhysSE).

For more information on the availability of ANU's new Molecular Force Probe, contact Dr Tim Senden (Tim.Senden@anu.edu.au). For more information on Molecular Force Probes in general, see http://www.asylumresearch.com/forcemeas.asp

It looks like a cappuccino machine but it's actually a Molecular Force Probe, ANU's latest venture into nanoscopic materials characterisation and manipulation. ▼▼



Mixing art and science

At the end of July, the Gold & Silversmithing Workshop (National Institute of the Arts) hosted a fascinating seminar on the ancient art of Mokume Gane.

The seminar was delivered by silversmith Ian Ferguson, a world expert on the art of Mokume Gane. Ian is an Aussie expat now based at the University of Manchester (Materials Science Department).

Mokume Gane involves melding thin layers of metal. Sheets of gold, silver and copper alloys are tied together and placed in a furnace. Just before they begin melting the sheets are removed and then rolled. The resultant block is beaten out into a sheet and the thin layers are exposed to release layers of colour that resemble wood grain.

Mokume Gane is Japanese for 'eye of the wood grain metal'. It's a 300-year-old craft that's been handed down the generations only by practical experience.

Ian has been attempting to extend the art with new metals. He's also attempting to better understand the process which is a form of solid state diffusion bonding. Besides producing some stunning works of art, which were on display during the seminar, Ian is also developing new techniques for the creation of an amazing set of metal materials.

For more information on the seminar, contact the head of the Gold & Silversmithing Workshop, Johannes Kuhnen (Johannes.Kuhnen@anu.edu.au).

◀◀ Ian with some of his metal art work produced using Mokume Gane.

▼▼ 'Exploring matter with synchrotron light' is a new educational CD-ROM just released by iMediasoft. See http://synchrotron.imediasoft.fr/indexEN.htm for details. See page 5 for details on Australia's new synchrotron facility.

Words of substance

"When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong."

Arthur C. Clarke's First Law

Metal-organic chemical vapour deposition

ANU operates one of the most sophisticated Metal-Organic Chemical Vapour Deposition (MOCVD) laboratories in the world, and thereby gives Australia the capacity to keep in touch with the latest developments relating to the industrial manufacture of opto-electronic devices.

The MOCVD facility is based in a purpose-built clean room in the Department of Electronic Materials Engineering (Research School of Physical Sciences and Engineering). It was established in 1991 and has undergone constant refinements and upgrades since then.

The first project using this technology investigated the growth and characterisation of gallium arsenide (GaAs) and aluminium gallium arsenide (AlGaAs) crystal layers (epigrowths) suitable for a range of applications in advanced communications systems.

Prof Jagadish has led the MOCVD group since early 1992. During this time there have been several research highlights, including world records for the highest concentration and most abrupt atomic layer doping, so-called delta doping, for carbon, silicon and zinc in GaAs and AlGaAs layers.

The group has also grown narrow multi layers, so called quantum well structures, with very interesting optical and phonon (vibrational) properties.

The MOCVD reactors and clean room ▼▼

The principle of MOCVD is quite simple. Atoms that you would like to be in your crystal are combined with complex organic gas molecules and passed over a hot semiconductor wafer. The heat breaks up the molecules and deposits the desired atoms on the surface, layer by layer. By varying the composition of the gas, you can change the properties of the crystal at an almost atomic scale. It can grow high quality semiconductor layers (as thin as a millionth of a millimetre) and the crystal structure of these layers is perfectly aligned with that of the substrate.

The MOCVD approach was chosen over other methods because of its flexibility in growing precision controlled layers for special applications as well as it's ability to be scaled up to industrial-scale production with relative ease.

◀◀ Dr Hoe Tan prepares a wafer ready for insertion into the new MOCVD reactor.

More recently, the group has taken giant steps towards the fabrication of practical devices. For example, the group has fabricated laser sources, light reflectors and modulators of the types used in CD players to record and read digital information stored on the disk. Novel optical modulators at wavelengths of 550-630nm have been produced.

