CSEM's
Materials Monthly
June 2003
Making materials matter

Ultra-hard
at the cutting edge

Ringwood Superabrasives are gearing up for success

It's been a long haul but there's growing confidence that basic research undertaken at ANU on the fabrication of ultra-hard diamond composites may soon result in commercial success.

The research was originally a spin off of work led by Professor Ted Ringwood at the Research School of Earth Sciences in the 1980s. Ringwood's group was investigating the structure and composition of earth materials deep inside the planet by subjecting mineral samples to extreme pressures and temperatures. In addition to pioneering studies on the structure and mineralogy of Earth's mantle, Ringwood was keen to extract practical applications from their studies of earth materials under extreme pressure and heat. One such application was SYNROC (see Champion Ted, page 5).

New cutting tool

Another venture into applied science stemmed from Ringwood's appointment to a scientific advisory board for one of Australia's major mining houses in the 1980s. Ted was amazed by the abundance of small industrial-grade diamonds flowing from the newly-opened Argyle mine in Western Australia. With corporate support he invented and patented a new diamond-based, cutting-tool material suitable for hard-rock drilling and ultra-hard ceramic machining.

The material is known as Diacom™. It's a patented polycrystalline diamond (PCD) made of diamond grit bonded by a ceramic alloy. Part of the process of creating it involves hot pressing the mix in one of the large piston-cylinder devices used by RSES to generate the high pressures and temperatures needed to study our planet's interior.

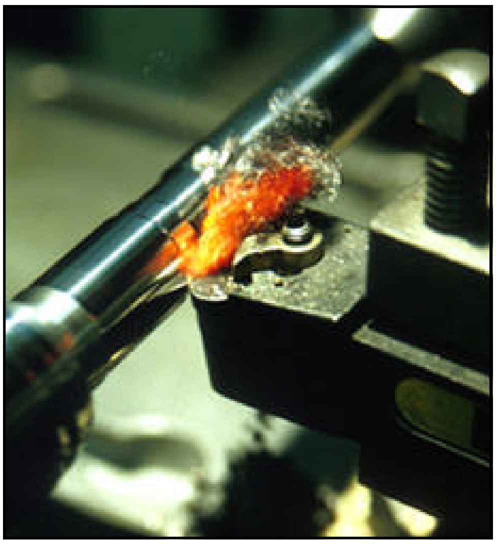
Another ultra hard material arising from this research is Cubicom™, a polycrystalline cubic boron nitride (CBN) composite comprising of cubic boron nitride grit chemically bonded by a different ceramic alloy. CBN is second only to diamond in hardness.

While there are many PCD and CBN ultra-hard materials available on the market, Diacom™ and Cubicom™ have several inherent advantages over competing products. These include being electrically conductive, capable of being produced in a wide range of shapes and sizes, and possessing incredible thermal stability. Indeed with this suite of advantages the products were believed to be destined for commercial success.

Long, bumpy road

However, as with many good ideas, the road to successful commercialisation has been a bumpy one with many twists and turns. For a variety of reasons, a series of attempts to turn the technology into a profitable enterprise have failed with the technology passing through the hands of several companies. Now the intellectual property rests with a new company called Ringwood Superabrasives. Based in Fyshwick, the company is quietly confident that this time

(Continued on page 2)



▲▲ Cubicom machining hardened tool steel. It's high thermal stability means no coolant is necessary.

Inside this MM

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Ultra-hard

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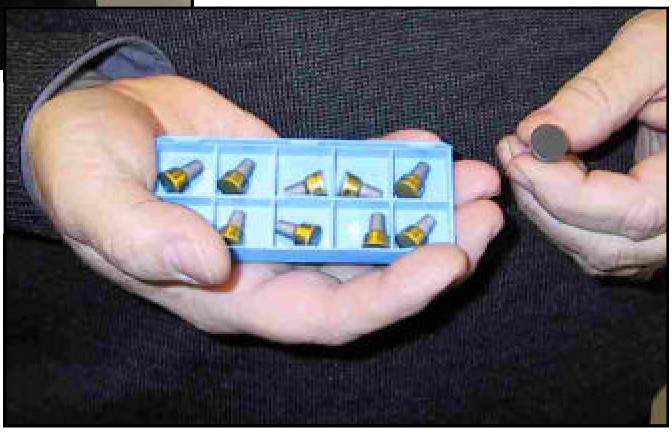

▲▲ Len Kosharek, Managing Director of Ringwood Superabrasives, with samples of the ultra-hard superabrasives custom mounted on specialised tooling equipment for the customer.

(Continued from page 1)

they've got the business side of the enterprise right.

