ANU Centre for Science and Engineering of Materials

Materials Monthly

Making materials matter *February 2002*

ANU snares a

Beaglehole Ellipsometer

▲▲
The basic Beaglehole Ellipsometer

Thanks to the Major Equipment Committee, ANU's materials scientists now have access to a precision imaging ellipsometer, a device that characterises the surfaces of a wide range of materials but is especially good at determining the nature of thin films.

Ellipsometry is an optical technique that uses polarised light to probe the dielectric properties of a sample. By analysing the state of polarisation of light reflected from a sample, ellipsometry can yield information about layers that are thinner than the wavelength of the light itself, down to a single atomic layer or less. Depending on what's already known about the sample, the technique can probe a range of properties including the layer thickness, morphology, or chemical composition.

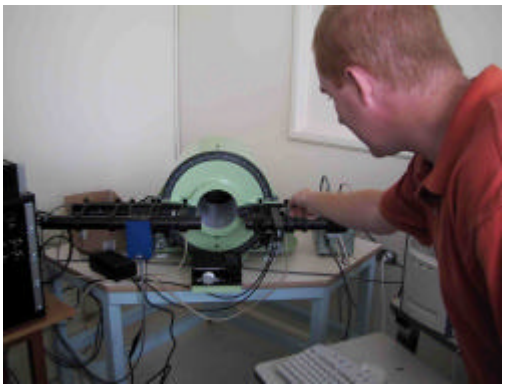
The name 'ellipsometry' stems from the fact that the most general state of polarisation is elliptic. The technique has been known for almost a century and today has many standard applications. It's mainly used in semiconductor research and fabrication to determine properties of layer stacks of thin films and the interfaces between the layers. However, ellipsometry is also proving useful in biology and medicine with measurements on unstable liquid surfaces and microscopic imaging.

There are many different ways of determining the polarisation of a beam of light. In the first ellipsometers, the operator observed the light beam that was reflected off the sample through an eyepiece. The polarisers and retarders were rotated by hand until the effect of the polarisation was inverted and no light would pass through the instrument. This is called the nulling technique. Modern nulling ellipsometers use computers to rotate the elements and to automatically calculate the ellipsometry signal very quickly. However, the nulling technique is not ideal for automated instruments because it's based on measuring a zero signal. This was an advantage in the early ellipsometers because the human eye is very sensitive to small changes in the signal around the 'null'. However, modern light detectors exhibit significantly higher noise at low intensities.

A technique that is more suited to modern-day instrumentation is phase modulated ellipsometry, where the polarisation of the light is modulated at a high light throughput and then measured after reflection. This results in higher sensitivity, faster response time, and lower signal noise than can be achieved with traditional rotating-element ellipsometers.

The ANU ellipsometer employs this technique. In addition to being able to make all the standard ellipsometer measurements, this new machine is also capable of doing a lot more. Depending on how it's configured,

Continued on page 5



▲▲
Tim Senden with the new ANU ellipsometer

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Volume III, Issue 2

Catalyst

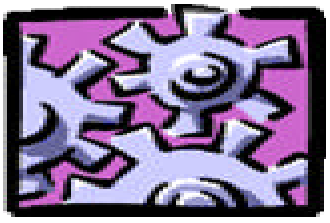
Ideas, news and opportunities

Materials Monthly welcomes your feedback on any of these stories

Hot wire

An experimental thermal diode has been created by scientists at the Massachusetts Institute of Technology. The diode converts heat to electricity and could pave the way to a revolution in energy recycling by harnessing wasted heat energy produced by machines. Imagine being able to harness the heat being emitted by the microprocessors in your computer or the engine in your car.

The thermal diode was devised and built by Peter Hagelstein from MIT and Yan Kucherov from the energy company Eneco. It consists of an indium antimonide-based semiconductor. One layer, the electron emitter, is doped with electron donating impurities. Another, the electron collector, is doped with electron-deficient impurities. By placing an additional highly doped electron rich layer between the emitter and the collector, the team got more electrons to transverse the gap when the device was warmed – thereby converting heat to electricity.



The device operates at temperatures around 200 degrees Celsius. The hope is that it can be refined to generate current at lower temperatures.

More info: http://www.trnmag.com/Stories/2001/121901/

The EvolutionProbe

Hailed by CSIRO as the best thing since sliced-bread!

CSIRO scientists have launched a second-generation probe described as the biggest advance in microscopy since the electron microscope. Called the CSIRO EvolutionProbe (CEP), it follows hard on the heels of the development of the prototype Scanning Kelvin Probe launched a year ago.

