MacDiarmid

Interface

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Inside this issue

The new MacDiarmid Institute Raman laboratory at Victoria University.

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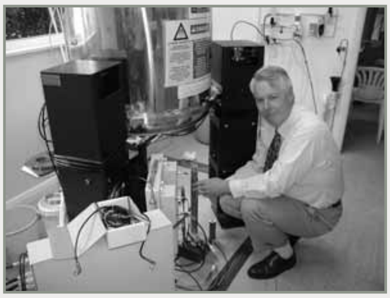

Associate Professor Ken MacKenzie is the 2003 recipient of The NZ Association of Scientists Shoreland Medal and Royal Society of New Zealand Hector Medal.

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The MacDiarmid Institute
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There are still secrets to uncover

by Veronika Meduna

The sun is the single biggest energy source in our solar system, firing almost 40,000 times as much power to the Earth than we use. With a growing population, providing energy to people will be one of the most pressing problems of the future - yet, an efficient and affordable use of solar energy remains a challenge.

Not so for plants, though, and David Officer's team at Massey University is taking a leaf out of the natural world by borrowing ideas from photosynthesis to harness the sun's power.

Professor Officer joined Massey University in the mid-1980s after a stint as an Alexander von Humboldt research fellow in Germany. He trained as an organic chemist, but was more interested in molecular logic devices and nano-scale smart materials than natural products. So he began investigating the light-harvesting qualities of a group of complex ring-shaped molecules called the porphyrins, which can be activated by particular wavelengths.

Today, Professor Officer is the director of Massey University's Nanomaterials Research Centre and his team heads the race to develop nanostructured plastic solar cells, using porphyrins and conducting plastics to harvest and convert light to power. His team's work also feeds into research at the MacDiarmid Institute for Advanced Materials and Nanotechnology, a Centre of Excellence that encompasses Victoria and Canterbury universities, partners at Otago and Massey universities and Industrial Research and the Institute of Geological and Nuclear Sciences.

In 2002, Professor Officer's scientific endeavour was boosted by a $5.7 million grant to develop cutting-edge solar technology, one of the biggest awards Massey University received from the Foundation of Research, Science and Technology. And last year, he became a 'Partner Investigator' in an Australian research centre with a similar mission to improve energy conversion systems.

Continued on page 3

From the Director

of the MacDiarmid Institute

At the dawn of the 20th century electricity was a curious new technology while air travel was a dream of science fiction. Physical science provided a self-contained and self consistent picture of the laws governing mechanics, electro-magnetism and thermodynamics, soon to be shattered by the discovery of atomic structure and the quantum mechanics which dominates the domain of the very small. At the dawn of the 21st century we stand on a new threshold, mesmerized by the power of modern molecular biology, by our seeming capacity to control life itself. Far from reaching the end of science, we find that science reaches deeper and deeper, in never ending layers of complexity, so that as we reveal each layer, more open to draw us on. Of only one thing can we be certain, that the pace of change will not relent, and that this coming century will see technologies which we can only struggle to imagine.

We have until recently manufactured our technologies with ever increasing complexity, built on the platform of new enabling materials, the ultra-strong and the light metals, the high performance polymers, the doped silicon, and the liquid crystals. In doing so we have miniaturized, top down, reaching the limits which optical control permits, the wavelength of light, on the order of one micron. Our electronic computational power has followed a power-law progression of improvement, reaching the point where silicon technology is facing its limit. To fabricate circuits with nanometer-sized control, an entirely different materials, architecture and fabrication paradigm is demanded. With the invention of the scanning tunneling and atomic force microscopes we have a glimpse of the atomic domain, and the primitive ability to manipulate individual atoms. The era of nanotechnology beckons, but the way forward is far from clear.

Recently we have witnessed an extraordinary rise in the capacity of chemistry to synthesise molecules to pre-ordained design, along with an explosive increase in our understanding of the molecular basis of living processes. Ironically, as the electronics industry has reached down to miniaturise, chemistry has reached upwards along the path of self-assembly while biology has found the pathways which govern life in the remarkable processes of replication and self-organisation manifest in the world of DNA and protein molecules. Two routes to the nanoworld are apparent, either through top-down assembly, using new lithographies and micro- then nano-machine assemblers, or from the bottom up, atom by atom, molecule by molecule, following mass self-assembly processes. By such a choice of path, biology, the ultimate nanotechnology, acts to inspire physical science while the techniques of synthetic chemistry provide our tools. Suddenly, biology, physics, chemistry and engineering have converged.

The impacts of advances in materials science and nanotechnology are expected to be widespread, including faster electronics and vastly greater memory storage capacity, cheap, disposable even wearable electronics, new optical and opto-electronic devices, new forms of drug delivery, cellular repair devices, molecular-scale motors, and new lightweight, ultra-strong self-healing materials. The US National Nanotechnology Initiative (NNI) is one of the few Clinton administration programmes to be strongly backed by the Bush administration. The nanotechnology research investment was US $600m in 2002. The US National Science Foundation predicts that nanotechnology will be a US $1 trillion industry by 2015, making it one of that fastest growing industries in history and larger than the combined telecommunications and information technology industries at the beginning of the technology boom in 1998. In the words of Rita Colwell, Director of the National Science Foundation “Nanotechnology is truly a portal opening to a new world”.