"Our products have unique advantages over the competition," says Len Kosharek, General Manager of Ringwood Superabrasives. "But having a better product isn't the end of the story. You need to match this with appropriate resourcing and systems for its manufacture and marketing."

And having the right balance may well prove critical to its future success because the world market for ultra-hard abrasives is currently dominated by big players such as General Electric and Sumitomo. However, Kosharek is confident Ringwood Superabrasives can take them on.

"Our product has the edge," he says. "For starters, we can produce large blanks with thicker cross sections than that of our competitors. This allows us to cut our superabrasives into large special shapes.

"On top of this, Diacom™ and Cubicom™ are electrically conductive whereas the superabrasives produced by our competitors are not conductive. This means we can work our blanks using EDM (electro discharge machining). This allows us to create any configuration requested by our customers, and it's relatively straightforward to produce.

"And then there's their thermal stability. Diacom™, for example, is stable up to 1,200 degrees Celsius, which leaves similar products way behind. Coolant is not normally required when cutting with either Diacom™ or Cubicom™."

Growing the business

With so much going for it, why hasn't it proved to be a winner so far? Kosharek, who was not involved in earlier efforts but has considerable experience in running technology based companies, believes there are a number of possible reasons. Part of the problem was internal with not enough resources going into the business infrastructure and marketing side of the operation. Part of the problem was external with industry not prepared to pay a bit extra for a higher quality superabrasive. But these hurdles are now behind them with considerable effort going in to getting the business balance right, and a growing awareness by industry of the value in using quality superabrasives.

The move by industry at the moment is very much towards lean manufacturing, and the products coming out of Ringwood Superabrasives are just what smart manufacturers are after. The intelligent use of ultra-hard superabrasives is saving both time and money. For example, Cubicom™ is designed to turn ferrous alloys of up to 70Rc, thus eliminating the need for many time consuming grinding tasks. It can perform at higher speed and greater cutting depths resulting in higher productivity, increased accuracy and a superior surface finish.

Diacom™ is significantly harder, stronger and tougher than other PCDs and will turn most non-ferrous materials at high temperatures. This enables improved performance and productivity in high speed turning. Diacom™ can even be used to turn other ultra-hard materials such as partially stabilised zirconia (PSZ), one of the world's hardest ceramics (and another product of Australian research).

Right product, right time

All of which leads Ringwood Superabrasives to believe they have the right product at exactly the right time. "Indeed, the only thing limiting our ability to grow the market", says Kosharek, "is the number of hours in the day."

Ringwood Superabrasives is also well positioned to adapt and refine the science and technology involved. "Canberra is a great place to set up shop," comments Kosharek. "It has a well educated work force and we're in close contact with the expertise at ANU's Research School of Earth Sciences. Not only do we have an agreement for access to some of it's equipment, we actually employ staff involved with the original research."

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Words of substance

"If a man is in too big a hurry to give up an error he is liable to give up some truth with it."

- **Wilbur Wright**

Biomolecular Tech

The Biomolecular Resource Facility

The Biomolecular Resource Facility (BRF) is based in the John Curtin School of Medical Research (JCSMR). It aims to provide researchers with access to DNA and protein technologies that would not normally be readily available to individual research groups.

The Facility services researchers at the JCSMR and the ANU as well as the broader regional scientific community. The BRF also provides a consultancy service on all aspects of protein and peptide technology (sequencing, chromatography, purification and peptide synthesis), DNA sequencing and real-time (quantitative) PCR.

The BRF is staffed by a Manager, Technical Specialist, several Technical Officers and an Administrative Assistant. It's overseen by a Users Committee comprising academics from JCSMR, RSBS and the Faculty of Science. The committee, in conjunction with the Manager, is responsible for governance, policy, and purchasing and replacement of equipment.

Services

The BRF's core service areas are DNA sequencing and fragment analysis, GeneChip microarray, protein sequencing and peptide synthesis.

In addition we have other equipment available as a resource to approved users: an ABI SDS7700 (*alias* TaqMan, real-time PCR analyser), ABI 877 Catalyst Molecular Biology LabStation (*alias* PCR robot) and AmershamBiosciences GeneQuant pro spectrophotometer.

The Facility is well equipped for biological liquid chromatography having both an AmershamBiosciences SMART system and AKTA *explorer*. These systems support a range of chromatography from micro- to macro- bore. Two horizontal 2D gel rigs are also available to reseachers. The School also has a state-of-the-art fluoimager/phosphorimager available.