It's named the EvolutionProbe because of the exciting new features it offers for real-time study of corrosion and other surface chemistry phenomena.

It's developer is Aaron Neufeld from CSIRO Sustainable Materials Engineering. He reckons the CEP is the only analytical instrument that can provide information about electrochemical reactions and surface changes on coated metal products affected by the thin films of moisture typically deposited as dew or rain"

The CEP can capture a picture of these electrochemical reactions within minutes compared to other instruments, which take hours and then only offer data from a small section of material.

The CEP can be used for a range of applications from accelerated testing, to quality control and quality assurance, and product/process refinement and development.

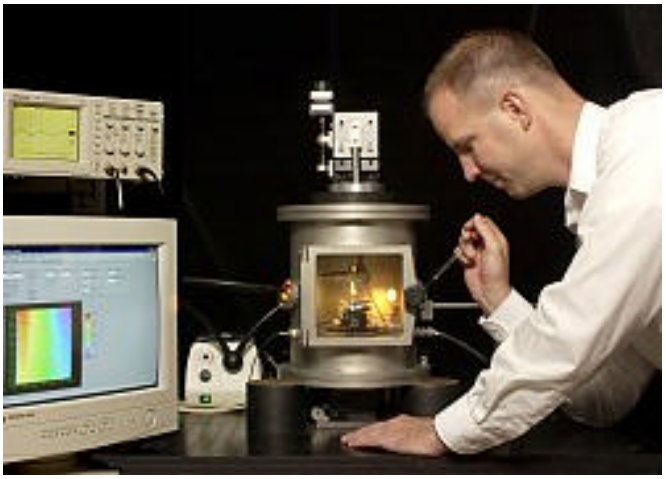
In particular the CEP offers easy quantification of the previously complex measurement of tribocharging effects. The generation of static electricity by friction or tribocharging, the magnitude of the charge and how fast the static charge decays, can all be measured quickly by the CEP.

Neufeld says, "This means we can tailor surface chemistry to minimise the effect of static charging. In effect, the CEP is a key to commercialising new technologies such as new composite materials where tribocharging may create product, production or packaging difficulties".

"It's enabled us to begin to unravel the riddle of unwanted tribocharging effects on polymer films."

Neufeld says, "Just as importantly, it can help to identify a replacement solution for the many current environmentally unfriendly antistatic compounds containing fluorines".

More information: http://www.csiro.au/index.asp?type=mediaRelease&id=EvolutionProbe



▲▲ Aaron Neufeld with CSIRO's second generation Scanning Kelvin Probe. The new-generation version has been named the CSIRO EvolutionProbe (CEP) because of its exciting new features for real time study of corrosion and other surface chemistry phenomena.

Nanothermometer

Fill a carbon nanotube with the metal gallium and you've got the world's smallest thermometer. It's sensitive enough to measure the tiny temperature change when groups of molecules react. It the work of researchers at the National Institute of Materials Science in Ibaraki, Japan. (excerpt from NewScientist, 9 February 2002; www.newscientist.com/news/archive.jsp)

We have the technology

The technology behind materials science and engineering at ANU

Mass Spec

The ANU Mass Spectrometry Facility (ANU-MS) was established to provide a comprehensive mass spectrometry service for staff at the ANU. Housed within the Research School of Chemistry, the Facility is one of the best-equipped MS units in Australia. As can be seen from the list of mass spectrometers shown here, there are instruments capable of handling almost any sample type, and tailored experiments can yield structural as well as compositional information.

VG ZAB-2SEQ

The VG ZAB-2SEQ is a hybrid sector instrument equipped with electron ionisation, chemical ionisation and liquid secondary ion sources. It is also equipped with 3 gas cells plus a deflector electrode (for collisional activation, neutralisation-reionisation and charge-reversal experiments) with two quadrupole cells *qQ* at the back end for low-energy collision induced dissociation experiments. That is, an RF-only quadrupole *q* or collision cell which precedes a scanning DC/RF quadrupole *Q*. This instrument was purchased in 1989 and is one of the few sector instruments in Australia capable of true collisional mass spectroscopy.

The ZAB-2SEQ is predominantly used for analytical purposes at present (magnet scans for structure confirmation and voltage scans for accurate mass measurements and thus confirmation of elemental composition), and occasionally CA experiments to determine peptide sequences and characterise natural products. Future modifications to the gas inlet and detection systems will enable the full-range of MS/MS/MS experiments to be performed.