This statement of the MacDiarmid Institute's nanotechnology vision introduced our portfolio bid to the Foundation for Research, Science and Technology. At the start of 2004, as we await the outcome of our Foundation funding bids, we begin a new year in excellent heart. In March, an international team comprising Professors Neil Ashcroft (Cornell), Mark Warner (Cambridge), Ed Samulski (UNC, Chapel Hill), and Jim Williams (ANU) will review our progress and advise the Board on our future science and investment strategy. We are determined to fix our sights on the very best international standards of science and technology achievement.

- Paul Callaghan

Continued from page 1

Porphyrin chemistry remains at the centre of his team's effort. "Porphyrins have a number of biological roles, including acting as carriers of oxygen and CO_2 in heme, and as the light-harvesting molecules in chlorophyll."

In these biological roles porphyrins are coloured molecules, courtesy of a range of metals at their centre, such as iron in heme and magnesium in chlorophyll. Professor Officer says that gives them great potential as their function and light-absorption capacities can be tuned by inserting different metals. "They have been studied for a long time and are known to have great photo- and redox-active properties, which means that you can add and remove electrons from them, and you can put at least 60 different metals in them to tune them."

As a bonus, porphyrins also have 20 times the light absorption of other coloured dyes, he says.

For the past three decades, photovoltaic cells have relied on silicon. But despite major investments into research and development, silicon cells are not yet efficient and cheap enough to provide a realistic alternative source of energy.

A significant change of direction took place in 1980, when Swiss scientists developed a new process to convert sunshine into electricity without silicon. This photoelectrochemical solar cell, developed by Michael Grätzel, uses a layer of titanium dioxide sandwiched between two layers of glass with a dye to absorb the light and a liquid to conduct the electricity. The Grätzel cell is in the process of being commercialised, and Professor Officer says it should come in at about 60 cents a Watt, compared to the $3/Watt of the cheaper versions of silicon cells. "The glass would be the biggest cost. Our aim was to put porphyrin dyes into these cells."

In order to use porphyrins as light harvesters, the team had to come up with ways of linking the molecules to the titanium dioxide layer and to assemble them in arrays, in an effort to mimic the way plants use chlorophyll molecules.

The result was a solar cell with a conversion rate of 4% - and scope for improvement. "The porphyrin is doing its job well. The conversion is 80%, which means that 80% of all the light falling onto the dye is converted into electrons and that's as good as it's going to get. The problem is the spectrum. There are a whole lot of wavelengths that aren't picked up, so the idea of arrays is that there could be different porphyrins for different wavelengths."

The team also decided to experiment with other elements of the cell and to include conducting polymers in their design. "Titanium dioxide wasn't the only way to go. I thought that we could put the porphyrins onto a plastic wire, then all we had to do was to shine light on the porphyrin, which would get excited and pass an electron to the plastic wire and bingo, we'd be able to collect electricity."

Professor Officer says his team had to learn quickly that things are never quite that simple. They experimented with different chain-lengths of a thiophene-based polymer, but found that conducting polymers differ from titanium dioxide in their willingness to take up electrons from the porphyrin dye. "Our porphyrin materials had confused the cell and made it work against itself. We came up with a bridge system, where the porphyrin is cross-linked and at right angles to the polymer, and we put zinc into the dye to increase the light-harvesting capacity. With all this, we might have expected a light-electricity conversion of about 5%, but we are only getting about 0.1%, so there are still secrets to uncover and lots of work to do. One of the keys may be to nanostructure the cells and that is one of the things that we are trying to achieve with the MacDiarmid Institute."

Professor Officer says these cells may remain less efficient, but would be vastly cheaper to make than silicon-based cells and they could be recycled. And while the work on solar cells continues, his team has achieved major milestones in related areas, such as the commercialization of a nickel-zinc battery to replace the power storage systems of current photovoltaic cells.

Professor Officer's enthusiasm for the potential of nanotechnology to deliver intelligent materials that respond to their environment is also infectious. In principle, he says, you could have a conducting polymer that is made into a jumper such that it would change its structure according to the temperature, so it would keep you warm outside, but as you entered a warm room, the fibre would sense that and open up to cool you down. A washable computer keyboard made from wool isn't far away, he says, nor is the Harry Potter inspired idea of video clips embedded in newspapers.

Judging by the pace of development of smart nano-materials, nothing will remain fantasy for too long. Professor Officer remembers giving a talk about molecular electronic devices to an audience of physicists at CSIRO in Melbourne in 1989 and receiving nothing but laughter from his audience. "It's wasn't nice, but the idea that we could make electronic componentry as single molecules and put together a molecular computer, while possible, just wasn't in the general scientific consciousness. After all the Nobel Prize for conducting polymers wasn't given until 2000. Now there are dozens of people working on such ideas, even some of the scientists who laughed."

Bright Lights Beckon for OLED Research

by Vicki Hyde

The bright lights of Las Vegas may get a little brighter thanks to some clever technology under development through a New Zealand collaboration of academic researchers and commercial interests.

One New Zealand company, ScreenSign Arts , is already exporting $10 million in gaming machines, making use of the current generation of screen-printed, light-emitting plastic sheets which light up casinos and gaming houses worldwide.

Dr Keith Gordon, of Otago University, is working on next-generation organic light-emitting devices (OLEDs), which takes the technology one step further, operating at the molecular level.

"The trick is to get the best molecules," says Gordon.