DNA sequencing & fragment analysis:

The Facility operates a range of analysers including the recently installed ABI 3730 state-of-the-art capillary Genetic Analyser. The new analyser has 48 capillaries (with an option to upgrade to 96) and a run-time of 2h using 50 cm capillaries. This means the facility can run a 96-well plate in 4h (providing a capability for high throughput project sequencing). The new technology in conjunction with BigDye 3.1 enables longer read lengths to be obtained (improved quality and reduced costs).

We aim for a turnaround time of 1-3 working days for the standard service (user prep) and 5 working days for the full service (core prep). Internal controls are included in all sequencing runs. Our pGEM controls routinely produce over 1000 base pairs of data with a Quality score >20.

GeneChip microarray:

The Facility has an Affymetrix GeneChip system (installed in July 2001). GeneChip probe arrays offer high volume and performance by providing high quality probe sequences using factory-manufactured Affymetrix probe array technology. The Affymetrix GeneChip DNA array system includes an Affymetrix hybridization oven, Affymetrix fluidics station and Agilent GeneArray scanner. The lab is also fully equipped to prepare RNA samples for hydridisation.

Peptide synthesis:

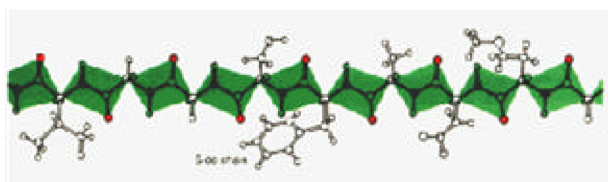
The BRF synthesises high quality peptides using a state-of-the-art SYMPHONY/MULTIPLEX multiple peptide synthesiser. The instrument is capable of producing up to 12 peptides simultaneously. The core of the instrument is a multiplexing matrix valve that permits different reagents to be transferred simultaneously to different reaction vessels without cross contamination. Different reaction times and protocols can be applied for each synthesis (or even each amino acid). Synthesis in any reaction vessel can start or stop at any time regardless of whether syntheses are being carried out in other reaction vessels. Reagents are dispersed from common reservoirs for the synthesis of all peptides.

▲▲ The SYMPHONY automated peptide synthesiser

Syntheses are performed using FMOC chemistry and solid phase peptide synthesis techniques. Peptides are synthesised at the 80 micromolar scale with a turnaround time of 1-3 weeks depending on length of peptide and whether purification is required. We routinely synthesise peptides up to 30 amino acids but are capable of synthesising longer peptides and are willing to attempt more difficult syntheses. The Facility is also able to provide chemically-modified peptides. Modifications include acetylation, N-terminal labelling (eg. biotin and fluorescein) and conjugation (eg. to KLH or MAPS). We can also synthesise peptides incorporating isotope labels, D-amino acids or unusual amino acids. Please contact us to discuss your peptide synthesis requirements.

More information:

http://jcsmr.anu.edu.au/brf

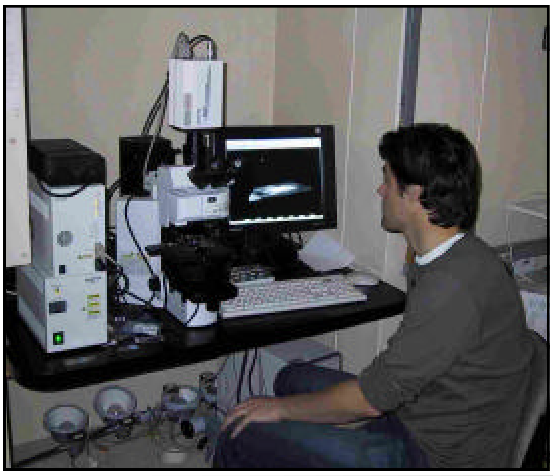


Opportunities

Shine on

Epi-fluorescence in the fishbowl

A demonstration Olympus epi-fluorescence BX61 microscope with Coolsnap camera, deconvolution and 3D reconstruction software will be on show in the EMU Fishbowl during June. Fluorescence illumination and observation is the most rapidly expanding microscopy technique employed today (see Pick the Pic, p6, for an example), both in the medical and biological sciences, a fact which has spurred the development of more sophisticated microscopes and numerous fluorescence accessories. Epi-fluorescence, or incident light fluorescence, has now become the method of choice in many applications. If enough people show interest in the epi-fluorescence demo set-up then a case might be made for purchasing it. More information, contact Sally Stowe (**stowe@rsbs.anu.edu.au**).



◀◀ Frederic Herman, a doctoral student at RSES, tests out the demo epi-fluorescence microscope at the EMU.