VG AutoSpec M

This is a sector instrument with "EBE" configuration which is used primarily for the analytical characterisation of small molecules (magnet and voltage scans). It is equipped with electron ionisation, chemical ionisation and electrospray ionisation sources. The latter two sources are useful for generating quasi-molecular ions (eg. $[M+H]^+$) from molecules that are not robust at higher temperatures, such as alkaloids and small peptides. Metastable ion monitoring experiments are also possible. This instrument supports the research efforts of the organic and inorganic departments of RSC, the chemistry faculty (ANU) and the school of chemistry at the University of Sydney.

VG Quattro II

This machine is a triple quadrupole instrument *Q1qQ2* equipped with an electrospray ionisation source. The first and third quadrupoles, *Q1* and *Q2*, are DC/RF or "scanning" quads, whilst the second, *q*, is an rf-only gas cell. This instrument is capable of MS/MS experiments ie. low energy CID, selected ion monitoring etc. The collision energy of mass-selected ions (*Q1* "parked") is controlled by biasing the voltage of the rf-only quadrupole *q* relative to *Q1*. This is a walk-up instrument particularly useful for the characterisation of biomolecules and other natural products. Other virtues of the Quattro II include low maintainance requirements and user-friendly software. It is heavily used by the natural products chemists of RSC and the chemistry faculty.

Micromass TofSpec-2e MALDI-TOF

The Micromass matrix-assisted laser desorption-ionisation (MALDI) time-of-flight mass spectrometer (TofSpec-2e) was purchased in 1999 and installed early 2000. It is equipped with a 337 nm nitrogen laser, delayed extraction, high mass detector which extends the effective mass range to >100 kilodaltons (useful for protein chemistry), a reflectron, and is capable of dealing with 396-well sample plates. It's planned to relocate this instrument to the University of Sydney later this year. It's replacement will be a bench-top Bruker Omniflex MALDI-TOF that will based in the RSBS.

Micromass/Waters LC-ZMD

This spectrometer consists of a Waters Alliance 2690 HPLC system coupled to, or in-line with, a Micromass ZMD Z-spray single quadrupole MS detector, limited to m/z < 2000. The detector is equipped with atmospheric pressure chemical ionisation (APCI) and electrospray (ESI) sources. The Masslynx diversity software enables automation and spectral acquisition for multiple samples. This is a robust instrument designed for high-throughput, and as such supports the research efforts of the Glaxo-SmithKline research group that is affiliated with RSC.

Agilent/HP 6890-5973

It consists of a programmable oven (gas chromatograph, 6890) with split/splitless injection port coupled to a (5973) single quadrupole mass detector. Ions are formed by electron ionisation of the column eluent. This instrument is used for the separation of complex mixtures of (mostly) non-polar synthetic and natural compounds. The 6890/5973 is chiefly used by the organic chemists of RSC, and occasionally the biochemists/biologists of RSBS.

Bruker 4.7 T FT Ion Cyclotron Resonance (FTICR)-MS

This impressive mass spectrometer is due to be commissioned sometime in 2002. It will possess switchable electrospray (ESI), electron ionisation/chemical ionisation (EI/CI), liquid secondary ion (LSIMS) and matrix assisted laser desorption-ionisation (MALDI) sources. In addition, there will be three pulsed valves and two molecular leak valves for ion thermalisation/ion-molecule reaction studies, and an "in-source" electron gun for electron capture-dissociation studies. This will undoubtedly be the centre-piece of the MS unit, and will assist small molecule characterisation and other fundamental studies related to natural products and biomolecules.

▲▲ The VG Quattro II, one of the many mass spectrometers available at the ANU MS.

For more information

Phil.Jackson@anu.edu.au

http://rsc.anu.edu.au/~mass_spec/index.html

Positions vacant

Australia

Postdoc Fellow/fluid flow in ore systems (closes 15/3/02)
RSES, ANU
http://www.anu.edu.au/hr/jobs/academic.html#803

Postdoc Fellow/gene transcription in immune responses, (closes 8/3/02)
JCSCMR, ANU
http://www.anu.edu.au/hr/jobs/academic.html#761

Official Analyst, (closes 15/3/02)
Aust Racing Forensic Lab, Sydney
More info: (02) 8344 5001

Synthetic Organic Chemists
Alchemia, Queensland
www.alchemia.com.au

Professional Officer/Helicopter Structures (closes 7/3/02)
DSTO, Melbourne
http://www.dsto.defence.gov.au/

Lecturer in Chemistry (2 positions), (closes 15/3/02)
Uni of Melb
http://www.hr.unimelb.edu.au/r/action.lasso?-database=hrjobs&-layout=posdetails&-response=detail.html&-recordID=35691&-token.cat=a&-search