Gordon started off looking at ways to make the light emitter material - zinc sulphide - better. Zinc sulphide tends to be fragile under intense light, and the light it emits is blue. Adding a pink dye to the mix to colour-correct the blue to white light works reasonably well, but the dye breaks down after three or four months. While having dyes bleach out on exposure to sunlight may not be an issue for enclosed casinos, it does tend to limit the possible applications for the technology.

In conjunction with researchers at Massey University, Gordon is looking at developing robust dyes that won't fade and teaming these up with highly efficient conducting polymers. He's looking at how to guide the structural componentry and relationships to produce the best possible results. And the results have been very promising - the nano-layering of the ruthenium-based OLEDs developed by Gordon and his team offers far greater control than the current technology, allowing excellent resolution, greater longevity and low power consumption.

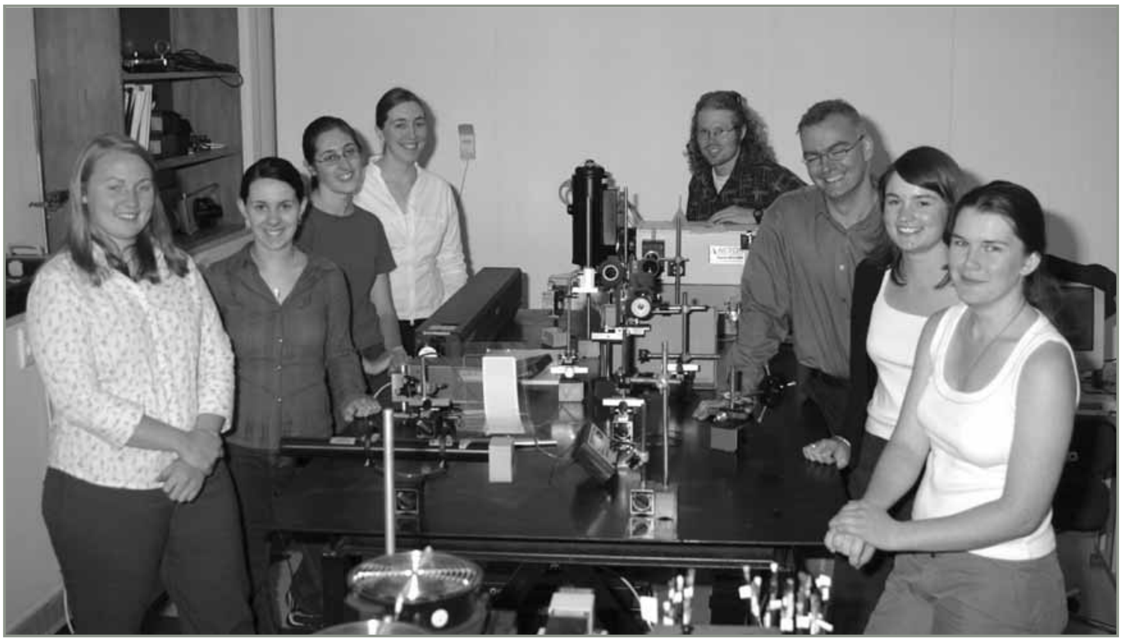
As an example of the possible applications now open, Gordon says look around any office and see how much money is invested in computer screens. OLEDs offer a way of making screens brighter and more readable, while significantly reducing power costs. A quick back-of-the-envelope calculation indicates that an OLED screen for his office would draw power at the milliwatt level, compared to the 30 watts his current plasma screen uses - or roughly a thousand times less electricity.

"The OLEDs will destroy the LCD market."

Gordon says that any application using an LCD now, from computer screens to mobile phones, transportation control systems to dishwashers, would benefit from the new approach. He thinks LCDs could go the way of the gas light within the next decade.

"If you can think of a lighting application, it can do it. It's much less expensive than plasma technology. More efficient than incandescent bulbs and the light is softer too."

In addition, OLEDs produce minimal heat and can be as flat as a sheet of paper.



Dr Keith Gordon (third from right) and his research group

Instead of having bulky monitors, a computer cubicle could have its walls coated with OLEDs. Take it one step further, and the long-heralded flat-screen, wall-sized TVs could be a reality for far less than the cost of the plasma screens now entering the domestic entertainment market.

Gordon says that, while his work could revolutionise the screen market, he's not in it to become a major hardware producer but is interested in making smart use of the technology's potential. His team is working with other organisations, such as ScreenSign Arts in Christchurch, to see what practical applications can be developed.

He sees this sort of development as one which could achieve excellent results for New Zealand.

"It could be very worthwhile to set up [a production plant] here to sell them. It's not like a semiconductor [manufacturing] plant, which is very expensive."

He looks to the future where investment in small-scale specialised OLED coating plants allows New Zealand a competitive edge, bringing in export dollars from the likes of Sanyo and Kodak.

Gordon believes that Kiwi craftsmanship has a role to play in any such success. He sees ScreenSign Arts, for example, as currently producing screens which are better than any on the market because of their careful attention to detail and quality control.

Add a little bit of science to the mix, he adds, and you've got a formula for a winning technology.

"To design the material that will be the most effective, you need to know the underpinning science. We have an industry which has clients and scientists backing up that industry."

