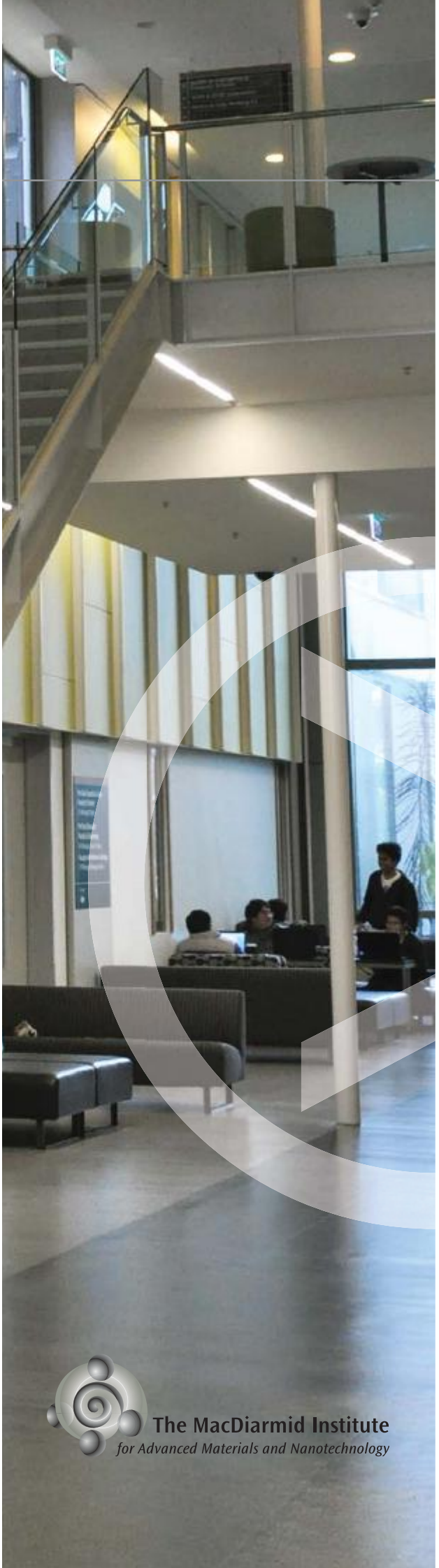


The MacDiarmid Institute
for Advanced Materials and Nanotechnology

MacDiarmid Institute highlights:

- Marked the **Transit of Venus** with a forum to discuss the role of innovation and science in New Zealand's future.
- Celebrated its **tenth** anniversary year.
- Welcomed **The University of Auckland** as a partner in the Institute.
- Finalised and implemented a detailed **Strategic Plan** to guide our activities and priorities in order to meet our goals of advancing New Zealand through scientific excellence, leadership and inspiration.
- Implemented a strategy to encourage Investigators and students to **commercialise more** of their research, promote a spirit of entrepreneurship and, in a unique approach by a CoRE, to establish strong links with industry.
- Awarded the first **Callaghan Commercialisation Fellowship** to Associate Professor Cather Simpson of the University of Auckland.
- Saw the launch of **three start-up companies** that commercialise MacDiarmid Institute research.

Science highlights:

- Discovery of a new way to control the **formation of nanoscale structures** – an important step towards eventual large-scale manufacturing.
- Development of a **biochip** to provide fast diagnosis in the health sector.
- Breakthrough in understanding the processes involved in the reaction of **polymer materials** to surface coatings to clear the way for their use in a wide range of materials.
- Development of tools for detecting molecules at extremely low concentrations – an important step forward in **detecting dangerous molecules** in the health, border security and food safety sectors.
- Success in etching, using lithography, smaller deeper patterns as a basis for new, **smaller computer chips**.
- Breakthroughs in the quest for new **computing device materials** based on rare earth nitrides.
- Development of clever ways of applying **diamond-like carbon coatings** that have potential in high-tech industry products that are required to be smooth, hard and low friction surfaces.
- A MacDiarmid Institute paper outlining new findings on the electrostatics behaviour of two charged conducting spheres was **second most cited and downloaded paper of 2012** on the Royal Society's Proceedings website for mathematical, physical and engineering sciences.