Semiconducting lasers are able to convert electrical impulses to light, and they have many uses in advanced optical communications. Indeed, EME researchers have made a range of so called GRINSCH (Graded Index Separate Confinement Heterostructure) lasers which have about 40 different layers of varying thickness, compositions and dopings. Some of the quantum well layers are only seven nm thick.

The original MOCVD reactor (the white cabinets in the pic above) has recently been augmented with a new, state-of-the-art reactor (the blue series of cabinets). Costing around $3 million to install, the new reactor can process more wafers in a given time, and deposit layers with a higher precision than the original reactor. Indeed, even after years of fine tuning the original reactor could only lay down layers to within 10% of the desired thickness. While this was a remarkable achievement when you consider how thin these layers are (measured in atoms), it still wasn't good enough for the devices they were attempting to build. The new reactor is able to deposit layers to within 1% of the desired thickness.

Nanotechnology is surely coming of age.

More information

Prof Jagadish: cxj109@rsphy1.anu.edu.au

http://wwwrsphysse.anu.edu.au/eme/history.html#1

Opportunities

Measuring Uncertainty

The evaluation of measurement uncertainty is an important new requirement for laboratories seeking accreditation to ISO/IEC 17025. To provide an overview of measurement uncertainty together with current information on international accreditation policy, the National Association of Testing Authorities Australia and the Australian Government Analytical Laboratory have produced a web based training course. Laboratory staff, accreditation staff and assessors, regulators and customers of laboratories will benefit from completing the course.

The course is arranged in six modules:

▶ Introduction to measuring uncertainty

▶ An integrated approach to quality assurance - the big picture

▶ Evaluating and reporting measurement uncertainty

▶ Requirements of ISO/IEC 17025

▶ How much is enough?

▶ Quiz

The course costs $120 and takes a couple of days to complete. For more information on the course and how to register, see:
http://www.mutraining.com/login/index.cfm

Grad Cert in Technology Commercialisation

The ANU National Graduate School of Management (NGSM) offers a Graduate Certificate in Management (Technology Commercialisation). The course has been designed for those involved in the commercialisation of technology and for those in professional business service and government organisations involved in supporting research commercialisation. It would be highly relevant both for those involved in the commercialisation of research from public sector research organisations and for those involved in developing new technology based enterprises.

The program involves the completion of at least four courses. Each of these will be taught through the NGSM's modular-intensive study format, involving an intensive one week at the NGSM. The Graduate Certificate can be completed in under one year or taken over two years.

The program combines core management subjects from the NGSM's MBA plus specific, practically-oriented courses on managing innovation and commercialisation.

The three required core subjects are:

▷ Corporate Strategy; and

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Conferences / Seminars

◀✧▶ **NIPS Seminar: Searching for Gravitational Waves with Laser Interferometer Gravitational-wave Observatory (LIGO)** — **11 October**
Stan Whitcomb - Detector Group Leader from the US LIGO project, 11.00am to 12.00pm
Huxley Lecture Theatre (bldg 56)

◀✧▶ **Geopolymer 2002** — **28-29 October**
An international conference on the commercialisation of geopolymers, Melbourne
More information: http://www.geopolymer2002.com/

◀✧▶ **Intellectual Property & Biotechnology: Access, Ownership and Control** — **8 November**
National Gallery of Australia, Parkes Place,
Australian Centre for Intellectual Property in Agriculture
More information: http://law.anu.edu.au/acipa/conference

◀✧▶ **Seminar: The Biotron Story**, Michelle Miller, Managing Director, Biotron Limited — **27 November**
12:30 - 2:00 pm National Graduate School of Management, Sir Roland Wilson Building (120)
More information: vicki.veness@anu.edu.au / X59883

◀✧▶ **ICAMP 2002** — **2-4 December**
2nd International Conference on Advanced Materials Processing, Singapore
More information: http://serve.me.nus.edu.sg/icamp/