Helping with that mix has been the MacDiarmid Institute, which has played a role in connecting the academics and facilitating the cross-over from theoretical to experimental science and the technological applications that develop. He's seen it as having a major impact in allowing his team to meet up with and work alongside other researchers and industry players, and something which will contribute to the eventual success of taking some "interesting" chemical properties and developing world leading technology.

Alan MacDiarmid in 2004

Professor Alan MacDiarmid will visit New Zealand again in 2004 when he attends the 4th APEC Ministers' Meeting on Regional Science. Last year he came to attend AMN-1, our International Conference on Advanced Materials and Nanotechnology, and to attend his investiture as a member of the Order of New Zealand. This year, Alan will attend the 4th APEC Ministers' Meeting on Regional Science and Technology Cooperation in Christchurch, on 10 and 11 March 2004. At this meeting, Research and Development Leaders from the APEC region will meet to explore and debate the theme of 'capturing value from science' with input from leading experts around the world including not only Alan but also Dr Rita Colwell, Director of the US National Science Foundation. Rita visited the MacDiarmid Institute when she was in New Zealand last year. After the APEC meeting, Alan will spend 14, 15 and 16 March visiting the MacDiarmid Institute at Victoria and Massey Universities.


Alan MacDiarmid

A helping hand from the MacDiarmid Institute

During September 2003, Dr Jason Hindmarsh, a University of Auckland Chemical Engineering graduate, left his Cambridge UK research laboratory to return to New Zealand for a two week tour of science research laboratories. The trip was sponsored by the MacDiarmid Institute in order to give this talented young kiwi scientist the chance to familiarise himself with science opportunities back home, and to find a possible sponsor for a post doctoral fellowship application to the Foundation for Research, Science and Technology. He put together a proposal involving collaboration between Auckland, Massey and Victoria Universities along with Fonterra Research, and his bid to FRST was successful. Jason's three year project, beginning February 2004, will be to establish a new widebore Magnetic Resonance Imaging facility, and to carry out research work on dairy products for Fonterra. This laboratory will also enable new biomedical, horticultural and materials science research of considerable benefit to New Zealand, a major "payoff" for a timely investment by the Institute.


Jason Hindmarsh

Collaborating while competing

The Foundation for Research, Science and Technology provides a major portion of the external grant funding enjoyed by MacDiarmid Institute researchers. At the establishment of the Institute in 2002, our combined university-based FRST grants totalled nearly $3 million per annum, while CRI-based principal investigators managed an even larger sum. In 2003, most of these grants expired and we were required to compete in the same "pool" - Innovation-based Enterprises. Institute Principal Investigators took the important step of working together to produce an integrated and coherent portfolio of programmes, in which new teams and alliances were formed. A series of workshops held during 2003 led to agreement on a combined portfolio bid for $19 million per annum in 15 separate programmes, involving staff from the four partner universities and the two partner CRIs (IRL and GNS). An accompanying umbrella document outlined the overall strategy behind the programmes as well as detailing linkages and interdependencies. To quote

"The enormous scale of international nanotechnology research begs the question as to the appropriate level of investment for New Zealand. A case for significant and sustained investment by the Foundation for Research, Science and Technology in Advanced Materials and Nanotechnology research is predicated on five major factors

(i) New Zealand is committed to a biotechnology future. Nanotechnology will not only provide the foundation for new biotechnologies, but will develop according to strategies informed by advancing knowledge in molecular biology.

(ii) New Zealand has significant intellectual capability in key underpinning science areas of nanolithography, nanowire formation, molecular electronics, conducting polymers, carbon nanotube physics and chemistry, polymer and soft matter physics, spintronics and semiconductor physics, ceramic and high temperature superconductor physics and chemistry, surface/sensor technology and radiation imaging and detection. We have the potential to develop niche technologies with significant IP value, with local technology manufacture and export.

(iii) New Zealand has made significant capital investment in key instrumentation underpinning science areas of nanotechnology and its related sciences. The MacDiarmid Institute has invested $9.8m in new state-of-the-art equipment adding to a preceding inventory of similar value.

(iv) Success in Advanced Materials and Nanotechnology research will require interdisciplinarity embracing physics, chemistry, biology and engineering, a strong connectivity between scientific and technology approaches, excellent cross-team inspiration and strong visionary focus. The formation of the MacDiarmid Institute has led to a completely new cooperative dynamic between universities and CRIs which incorporates these key factors.

(v) As a first world nation dependent on trade and seeking to develop a knowledge economy, New Zealand needs to develop capability in this 'portal opening to a new world'.

This document presents a case for supporting what we regard as a carefully constructed portfolio of New Zealand Research in Advanced Materials and Nanotechnology, under the umbrella of the MacDiarmid Institute, a New Zealand Centre of Research Excellence. This portfolio has its heritage in antecedent research, much of which has been supported by FRST through prior NERF programmes. However, the research included under the MacDiarmid umbrella represents a significantly new approach in that:

(i) As a result of a series of discussions taking place between MacDiarmid Institute researchers over the past year we have completely realigned our research activity, identifying promising new lines of investigation and forming new research alliances designed to meet our key objectives.

(ii) Each research programme in the portfolio, while being hosted by either a university or CRI, forms part of an interlocking, MacDiarmid-managed cooperation.

(iii) A strong feature of our portfolio is the high level of inter-institutional and inter-disciplinary cooperation. Of particular interest is the way we have managed a high degree of cooperation between CRI and University research staff. Key research staff have been assigned to research programmes based on their skill contributions, rather than their institutional or disciplinary affiliation.