ALAN
MACDIARMID
1927–2007
NOBEL
PRIZE
CHEMISTRY
2000

About The MacDiarmid Institute

> Who we are and how it began

Background

The MacDiarmid Institute for Advanced Materials and Nanotechnology is a partnership between five universities and two Crown Research Institutes. Our researchers include New Zealand's leading scientists based in Auckland, Palmerston North, Wellington, Christchurch and Dunedin.

Delivering excellent scientific research and education

We build materials and devices from atoms and molecules, developing and applying cutting-edge techniques in physics, chemistry and engineering.

+

Forging New Zealand's future leaders

We train entrepreneurial and socially-aware young scientists many of whom go on to work in industry or start their own companies in a culture of excellence and collaboration.

+

Inspiring New Zealanders about science and innovation

We work to inspire a culture that celebrates science and innovation as the keys to New Zealand's future prosperity, sharing the results of our research with the public and with Government.

=

Advancing a new future for New Zealand

Taken together, these goals allow us to work alongside New Zealand businesses to turn our research into innovative new technologies for export markets in sectors as diverse as health, electronics, food and fashion.

The science

In 2012, our scientific research was divided into six themes:

1. Nanofabrication and Devices
2. Electronic and Optical Materials
3. Molecular Materials
4. Soft Materials
5. Inorganic Hybrid Materials
6. The intersection of Nanoscience and Biology

The individual research projects are led by Principal and Associate Investigators.

The structure

The MacDiarmid Institute is a nationwide organisation administered by a small management team based at Victoria University of Wellington. In total, 40 principal investigators, 30 associate investigators, and more than 220 graduate students and postdoctoral researchers carry out the range of research in advanced materials and nanotechnology that mark out the MacDiarmid Institute as a leading Centre of Research Excellence (CoRE).

The MacDiarmid Institute is led by its Director, Professor Kathryn McGrath, and two Deputy Directors. Professor Shaun Hendy* is responsible for stakeholder engagement, an important part of the MacDiarmid Institute's role in bringing science to the wider New Zealand society. Professor Simon Brown, is responsible for encouraging and fostering commercialisation of MacDiarmid Institute science to ensure the benefits of research are available to those who can put them to productive use, and that our members gain expertise in commercial analysis of their research.

The Director is supported in her decision-making by the Science Executive, which represents the MacDiarmid Institute's scientific cohort, and the expertise of an International Advisory Board (IAB) which comprises some of the world's leading scientists in the fields of research represented by the institute. The MacDiarmid Institute Board, under the Chairmanship of Dr Steve Thompson, is responsible for the wider governance of the institute.

*Shaun Hendy stepped down from the Deputy Director role on 31 December 2013, to be replaced by Professor David Williams of the University of Auckland.

Partner organisations

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND
Te Whare Wānanga o Tāmaki Makaurau

Callaghan Innovation

UC UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

GNS SCIENCE
TE PŪ AO

MASSEY UNIVERSITY

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

VICTORIA
UNIVERSITY OF WELLINGTON

Chair's report

Very few people are privileged to work to create our future as much as researchers. Both the Board and the Investigators of the MacDiarmid Institute have spent most of their time in the future this year.

For the first time in its history, the Institute has completed a comprehensive strategic plan to map out its contribution to New Zealand. It sees its mission of course as delivering excellent research and scientific education. But more than that, it is forging New Zealand's future leaders. They, and the Institute as a whole, will continue to do all in their power to inspire New Zealanders and to advance a prosperous future for the country.

The plan contains more than lofty aspirations. It sets out the practical measures we will undertake to ensure that we achieve those goals. We will not work in isolation, however. An essential element will involve collaboration with others following the same road - not least the newly formed Callaghan Innovation, named for the vision of a re-vitalised New Zealand so passionately expounded by MacDiarmid Institute's founding director - Sir Paul Callaghan. The Institute already works closely with leading high-tech companies, as well as those spun out from the Institute itself.