NANO

Following the announcement of the Australian Materials Technology Network in the last issue of MM, it's timely to mention another uni based network announced back in 2001. The Nanostructural Analysis Network Organisation (NANO) received $11.5 million from the Commonwealth Government as part of the Major National Research Facility Program. The aim was to establish a national facility in nanostructural analysis to serve the emerging fields of nano- and biotechnology.

According to its website, NANO will "provide the peak Australian facility for nanometric analysis of the structure and chemistry of materials in both physical and biological systems. NANO will operate and maintain state-of-the-art facilities for the characterisation and manipulation of matter at the atomic and molecular scale. With a primary focus on microscopy and microanalysis, this network organisation will create collaborations so as to explore and define the structure-function relationships which enable innovation in nanotechnology and biotechnology. The NANO-MNRF will develop and support a commercial-arm so as to provide a vehicle for the rapid commercialisation of results."

More information: http://nano.emc.uq.edu.au/nano.html

Diary: conferences and seminars

◀✧▶ **ISEC 2003** — **7-11 July**
International Superconducting Electronics Conference
Manly, Sydney, http://www.tip.csiro.au/ISEC2003/

◀✧▶ **WC 2003** — **24-29 August**
World Congress on medical physics and biomedical engineering
Sydney, http://www.wc2003.org/

◀✧▶ **LMT 2003** — **18-20 September**
1st International Conference on Light Metals Technology
Brisbane, http://www.lightmetals.org/

◀✧▶ **Materials 2003** — **1-3 October**
Adaptive materials for a modern society (IMEA), Uni of Technology, Sydney
http://www.mateng.asn.au/MAT2003/

◀✧▶ **New Materials and Complexity** — **3-7 November**
incorporating the Australian fundamentals of soft matter workshop
Canberra and Kiola (NSW)
http://wwwrsphysse.anu.edu.au/~col110/mat_complex.html

◀✧▶ **2nd International Symposium on Ultrafine Grained Structures** — **11-13 November**
Geelong, Victoria, http://www.mateng.asn.au/ISUGS/

◀✧▶ **National Steel Conference2003** — **17-18 November**
Wollongong, NSW, http://www.mateng.asn.au/NSC/

Materials Grab Bag

Ultra-hard
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And there's a neat twist to this story. There's a real possibility that Ted Ringwood's vision of a commercial ultra-hard material arising from RSES science might come full circle. The reason being that Cubicom™, the ultra-hard material borne of the science, might be a candidate for replacing the tungsten carbide used in the high pressure devices used at RSES to simulate conditions deep inside the planet. In so doing the researchers can generate even greater pressures (in the order of 400,000 atmospheres). Now, that would be a development sure to have pleased the Professor.

More information on Ringwood Superabrasives www.ringwoodsuperabrasives.com/default.htm

Champion Ted

The late Ted Ringwood was one of the Research School of Earth Science's best known and most influential champions. He argued strongly for the formation of the RSES (which formed as an offshoot of the Research School of Physical Sciences in 1972) and was its Director from 1978 to 1983. Besides carrying out pioneering work on the geochemistry and composition of the Earth, the Moon and the terrestrial planets, he was always looking for ways of deriving greater benefit from his science and technology.

Professor Ted Ringwood

In the mid 70s he devised an ingenious method for safely storing high level nuclear waste in a titania-based ceramic called SYNROC. The constituent minerals in SYNROC have the capacity to immobilize, in their crystal lattices, almost all of the radionuclides in nuclear waste.

Ted Ringwood demonstrated an entrepreneurial streak in his science from an early age. While studying for his MSc, Ted was involved with a field-mapping and petrology project in the Devonian Snowy River volcanics of northeastern Victoria. Whilst mapping, Ted explored an exhausted silver mine where large quantities of galena-rich tailings had been discarded. Ted seized the opportunity by bagging the galena and transporting it to Melbourne for sale as feedstock for the Melbourne shot tower. (The shot tower is still preserved within what was the Daimaru Shopping Centre.) The venture was profitable and may have been an important influence on Ted's view of the connection between science and commerce.

More information on the life of Ted Ringwood: http://www.science.org.au/academy/memoirs/ringwood.htm#honours

The finer points of CBED

ANU was lucky to have Prof Jean Paul Morniroli on campus this month (visiting Ray Withers, RSC). Jean Paul, from the Université des Sciences et Technologies de Lille, France, is a leading authority on the Convergent-Beam Electron Diffraction (CBED) and Large Angle CBED, and shared his experience at a seminar on 11 June. (CSEM put on a wine and cheese following the seminar.)

Jean Paul also ran several workshops and tutorials on the technique, with three post doc students from Electronic Materials Engineering (RSPhySE) getting a hands on demonstration of CBED and LACBED for characterising semi-conductors using EMU's CM300 transmission electron microscope (which operates out of RSES).