(iv) Key infrastructure issues have been managed cooperatively, by assigning to each programme a component of cost associated with critical underpinning services, such as electron microscopy.

(v) Small bids have been eliminated, the size of programmes included ranging from ~ NZ $300 k per annum to ~ NZ $3000 k per annum.

(vi) Each programme offers a high level of quality assurance, based on the excellence criteria of the MacDiarmid Institute as monitored by our international advisory board and the New Zealand governance board.

(vii) Our international linkage is, we believe, unparalleled, featuring active collaborations with the best materials science and nanotechnology groups in the world.

(viii) The portfolio is interlocking. Each programme, supports the remainder.

(ix) The combined progammes feature the strong leadership and shared values that distinguishes the MacDiarmid Institute. We have the scientific buoyancy that comes from being involved in a remarkable adventure. We invite the Foundation to partner us in that."

This is the first time that teams of scientists across a wide range of institutions have cooperated in such a process. As the *Interface* goes to press, 12 of the 15 programmes have passed the first stage of evaluation.

Rheology in Pittsburg

During October last year, MacDiarmid PhD student, Rosario López González had the opportunity to fly to Pennsylvania for The 75th Annual Meeting of the Society of Rheology† conference held in Pittsburgh. She gave her first oral presentation, part of a collaboration involving Professor Paul Callaghan (her supervisor), Professor Panos Photinos from the Southern Oregon University, and Dr William Holmes from Victoria University of Wellington who recently move to Exxon in New Jersey. She presented her research on surfactants molecules, which play an important role in our lives due to their application in many areas such as cosmetics, adhesives, medicines and food products. The systems that Rosario is looking at are characterized by flow instabilities under shear. She is developing new methods to study these flow instabilities using Rheology and Nuclear Magnetic Resonance (Rheo-NMR). "Around 300 delegates attended the conference and the presentations were outstanding" said Rosario. "This meeting has been held for 75 years and is the pre-eminent Rheology conference. I had the chance to interact with very famous Rheologists such as R. B. Bird, G. Marrucci, A.B. Metzer, Peter Olmsted, and Jay Schieber. On this occasion the conference trip was a delightful boat-ride along the river Ohio, which diverges into the Allegheny and Monongalela rivers located in front of the conference site, followed by a gorgeous dinner and live music. The view of the city at night was magnificent."

Rosario López González

† *Rheology is a branch of Physics that describes the deformation and flow of matter.*

New Marsden grants for MacDiarmid researchers

Three research teams from the MacDiarmid Institute gained new three-year Marsden research grants in the 2003 round out of the 12 awarded by the Physical Sciences and Engineering panel. The projects were:

"Sub-wavelength optics using surface plasmons" at $255,000 per annum, led by Associate Professor Richard Blaikie and Dr Maan Alkaisi;

"Inhomogeneity and high-temperature superconductors" at $200,000 per annum, led by Professor Jeffery Tallon and Dr Grant Williams, IRL, with associate investigators including Dr Pablo Etchegoin;

"Rheo-NMR, Rheo-optics and complex soft matter" at $240,000 per annum, led by Professor Paul Callaghan and Dr Yacine Hemar, with associate investigators Dr Kate McGrath and Professor David Beaglehole.

These Marsden grants provide important new funding for the Themes I, II and IV respectively as well as a useful benchmark for the quality of our research programmes.

Getting the Blues

by Anna Meyer

Listening to music in the car is a simple pleasure that many of us enjoy. However, especially on long journeys, it can often seem like a startlingly short amount of time before the CD ends and needs to be changed. The problem is that there is simply a limited amount of information that can be packed onto a CD. But now research being done by Professor Joe Trodahl and his colleagues at the MacDiarmid Institute may provide a solution to this frustrating problem.

Joe Trodahl in the new Raman laboratory, Victoria University along with colleague Ben Ruck and student Mike Dalley

Professor Trodahl's research revolves around a family of materials essential in all aspects of the electronics industry, known as semiconductors. Semiconductors are interesting because their electrical properties can easily be manipulated, simply by varying factors such as temperature or the presence of impurity atoms. It is this versatility that makes them so useful in a variety of electronic components.

Silicon is the by far the most common element used in producing semiconductors. It is a convenient element to use, largely because it is so abundant. Pure silicon forms a lattice structure, much like the structure of diamond that is formed by carbon atoms. However, silicon has one severe disadvantage - it can not emit light. A variety of electronic components need to emit light, such as light emitting diodes (LEDs) and lasers, and therefore these cannot be made from silicon.

To make a semi conductor that emits light, it is instead necessary to use a substance that has the same structure as silicon, but is instead made up of an equal mixture of atoms from group three and group five on the periodic table, "Because they have the same number of electrons per pair of atoms as silicon does" said Professor Trodahl, "they end up with the same structure". Depending on which group three and group five atoms are combined, different light emitting properties can be gained. For example Gallium Arsenide, a common semiconductor used in a variety of electronic components, emits light in the red to infrared range.

However, there is one colour that has proven extremely difficult to produce with traditional semiconductors - blue light. It is not possible to make a blue laser with Gallium Arsenide, for example. Although a variety of tricks have been developed that can be used to move towards the blue end of the colour spectrum, it is not possible to get very far with it.