Much more needs to be done, however. New Zealand cannot yet claim to have a fully cohesive, highly evolved, advanced manufacturing sector. We must collaborate with all our partners not just to grow the sector, but to create large parts of it.

Collaboration works. An outstanding feature of CoREs is the capital made available by government to invest in equipment which is shared among all Institute investigators. Collaboration using this equipment has led to a tremendous leap in our knowledge of advanced materials over the past ten years - a leap which would not otherwise have been possible. As one of our Board members put it: "MacDiarmid Institute research does not simply add value to New Zealand's economy, it opens up possibilities for new sectors and industries which yesterday did not exist, based upon properties of complex and nano materials which we are only now beginning to understand".

Collaboration is the hallmark of the Board's work in concert with the Institute's investigators. The Board's role has been to ensure a creative environment for researchers, who form the intellectual powerhouse of the Institute. The strategic plan is thus a creation stemming from the scientists themselves, rather than being imposed upon them.

One outstanding event in particular in 2012 has seen that creativity at work. The Institute co-hosted the Transit of Venus meetings in Gisborne. The meetings honoured Paul Callaghan's involvement with this Century's first Transit in 2004 and fulfilled his dream of a national forum to discuss how science can help our economy prosper while conserving our environment. If we were to sum up our aim in the MacDiarmid Institute, it would be to make New Zealand, in Paul's words, "a place where talent wants to live".

Steve Thompson
Chair, MacDiarmid Institute Board

From the Director

In 2012, our 10th anniversary year, we initiated a series of programmes to ensure the evolution of the MacDiarmid Institute into a national organisation that transcends the initial goals laid out for the CoREs.

First, we will foster a culture where all New Zealanders are scientifically literate and appreciate the importance of science and technology. That requires us to develop connections across society so scientific know-how is put to use to achieve a prosperous and sustainable New Zealand. It means ensuring we have a strong representation of emerging scientists who are carrying out internationally recognised research and pushing the boundaries of knowledge in their fields. We also want a scientific cohort that is dedicated to taking their knowledge to the people who can apply it to bring direct economic, social and environmental benefit to New Zealand.

Our commitment to delivering greater benefit to New Zealand is only as good as our partnerships and we appreciate the support of our research partners in choosing to reinvest in our co-investment funding of advanced materials and nanotechnology research and infrastructure. Our ability to create an environment in which people can achieve at the highest levels depends on this commitment. We also welcomed a new partner during the year: the University of Auckland has now joined the Institute and we welcomed Distinguished Professor Jane Harding as the university's representative on our Board.

Our founding Director, Professor Sir Paul Callaghan, died on 24 March 2012. While Paul's death was anticipated it has been a considerable loss, personally and collectively. Paul's leadership, guidance and sheer hard work during the formation and development of the MacDiarmid Institute ensured that today we are an organisation of national and international standing.

Paul's contributions, initiatives and ambitions continue to underpin many of our activities – none more so than the enormously successful Transit of Venus Forum, held in Gisborne in June. The success of the Forum lay in the partnership between the MacDiarmid Institute, VUW, the Royal Society of New Zealand (RSNZ), Te Aitanga a Hauiti iwi and the Üawa (Tologa Bay) community. It was striking to see the way everyone came together in a spirit of collaboration for this major initiative to advance the New Zealand cause. For the MacDiarmid Institute it was a case of putting into practice our ideals for strong links between science and the society it operates in.

In 2012 we took on the role of secretariat and Chair of the association of Centres of Research Excellence (aCoRE). This is a very important time in the history of the centres: the Ministry of Education is currently leading a review of the CoRE policy and the CoREs have become formally associated with a third government agency, the Ministry of Business, Innovation and Employment as part of the Government's mandate for building innovation. As we engage with the various government agencies working to define the science, research and innovation landscape we are striving to provide a vision of what can be achieved through the collaborative model and how CoREs can participate in, and drive, greater integration in the sector.