◀✧▶ **Workshop: Neutron beam applications for the earth sciences** — **12-13 December**
Lucas Heights, ANSTO
More information: http://www.ansto.gov.au/ansto/neut/workshop8.html

◀✧▶ **Logic and Automated Reasoning Summer School** — **2-13 December**
RSISE, ANU, More information: http://arp.anu.edu.au/lss

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▷ Managing People and Organisations

▷ Commercialisation of Research & Development;

Technology management and commercialisation courses can be selected from:

▷ Technology & Innovation Management ;

▷ Tools/Techniques for Business Project Management;

▷ Management of the High Technology Small Firm;

▷ Managing Technological Collaboration;

▷ Entrepreneurship;

▷ International Technology Transfer Firm.

▷ Intellectual Property Management (tbc)

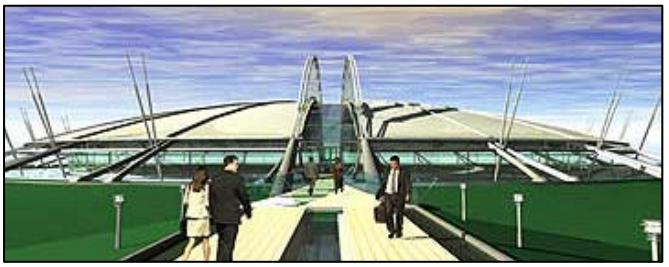
Enrolment in individual courses is possible and an associated ANU Graduate Course Award Certificate can be obtained for each course successfully completed. The courses may be recognised in any subsequent enrolment in the Master of Management or other NGSM degree programs.

Applications will be accepted at any time. Refer to http://ngsm.anu.edu.au for course timetables. Part time students can start any time during session times. The fee the full program for 2002 is $7,700. The ANU General Services Fee is an additional $195 a year.

More information: http://ngsm.anu.edu.au
Email: hanna.heyko-porebska@anu.edu.au
Phone:X59830

The Australian Synchrotron

A technical summary



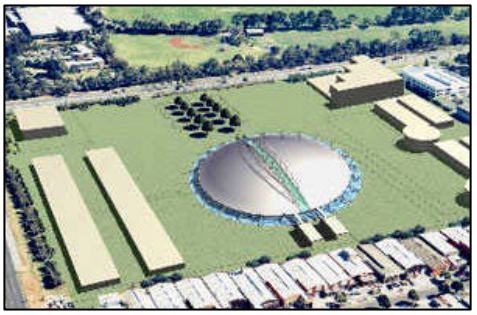
Design: The Australian Synchrotron will be a third generation facility incorporating the same technical design concept as the 1999 "Boomerang Light Source" proposal which was derived from an extended and improved version of the ANKA facility in Germany and incorporates some aspects of the Canadian Light Source design.

Specs:

Beam Energy: 3 GeV
Beam Current: At least 200mA in Phase 1
Emittance: Better than 12 nm rad from a dispersion of less than 0.3 m
Long straights: More than 9
Life time: Greater than 20 years
Circumference: Less than 200 m
Beam lines: Up to 44 m in length, 9 beam lines in phase 1

Materials Grab Bag

Facility housing: The proposed housing for the synchrotron is a domed structure approximately 110 metres in diameter on a contiguous isolated slab. The machine hall space will be approximately 10,000 square metres with externally-located building services plant on separate isolated slabs. The storage ring enclosure will comprise in-situ concrete walls and roof of up to 0.8 metres thickness with selective lead shielding. The housing design may change once the technical specifications for the synchrotron are finalised.



Location:
The selected site is at the corner of Wellington Road and Blackburn Road adjacent to the main campus of Monash University at Clayton, Victoria. The site allows for a set-back of approximately 180 metres from major roads. Preliminary vibration and geotechnical testing of the site has been completed and no adverse results were encountered, although further testing will be necessary prior to completing detailed design.