"The only material that can do that with any efficiency at the moment is Gallium Nitride", Professor Trodahl explained. Gallium Nitride (GaN) is part of the group of substances known as group three nitrides, and it is these compounds that are the subject of Professor Trodahl's research. Specifically, the research involves developing new techniques for making thin films of group three nitrides, Gallium Nitride in particular. A thin film is a very thin layer of the substance, bonded to substrate such as silicon, and these are essential for use in electronic components.

Actually making a thin film of Gallium Nitride, however, is no easy matter. "It's hard to make this material", said Professor Trodahl, "because normally it is a gas". Usually, thin films of semiconductors are created by melting the components together, but this is not possible for Gallium Nitride. "If you try to melt Nitrogen and Gallium together, the nitrogen gas leaks out" Professor Trodahl explained. "So you have to devise a new way of making it." Developing new methods for making thin films of Gallium Nitride and other related semiconductors is precisely what the team are working on. "We have devised a new way of making thin films of Gallium Nitride," said Professor Trodahl. Basically, the process is as follows. To begin, the substrate is placed into a very good filtering system, to prevent any impurities. Then, they simultaneously deposit nitrogen and gallium ions onto the substrate. The result is the sought after thin film of Gallium Nitride.

Thin films of Gallium Nitride have several potential uses. For example, as mentioned in the beginning of this article, one interesting use could be to improve the technology used in CD players. "By using blue light instead of red light in the lasers that read CDs, - they are all read with red light at the moment - you can pack twice as many tracks on the CD, because the wavelength is shorter", said Professor Trodahl. Other uses of the blue light emitted by thin films of Gallium Nitride include use in diodes for navigation equipment, and to complete the colour in full colour displays made from solid state materials, which are more efficient. In these situations, Gallium Nitride provides the missing blue colour that other materials can not provide.

Besides their usefulness in emitting blue light, there are a range of other applications that thin films of Gallium Nitride could be used for. For example, Professor Trodahl and his colleagues are currently trialling an application where Gallium Nitride is turned into a magnetic material. This would have applications in a field known as spintronics - electronics in which not only are the number of electrons controlled, but also a property known as their spin state. Control the spin state, Professor Trodahl says, and "You can do a lot more fancy stuff with it".

The team also has a collaboration in France with researchers who are exploring whether or not Gallium Nitride, or any other nitride film can be used to store lithium. The interest there is it would make a very lightweight lithium battery. This would be useful anywhere small batteries would be an advantage, for example in hearing aids.

So far, Professor Trodahl has concentrated his efforts on thin films of Gallium Nitride, but there are also many other possibilities for working with other group three nitrides. "The other obvious candidates are Aluminium Nitride and Indium Nitride, or mixtures of those three, to make diodes and so on that emit various colours" he said. Another possibility is in making layers of combinations of group three nitrides. "There is a real advantage in making layers of Gallium Nitride followed by Aluminium Nitride, and other combinations" Professor Trodahl explained. "It's a very unexplored area."

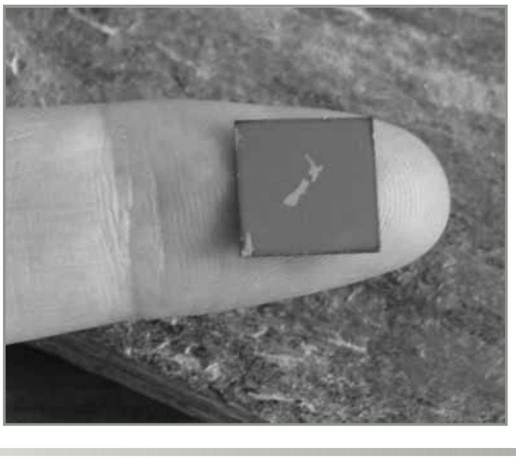
Canterbury Outreach

by Rebecca Hurrell

The University of Canterbury Science Outreach Programme sends graduate students into secondary school classrooms to deliver presentations on topical issues in science and engineering. In 2003, the MacDiarmid Institute funded the Science Outreach Programme to provide presentations on Nanotechnology and Materials Science, and to develop hands-on activities for visiting students and teachers.

The first presentation, entitled "Nanotechnology: The future of electronic devices", was prepared in collaboration with Dr Simon Brown from the Department of Physics and Astronomy. It has been given, to enthusiastic audiences, on numerous occasions in schools in the Canterbury and Nelson regions, by graduate students from the Department of Physics and Astronomy and the Department of Electrical and Computer Engineering. The second presentation entitled "Materials: Stone age to modern age" has just been completed by a graduate student from the Department of Chemistry.

A series of three hands-on activities have also been developed. The first uses Optical Lithography to produce maps of the world and New Zealand on silicon. The world maps are about 10 cm in diameter, which makes New Zealand only a few millimetres high.



The second activity uses Electron Beam Lithography to make scale maps of Christchurch on these maps of New Zealand, while the third uses Atomic Force Microscopy to zoom in and visualise these Christchurch street maps. These fascinating activities have proven to be very popular with both teachers and students.

In 2004, the MacDiarmid Institute will fund the Science Outreach Programme to deliver more presentations in schools and provide two more professional development workshops for teachers. The presentations and activities will also be part of the programme for SciCon 2004, a biennial science educators' conference that will be hosted by the University of Canterbury.