Overseas

Research positions (3)/Photonic Crystals (closes 1/4/02)
University of Bath, UK
http://jobs.ac.uk/jobfiles/HM331.html

Professor of Materials (closes 27/3/02)
Uni of Nottingham, UK
http://jobs.ac.uk/jobfiles/HM326.html

Professor of Materials (closes 27/3/02)
Uni of Nottingham, UK
http://jobs.ac.uk/jobfiles/HM326.html

Postdoc res assoc/supercapacitors based on carbon nanotubes (closes 27/3/02)
Uni of Cambridge, UK
http://jobs.ac.uk/jobfiles/HM266.html

Postdoc/Nanoscale materials (closes 18/3/02)
Dartmouth College, UK
http://jobs.ac.uk/cgi-bin/advsearch2.cgi

Postdoc/Mineral Physics (closes 18/3/02)
Uni of Cambridge, UK
http://jobs.ac.uk/jobfiles/HL852.html

For the Diary

◄✧► **Seminar: Why is the Nordic Area a World Leader in Mobile Telecommunications? Government and Industry in the Development of Radical Innovation.** — **12 March, 2002**
5:30pm, Sir Roland Wilson Building, ANU. Enquiries to Vicki Veness on 6125 9883

◄✧► **Seminar: Human digestive strategy and its evolution, Dr Judith Caton** — **15 March, 2002**
3pm, Manning Clark Theatre 4, ANU. Enquiries to Amanda Kennedy on 6125 0470

◄✧► **Seminar: Biotech and IT Industry Development in Germany - an alternative to the American model.** — **10 April, 2002**
12:30pm, Sir Roland Wilson Building, ANU, Enquiries to Vicki Veness on 61259883

◄✧► **Seminar: Take-up of ICT in Australian Firms: Perceptions, Policy and Potential** — **15 May, 2002**
12:30pm, Sir Roland Wilson Building, ANU, Enquiries to Vicki Veness on 61259883

◄✧► **Lecture: "Flaws in the Fabric: Why Physics and Chemistry have never contributed generally to the Biological Sciences". Professor Barry Ninham.** — **20 March, 2002**
4.45pm, Coombs Lecture Theatre, Enquiries to Russell Doust

◄✧► **ICPP 2002** — **15-19 July, 2002**
11th International Congress on Plasma Physics, 2002, Manly, Sydney
http://www.ise.canberra.edu.au/ICPP2002/

◄✧► **Seminar: 'Adventures with natural and "un-natural" products chemistry to molecular biology' Prof TJ Simpson** — **15 March, 2002**
11.00am, RSC, ANU,
Enquiries: Lew Mander, 6125 3761

(Continued from page 1)

Beaglehole Ellipsometer

the new ellipsometer can study the dynamics of adsorption, perform in-situ monitoring of the growth of thin films or measure liquid surfaces where conventional instruments are often disturbed by surface waves. The instrument can measure over a wavelength range from 220 nm to 1800 nm. A sensitive CCD allows ellipsometric measurements to be recorded over an area rather than at a single point.

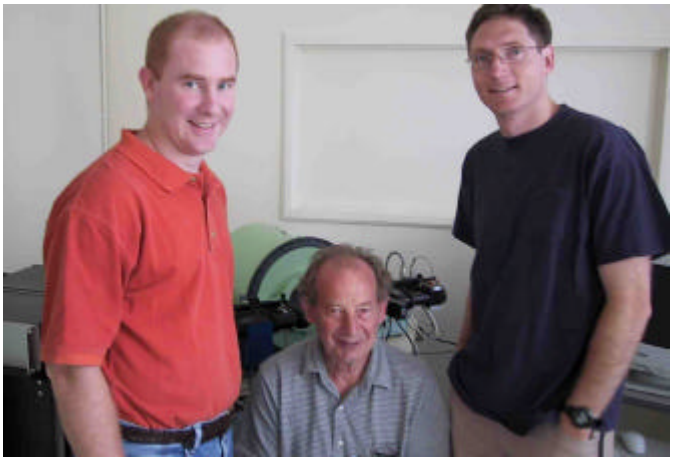
ANU's new machine will be housed in the Department of Applied Maths, Research School of Physical Sciences and Engineering. It's the result of persistent lobbying by Vincent Craig and Tim Senden, both from Applied Maths, and Prof Chennupati Jagadish, from Electronic Materials Engineering, to ANU's Major Equipment Committee. It costs $300K to build and install and will come on line over February and March.