Scientifically, 2012 saw us continue to show the strength of our metal. Drs Geoff Willmott and Martin Allen were awarded Rutherford Discovery Fellowships and many of our Investigators received national recognition through grants, medals and awards. Individuals such as Pablo Etchegoin, Alison Downard and Justin Hodgkiss cemented their international science leadership in their respective fields of Raman spectroscopy, surface modification and ultrafast spectroscopy, and the team led by Ben Ruck and Joe Trodahl continued to define the scientific research bar in rare earth nitrides materials development and you can read more about their work, among others', in this report.

We undertook a review of our Principal Investigators during the year and the result was a significant change, with two of our six research themes being absorbed into other theme areas with effect from 1 January 2013. Six new Principal Investigators and six new Associate Investigators were appointed as of the beginning of 2013.

As 2012 came to an end we farewelled Professor Shaun Hendy as Deputy Director. During his tenure he provided the Institute with his effective leadership and I have appreciated his support since I was appointed Director. The position has been taken on by David Williams, who is based at the University of Auckland and I know this too will be a very productive working relationship.

Finally I want to pay tribute to our Investigators. Over the past 12 months they have constantly shown their commitment to delivering science research at the highest levels, ensuring the MacDiarmid Institute continues to be associated with excellent science, but also fulfilling our broader goals. I thank each of you.

Kathryn McGrath
Director, MacDiarmid Institute

Ten years of The MacDiarmid Institute

How it began

The MacDiarmid Institute for Advanced Materials and Nanotechnology owes its existence to Sir Paul Callaghan, a world-renowned experimental physicist and a pioneer in the new field of NMR spectroscopy. Not long before his death on 24 March 2012, Sir Paul talked about setting up the Institute in an interview for the Institute's regular news magazine, *Interface*. He recalled that in 2001 the Tertiary Education Commission announced plans for six new entities—to be known as CoREs—to encourage collaborative tertiary education that produced excellence, was strategically focused and resulted in significant knowledge transfer. He was asked to lead VUW's bid to establish one of those CoREs.

"I had time on my hands so I thought, why not – that could be fun."

The initial bid was for a research institute for Advanced Materials but then bidders were given an opportunity to see what others were offering and to think about amalgamating.

"This turned out to be extremely important for us because [among the bids] was one from the University of Canterbury in nanotechnology .....and it involved several collaborators of ours."

On the suggestion of VUW colleague Joe Trodahl, Sir Paul flew to Christchurch to discuss joining in a single bid and nanotechnology research was added to the agenda.

Professor Richard Blaikie, who went on to be Deputy Director of the MacDiarmid Institute under Sir Paul, was contributing to the Canterbury bid by remote control—he was on study leave in the US at the time. He recalls: "We were just upstarts really, with youth and beauty on our side. We were up against a combined bid backed by Victoria and Massey Universities, Industrial Research Ltd and others but Paul Callaghan eventually got everyone together to make a bid that was ultimately successful."

The first hurdle was being chosen as one of 12 bids selected by an international panel for the final cut from a total of about 50 and, from the very start, the philosophy of the MacDiarmid Institute went beyond just research.

"We realised that the final round would not involve discussion of research capability – that would have been determined by the international reviewing process. All that would matter would be value to New Zealand," Sir Paul recalled.

The broader objectives of the Institute would include education, innovation and catalysing change. When the bid got the nod, Sir Paul recalled that a lot of care went into the partnership agreement to safeguard the values of the Institute and make sure no single partner became dominant.

"We decided to be an institution that employed no one, owned no IP and certainly didn't own its own capital."

Instead he says, the MacDiarmid Institute tapped into the university and CRI research system already in place and funded research directly to the science leaders – known as Investigators – who gathered around them their own teams with the minimum of bureaucratic interference. If the Investigator moves, the funding goes with them.

The Institute is, of course, named after one of New Zealand's Nobel Prize winners, Alan MacDiarmid. At about the same time as the Government was launching the CoRE initiative, the eminent scientist visited Wellington and Sir Paul Callaghan, as VUW's Alan MacDiarmid Professor of Physical Sciences, spent time with him. He remembers MacDiarmid drawing a capacity crowd to his public lecture at the Wellington Town Hall.