Beamline info**: http://www.synchrotron.vic.gov.au/**

Science committees:

International machine advisory committee

Mr Alan Jackson (Chair), Lawrence Berkeley Nat Lab, USA
Professor John Boldeman, University of Queensland
Dr Jeff Corbett, Stanford Synchrotron Radiation Lab, USA
Professor Dieter Einfeld, SESAME, Jordan
Dr Dieter Kraemer, BESSY II, Berlin, Germany
Dr Annick Ropert, European Synchrotron Fac, Grenoble, Fr
Dr Stephen Milton, Advanced Photon Source, USA

The national scientific advisory committee

Professor Frank Larkins AM (Chair), Uni of Melbourne
Professor David Cohen, ANSTO
Professor Dudley Creagh, University of Canberra
Dr Ian Gentle, University of Queensland
AssocProf Andrea Gerson, University of South Australia
Professor Sydney Hall, University of Western Australia
Dr Brendan Kennedy, The University of Sydney
Professor Robert Lamb, University of New South Wales
Professor Robert Leckey, La Trobe University
Professor Robert Lewis, Monash University
Dr Jenny Martin, The University of Queensland
Professor Keith Nugent, University of Melbourne
Professor Brian O'Connor, Curtin University of Technology
Dr Mark Ridgway, Australian National University
Dr Jose Varghese, CSIRO Health Science and Nutrition
Professor John White CMG, Australian National University
Dr Steve Wilkins, CSIRO Manufact Sci and Technology
Professor Jim Williams, University of Western Australia

International scientific advisory committee

Professor H Kamitsubo, Spring8, Japan
Professor Tadashi Matsushita, Photon Factory, Japan
Professor Herbert Moser, Singapore Synch Light Source
Dr Neville Smith, Advanced Light Source, USA
Professor Herman Winick, Stanford Synchrotron Radiation Laboratory, USA
Dr Gopal Shenoy, Advanced Photon Source, USA
Professor Volker Saile, ANKA GmbH, Germany
Professor Albin Wrulich, Swiss Light Source, Switzerland
Professor Frank Larkins AM, University of Melbourne,
Dr Mike Bancroft, Canadian Light

MM webspotting:

CSEM's Curls

(CSEM's cool urls)

- **Australasian Ceramic Society**
  http://members.ozemail.com.au/%7Eausceramsoc/
- **Australian Electrical &Electronic Manufacturer's Association**
  http://www.aeema.asn.au/
- **Australian Microscopy and Microanalysis Society**
  http://www.microscopy.org.au/
- **Institute of Materials Engineering Australasia**
  http://www.mateng.asn.au/
- **Royal Australian Chemical Institute**
  http://www.raci.org.au/New_Site_2001/raci.shtml
- **The Vacuum Society of Australia**
  http://members.optusnet.com.au/~mshivac/vsa.htm

To get to any of these destinations with a click of a mouse, just go to:
http://www.anu.edu.au/CSEM/links.htm

CSEM's new blue Website

After much prevarication, a couple of Dreamweaver courses and countless coffees, we've finally got around to updating the CSEM website. It's much like the old site (ie, simple, up to date and with heaps of links) but with a touch more design and functionality. We'd be interested in knowing if there's anything you'd like it to include. For example, got any red hot links we could add to our links page? On the left are a few of our current links. You can reach any of these with the click of a button; just make our links page one of your favourite bookmarks.

CSEM

ANU Centre for Science & Engineering of Materials

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

Institute of the Arts
Materials Workshops

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

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Contacting CSEM

Director: Dr Zbigniew Stachurski / Ph: (02 6125 5681 / Email: zbigniew.stachurski@anu.edu.au

Communications: David Salt / Phone: (02) 6125 3525 / Email: david.salt@anu.edu.au

Administration: Sylvana Ransley / Ph: (02) 6125 3525 / Email: sylvana.ransley@anu.edu.au

Fax: (02) 6125 0506, Postal: Department of Engineering (Bld #32), Australian National University ACT 0200
Location: Room E112, Department of Engineering (Bld #32), cnr of North Road and University Ave, ANU

Materials Monthly comes out 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**