The machine, one of the finest of its type in the world, is the brainchild of Professor David Beaglehole, a physicist originally from Victoria University in New Zealand. He's being developing and tinkering with ellipsometers for over 20 years and left his university stamping ground when the NZ government offered him a grant to refine his designs into working machines. He set up his own company named Beaglehole Instruments, a name that's now synonymous with quality ellipsometry.

Professor Beaglehole himself journeyed over from New Zealand to oversee the installation of the new device, and held an introductory seminar for people interested in getting into ellipsometry. The introductory seminar was jam packed, suggesting there are scientists from all over campus interested in making use of the device.

For more information on Beaglehole ellipsometers, see http://www.beaglehole.com/index.html

For more information on how to gain access to the ANU machine, contact Tim Senden (Tim.Senden@anu.edu.au) or Vince Craig (Vince.Craig@anu.edu.au).



▲▲
Tim with Vincent Craig and Professor David Beaglehole in front of the new ANU ellipsometer

Materials Grab Bag

EM Excellence

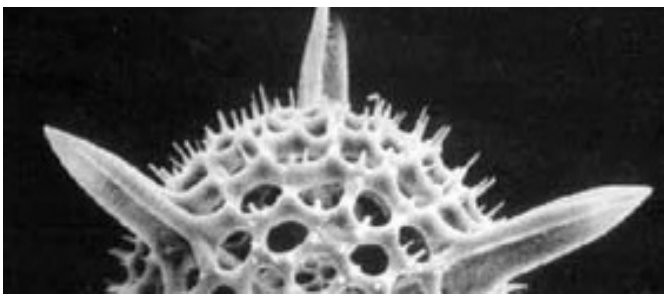
contributed by John FitzGerald

News from the 17th Australian Conference on Electron Microscopy held in Adelaide at the beginning of February.

Amongst the awards presented by the Australian Society for Electron Microscopy, two ANU scientists were honoured.

The Cowley-Moodie Award was presented to Jodie Bradby from Electronic Materials Engineering for her work on the indentation of semiconductor materials. The Award was open to physical scientists and, courtesy of FEI Australia, provides an international air ticket for the recipient to visit overseas laboratories. The award was judged on the basis of a piece of research carried out in Australia involving electron microscopy, completed since February 2000, and of international importance. Candidates were to be under the age of 42.

The John Sanders Medal was presented to Dr. Ray Withers from RSC for his outstanding work in uncovering the atomic-scale features responsible for incommensurate and diffuse intensities in electron diffraction patterns of many partially disordered crystalline materials. The medal was established to promote excellence in developing or applying electron microscope techniques with particular attention to problems of practical importance in the physical or chemical sciences. It's open to persons resident in Australia for at least 5 of the previous 7 years. Preference is given to younger scientists of international standing whose original research work and publications have led to important contributions in their chosen subject.



EM in Oz

And while we're on the topic of electron microscopy in Australia, the Australian Society for Electron Microscopy has just released a guidebook to electron microscope facilities and users in Australia.

It's called an Australian Directory of Microscopy and Microanalysis, a guide to facilities and staff. It's available to free to all members of the Australian Society for Electron Microscopy, and you can join through their website: www.microscopy.org.au

MM webspotting: Uni EM units

- **ANU Electron Microscope Unit**
  http://www.anu.edu.au/EMU/
- **Uni of NSW Electron Microscope Unit**
  http://srv.emunit.unsw.edu.au/
- **Uni of Sydney Electron Microscope Unit**
  http://www.usyd.edu.au/su/emu/index.html
- **Uni of Queensland Nanoworld**
  http://www.uq.edu.au/nanoworld/nanohome.html
- **Uni of Adelaide Centre for Electron Microscopy and Microstructure Analysis**
  http://www.adelaide.edu.au/CEMMSA/
- **Qld Uni of Technology Analytical Electron Microscopy Facility**
  http://www.sci.qut.edu.au/aemf/
- **Uni of WA Centre for Microscopy and Microanalysis**
  http://cmm.uwa.edu.au/

Wanted

Good scientists & engineers

to give talented young senior secondary students a real experience in materials research

The CSIRO Student Research Scheme pairs up some of Canberra's top students with research scientists, and gives them a taste of what research is about. Students are expected to perform a minimum of 20 hours on a research project (arranged to suit the researcher and the student) under the guidance of the researcher.
Please contact CSEM if you'd like to participate.

CSEM

ANU Centre for Science & Engineering of Materials

Faculties
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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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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**