"I'd never seen that before, a scientist getting people in these numbers and moving them emotionally. Alan was also political – he saw science and technology had social and political impacts and he wasn't afraid to make politically provocative statements."

It was an attitude that Sir Paul was to take to heart: "I saw the potential to move beyond the whinging scientist complaining about lack of funding; to say "stop this crap! Let's start acting positively by working in partnership with society and politics"."

It is a role that Sir Paul Callaghan wholeheartedly embraced as he promoted a new future for New Zealand in the 21st century and, in doing so, filled venues to capacity for his own public lectures.

The impact

Sometime during 2012, the MacDiarmid Institute's 1000th research paper was indexed by the world's leading database of scientific papers, the Web of Science.

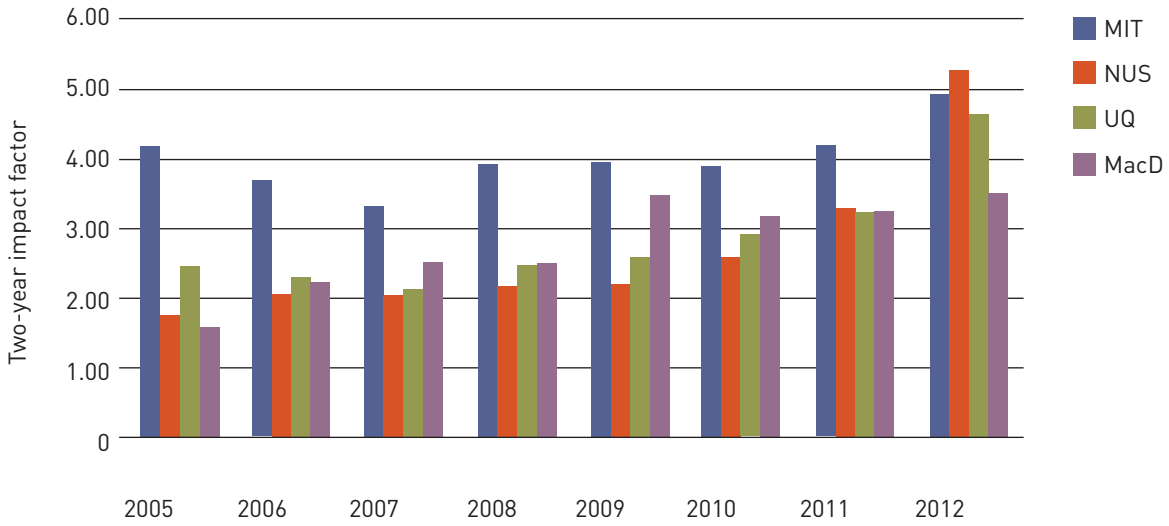
According to its statistics, the Institute has produced around 1.5% of New Zealand's scientific articles. Just as importantly, those papers have been cited more than 10,000 times – an average of more than 10 citations per paper. In reality, some have been cited much more.

The most cited paper authored by a MacDiarmid Institute investigator – with 400 citations - appeared in *Nature Materials*[1] in 2008. A co-author on that was Professor Pablo Etchegoin from Victoria University. The research came out of an international collaboration the MacDiarmid Institute was part of and described the effect of controlling the micro-structure of plastic solar cells to optimise their performance.