Update on the Synchrotron Project

by Jim Metson

For a facility that is scheduled to see first light in 2007, much seems to be happening right at the moment in the Australian synchrotron project. A number of milestones, critical decisions and documents have appeared since the report in the August 2003 issue of *Interface*. On both sides of the Tasman we are in the midst of decisions on participation and how the development of beamlines will be funded and managed.

There are essentially two projects to be considered within the wider task of building the synchrotron. The first, the construction of the buildings, the infrastructure and the booster and storage ring itself, is proceeding on an ambitious schedule, but with considerable momentum. The main building is now well underway (see figure 1). The project team is largely in place and major contracts have now been signed for the accelerator and booster ring (see figure 2 for the floorplan), with the ring magnets and chambers soon to follow. This phase of the development is being funded and executed through the Government of Victoria.

The second area within the wider project is the funding, selection, design and construction of an initial suite of beamlines and end-stations to undertake the science. The anticipated cost of an initial tranche of perhaps 9-10 beamlines is A$50M. The suggested makeup of an initial 13 is shown in Table 1. It is anticipated that the additional lines in the Table will be either be priority 2 (Circular dichroism, VUV), or commercially funded (lithography and microprobe). The Table represents the current thinking of the National Science Advisory Committee on the best match we currently see for demand, both current and anticipated, and was reached after extensive feedback from the Australian and New Zealand Science communities. I should emphasise that there is an extremely strong desire that these beamlines will be internationally cutting edge in performance when commissioned - there is little point in attempting to attract the major user communities back to an Australian facility if the technical capability cannot match what is available elsewhere.

The Australian Science case for the funding of the beamlines [1] was released in January and coincided with the announcement of a A$15M funding contribution from a three way partnership of the University of Melbourne, Monash University and CSIRO. This will provide crucial leverage with the major Australian funding agencies, and gives momentum to the very important task of defining and building the science capabilities of the facility.

On this side of the Tasman, the very successful user meeting in Auckland in September was followed by a request from the Ministry of Research Science and Technology to the Royal Society of New Zealand to prepare a New

Table 1. Possible initial beamline selection and configuration.
Note the extreme energy window across these lines from 0.001 eV to >100keV.

No Beamline Description	Source	Energy Range
1. High Throughput Protein Crystallography	Stage 1: Bending Magnet Stage 2: Undulator	2 - 20 keV
2. Protein Micro-crystal & Small Molecule X-ray Diffraction	Undulator	2 - 20 keV
3. Powder X-ray Diffraction	Stage 1: Bending Magnet Stage 2: Wiggler	4 - 60 keV
4. Small and Wide Angle X-ray Scattering	Undulator	5.5 - 20 keV
5. X-ray Absorption Spectroscopy	Wiggler	4 - 65 keV
6. Soft X-ray Spectroscopy	Undulator	0.1 - 3 keV
7. Vacuum Ultra Violet (VUV) Spectroscopy	Undulator	10 - 350 eV
8. Vibrational & Optical Spectroscopy (Infrared to near UV)	Bending Magnet	0.001 to 2 eV (2 - 20000 cm-1)
9. Microfocus Spectroscopy (submicron-XAS, XANES, XFS & XPS)	Undulator	5.5 - 25 keV
10. X-ray Imaging & Therapy	Wiggler	10 - 120 keV
11. General Purpose Microprobe (XRD & XRF mapping)	Bending Magnet	4 - 20 keV
12.. Circular Dichroism	Bending Magnet	2-10 eV
13. Lithography	Bending Magnet	2 - 25 keV

Figure 1. View of the pre-cast columns for the main building from the entry road - december 2003.

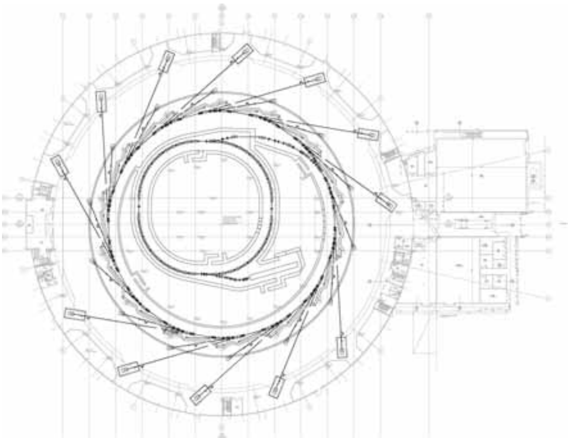


Figure 2. Floorplan of the building with an initial 12 beamlines in place.

Zealand report on participation in the Synchrotron project. A small expert committee, including the MacDiarmid Deputy Director Richard Blaikie, was convened and reported in early November. Much of this report is available on the Royal Society website [2]. Notable is the very broad response to a survey of New Zealand scientists asked to indicate their interest in synchrotron science. Wide ranging and detailed responses were forthcoming from almost every research establishment in the country. Interestingly, the report followed hard on the heels of the announcement of the sharing of the 2003 Chemistry Nobel prize by Roderick MacKinnon for his largely synchrotron based work on ion channels [3].

Overall, progress has been dramatic, but New Zealand is rapidly approaching decision time with regard to the nature and extent of our participation in this venture. There are few models to guide such an investment, but the Ministry of Research Science and Technology is taking a very pro-active role in defining how this participation might be achieved. There is a clear window of opportunity to participate in one of the largest science ventures ever to be undertaken in our region of the world. I would suggest that for the sake of the future of science, its impacts in our economic, environmental and bilateral relationships, this opportunity must not be missed.