▲▲ Jean Paul (2nd from right) chats with Zbigniew Stachurski at the CSEM wine and cheese following the presentation on CBED.

CBED and LACBED are excellent techniques for the characterisation of crystal structures (point and space group identifications). LACBED patterns are very well adapted to the analysis of the microstructure (crystal defects) because they are performed with a defocused incident beam and therefore they contain information on both the reciprocal space (the Bragg lines) and the direct space (the shadow image of the illuminated area of the specimen) and can be regarded as an image-diffraction mapping technique.

Jean Paul is in Australia for the next four months at the University of Queensland.

For more information on CBED, LACBED or how to contact Jean Paul, contact John Fitzgerald (john.fitzgerald@anu.edu.au) or Ray Withers (withers@rsc.anu.edu.au).

◀◀ Electronic Materials Engineering post docs Jenny Wong-Leung, Jody Bradby and Susie Kluth take instruction from Jean Paul on the use of CBED on the CM300 TEM.

Jenny Wong-Leung questions Jean Paul on an aspect of LACBED. ? ?

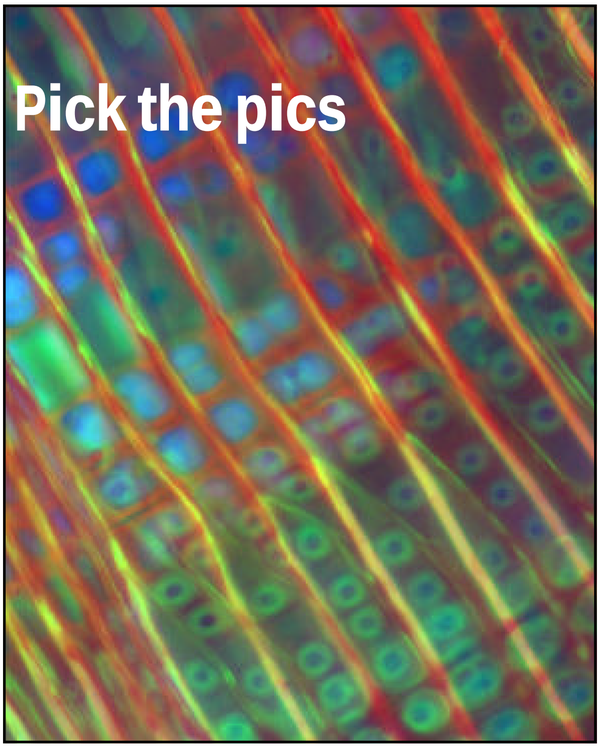
the backpage

MM webspotting

Superabrasives

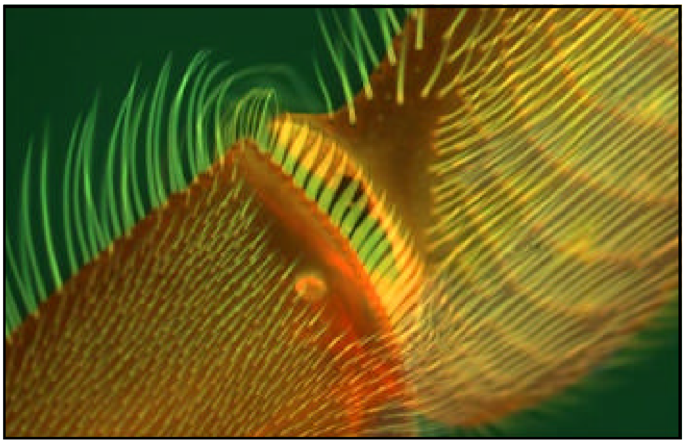
- **Ringwood Superabrasives**
  http://www.ringwoodsuperabrasives.com/default.htm
- **Taking advantage of superabrasives**
  http://www.mmsonline.com/articles/069703.html
- **GE Superabrasives**
  http://www.abrasivesnet.com/en/
- **3M Superabrasives**
  http://www.labenson.com/superandmicro.html
- **General superabrasives knowledge**
  http://members.tripod.com/cncgrind/gsk.htm
- **The value of superabrasives**
  http://www.huffmancorp.com/Downloads/NewsEvents/WhitePapers/SuperAbrasiveGrinding.pdf

Pick the pics



▲▲ Xylem tracheids in wood from pine trees (*Pinus*).

The leg of a honeybee ▼▼



The above images were captured using fluorescence microscopy (and can be found with many other examples at the Olympus website) **(http://www.olympusmicro.com/primer/techniques/fluorescence/fluorogallery.html)**

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