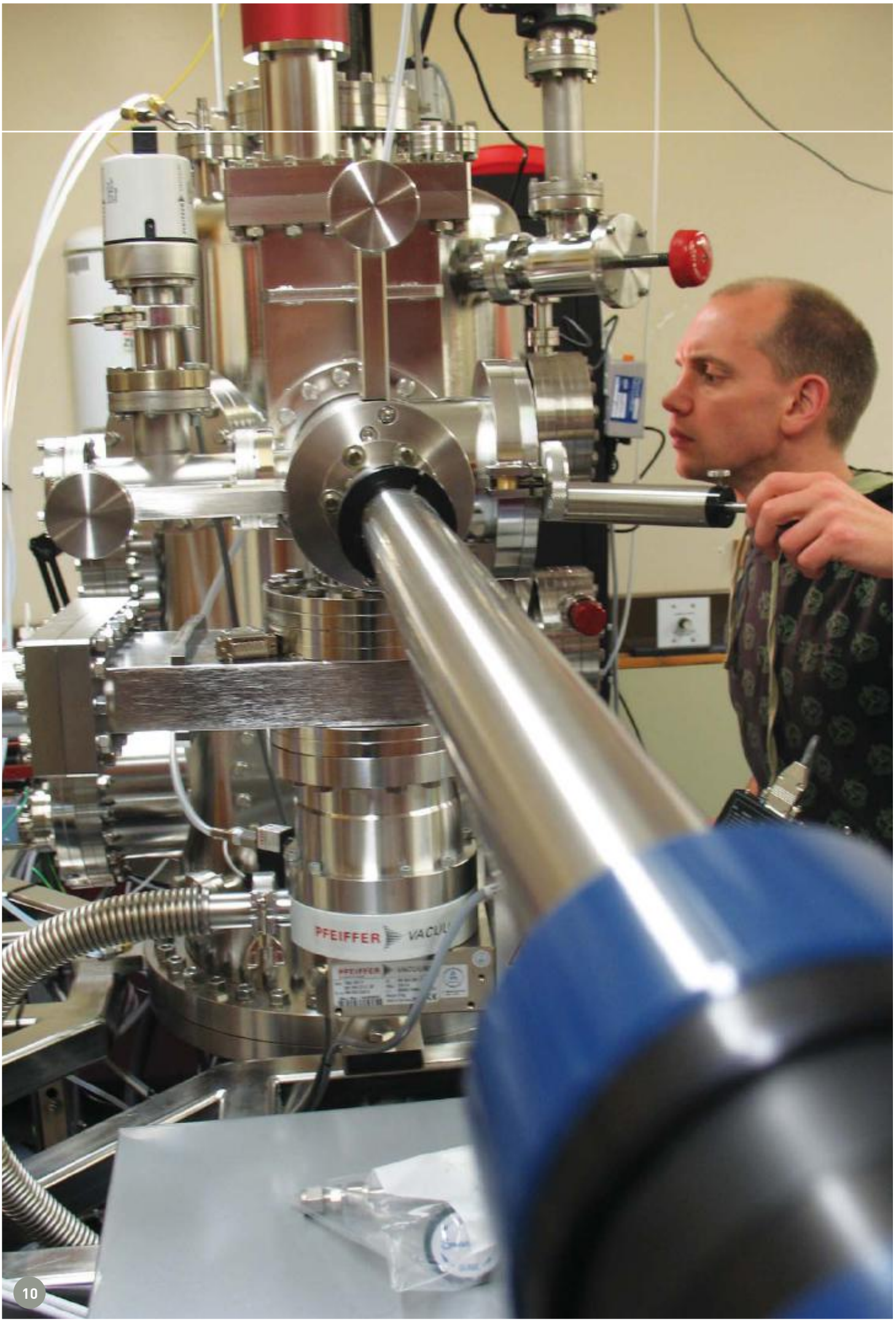
The next most cited paper – 200 citations – is entirely owned by the MacDiarmid Institute and is an article by Professor Blaikie and David Melville his PhD student at the University of Canterbury. Published in 2005 in *Optics Express*[2] it reported on their ground-breaking work using near-field lithography to make nanoscale silver gratings.

And how does the MacDiarmid Institute stand against international competition? The table below shows the Institute's performance on a par with the highest ranked Australian and Asian universities and edging up on one of the world's best, the Massachusetts Institute of Technology in the US.