1. See http://www.synchrotron.vic.gov.au/general_info/nationalsciencecase.asp
2. See http://www.rsnz.org/news/synchrotron/
3. See http://www.nobel.se/chemistry/laureates/2003/index.html .... or the article in the November issue of "Chemistry in New Zealand."

2004 Videoconferences

20 February 2004

Molecular Controlled Electronic Devices. Is it all a matter of contacts?

David Cahen, Weizmann Institute, Rehovoth, Israel.

Seminar presented from Victoria University. Victoria, Canterbury, Otago, Massey, IRL (Lower Hutt)

The 2004 Videoconference programme coordinator is Kate McGrath.

Patent Battle Victory

Two MacDiarmid Institute Principal Investigators, Professor Jeff Tallon and Dr Bob Buckley, are part of a team which has won a 14 year international patent battle. A patent has finally been awarded by the US Patent Office for Industrial Research's key high-temperature superconducting ceramic discovery. This material is the only substance being used commercially in the world today for the production of high-temperature superconductor (HTS) wire.

A Trade and Enterprise report estimates a potential market of $300 million per year for New Zealand companies. Industrial Research is developing a new business expected to earn up to $25 million per year around the design and development of components for industrial magnets, generators and electric motors based on HTS technology.

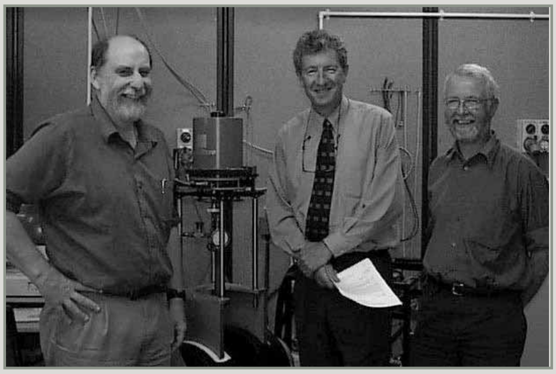
Jeff Tallon, one of the principal scientists who led the world in the discovery of the material in 1988, said the awarding of the patent in the US was a significant win a long time in the making. "It's terrific really" Dr Tallon said. "It's extremely satisfying that we've been through a long drawn out

Continued on page 12

battle and that we've emerged victorious. We own the fundamental patent for the only material at the moment which is used for commercial high-temperature superconductor wire applications" he said. "In fact it's been rather beneficial to us that it's been such a long time in coming because it allows us to take advantage of the ramp-up which is only just now occurring in the superconductivity business."

The material itself is a metal oxide consisting of bismuth, lead, strontium, calcium, copper and oxygen - known as BSCCO-2223. Co-inventors on the patent are Industrial Research's Bob Buckley and Murray Presland. In March 1988 after some clever sleuth work, the New Zealand scientists correctly identified the structure and composition of an exceptionally high performing ceramic compound. At first they assumed that other research teams throughout the world would also have come up with the same answers.

Jeff Tallon realised they should put a few details of their discovery down on paper. At lunch at the time, within a few minutes he covered the back of a greasy brown paper bag with a description of the new material. In jest, this was then signed and dated. After a month it became apparent that no one else around the world had managed to crack the problem. Dr Tallon retrieved the brown paper bag and filed a patent for the material, and with Dr Buckley and other colleagues published details of their research in the science journal Nature in May 1988.



From left: Bob Buckley, Jeff Tallon and Murray Presland

Almost overnight the New Zealand team became recognised as an international force in the field of superconductivity. Such was the potential commercial value of the discovery that interminable international patent court wrangles have been waged ever since, disputing the New Zealanders' claims to be first.

Following the awarding of a patent in Europe several years ago, the US Patent court decision is hugely valuable. American Superconductor is now producing and installing kilometre lengths of electric transmission cable based around the New Zealand materials technology.

AMSC has just won a contract to supply 18 miles of cable to China and to install half a mile of high-temperature superconducting cable for the Long Island Power Authority, New York - the first to be installed in a fully powered transmission grid.

Singaporean Focus

Over the past two years, the MacDiarmid Institute has hosted visits by the ambassadors of both The United States and Mexico. During 2003 both our Canterbury and Wellington laboratories were visited by Singaporean diplomats. They must have liked what they saw. On the 26th of November, the Deputy Prime Minister of Singapore, Mr Lee Hsien Loong, visited the MacDiarmid Institute's Victoria University of Wellington laboratories, accompanied by the Singapore High Commissioner and a party of New Zealand and Singaporean officials. After a briefing on the work undertaken by the Institute, Mr Lee met with MacDiarmid students and research staff and discussed their work, incisively as it happens (Mr Lee is a Cambridge University mathematics graduate). The visit ended with a meeting between Mr Lee and four Singaporean students, all of whom seemed quite delighted with the chance to talk with their Deputy Prime Minister.

From the left, VUW Vice Chancellor Stuart McCutcheon, Mr Lee Hsien Loong (beholding with some interest, a sample of wormlike micelles provided by graduate student Rosario López-González) and His Excellency Mr Tan Keng Jin, Singapore High Commissioner to New Zealand

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