Impact factor since 2005



Impact of MacDiarmid Institute publications compared to that of leading international institutions with strong materials science and nanotechnology focus
(Source: Thomson Reuters Web of Science, Search Terms: MacDiarmid Institute; New Zealand)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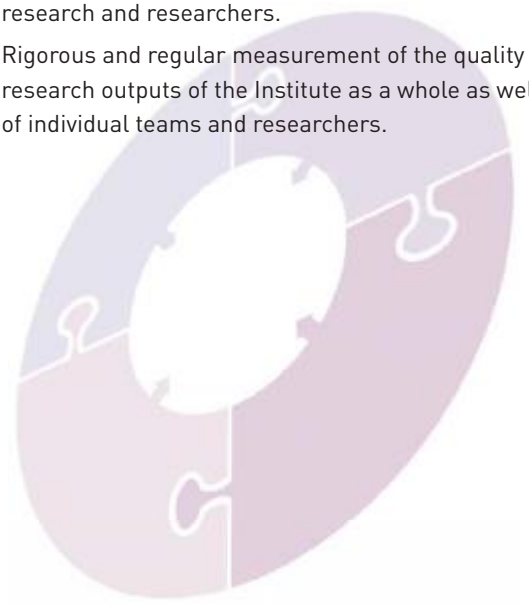
Scientific excellence

> To deliver excellent scientific research and education

Scientific excellence

The MacDiarmid Institute maintains and extends the excellence of its science through:

- Multi-institutional collaboration that brings together the best scientists in the field and provides them with the excellent research infrastructure they need to support their work.
- Demonstrating scientific leadership and ensuring the internationally recognised impact of our science.
- Recognising excellence and ensuring that it is sustained by supporting established and emerging research and researchers.
- Rigorous and regular measurement of the quality of research outputs of the Institute as a whole as well as of individual teams and researchers.



Welcome to University of Auckland

The MacDiarmid Institute concluded an official partnership with the University of Auckland in April 2012. The new arrangement builds on a long-standing relationship between the two institutions and will allow for greater collaboration and sharing of resources. Four Principal Investigators and five Associate Investigators are currently based at the university and the new agreement will broaden their access to MacDiarmid Institute resources and pave the way for greater access to MacDiarmid Institute funds, including funds for capital equipment.

MacDiarmid Institute Director Professor Kathryn McGrath sees the move as very significant for the Institute

"The University of Auckland is an exceptional university, with great people and extensive infrastructure. We're thrilled to have them coming on board as a full Partner, she says. "It allows us to become a truly national institution, bringing together New Zealand's leading scientists in our area."

University of Auckland Professor of Chemistry, David Williams, who is a MacDiarmid Institute Principal Investigator, says the university will benefit from the partnership in other ways too:

"The MacDiarmid Institute is internationally recognised as a leading player in materials science and nanotechnology in a way that the individual partners are not," he says. "Our real competition is not ourselves but the rest of the world. If we want to be serious, and make a serious contribution to a science-led economy, we have to use all the brains and capability we have collaboratively."

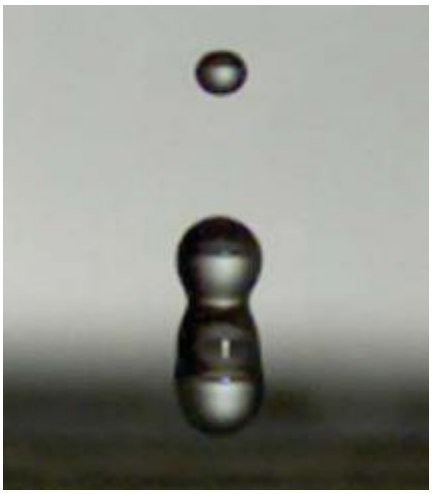
As part of the new agreement, the University of Auckland gains a seat on the MacDiarmid Institute's Governance Board, which will give it a say in the MacDiarmid Institute's future development. Investigators throughout the MacDiarmid Institute will gain access to resources at the University of Auckland. Research collaborations across the MacDiarmid Institute network will also benefit from the University's strengths in materials science, engineering and chemistry, as well as its experience with commercialisation.

Success in Marsden fund grants

Two Principal Investigators with the MacDiarmid Institute and one of our Associate Investigators secured funding in the 2012 Marsden Funding round. The Marsden Fund was set up in 1994 to encourage high-quality fundamental research across a range of scientific disciplines and competition for funding is intense since it is regarded as the hallmark of excellence for research in New Zealand.

Professor Richard Blaikie of the University of Otago received $910,000 over three years to further his research in nanophotonics. This involves using visible light to sense or image light at molecular size – so small it is not visible to the eye. Once in the right place at the right wavelength, the resulting light can potentially be used in a range of applications, including biosensors and nanofabrication. Professor Blaikie and his team have already developed a novel way to dramatically improve imaging at the nanoscale and the Marsden funding will allow the programme to be expanded to provide a comprehensive set of principles for designing new advanced sensing and lithography systems

Dr Geoff Willmott received $345,000 over three years to further investigate how drops of liquid land on extremely water-repellent surfaces, known as superhydrophobic surfaces. These are generally of varying forms of roughness, which affects the way the drop lands and reacts. Dr Willmott and his research team will design superhydrophobic surfaces that consist of a series of posts at the micrometer scale that are laid out in different patterns and then study how drops react on them. The research could have application in a range of novel superhydrophobic surfaces to manage condensation, prevent the build-up of ice and act as self-cleaning surfaces as demonstrated in nature by the leaves of lotus and nasturtium plants.



Associate Investigator Dr Aaron Marshall also received funding of $345,000 over three years to investigate an effective way to convert carbon dioxide into methanol. An efficient process for doing this would revolutionise energy technologies and Dr Marshall and his team will research an electrocatalyst that could overcome current issues that mean the process of conversion uses huge amounts of energy compared to the methanol produced. The research will look at the feasibility of an electrocatalyst that uses renewable energy such as solar or wind power, and uses a combination of metallic nanoparticles and oxide for the conversion process itself.

In all, 86 research projects received funding in the 2012 Marsden round.

Investigators secure $30 million in MSI funding

Ten MacDiarmid Institute Principal Investigators were successful in the 2012 Ministry of Science & Innovation (now the Ministry of Business, Innovation and Employment) research funding round.

The grants total more than $30 million over four years. The successful research projects include research relating to solar energy, magnetic devices, new NMR technologies, high performance sensors and micromachining using laser technology.

Meanwhile, Associate Professor Bill Williams, Principal Investigator at Massey University has received funding through the Primary Growth Partnership research fund. His expertise is in the area of soft materials.

Researchers named Fellows of RSNZ

MacDiarmid Institute Deputy Director Professor Shaun Hendy, Professor Keith Gordon, and Professor Juliet Gerrard were elected as Fellows of the RSNZ during the year. All three are MacDiarmid Principal Investigators and have been, or are currently, members of the Science Executive where they have made a significant contribution to the leadership and direction of our research. In announcing the new Fellows, the Chair of the RSNZ Academy, Professor Le Heron emphasised the significance of being elected as a Fellow. It was an honour, he stated, given to New Zealand's top researchers for showing exceptional distinction in research or in the advancement of science, technology or the humanities.

Professor Gerrard of the School of Biological Sciences at the University of Canterbury and of IRL, focuses in her research on proteins and how they assemble and the results of her work have been applied to the design of novel therapeutics, the assembly of novel materials and the alteration of food texture.

Professor Gordon of the Department of Chemistry at the University of Otago is internationally recognised for his scholarship and scientific achievements in the area of molecular electronic materials, particularly on new materials that can be used in solar cells or as displays.

Professor Hendy of Industrial Research Ltd (IRL) and VUW was elected a Fellow of the RSNZ for his significant, sustained contribution in the application of mathematical and computational techniques to the chemical and physical sciences, with a particular focus on nanotechnology.

The three new Fellows join current RSNZ Fellows on the MacDiarmid research team: Professor Richard Blaikie, Professor Pablo Etchegoin, Dr Ian Brown, Professor Jeff Tallon, Professor Ken MacKenzie, Professor Alan Kaiser, Professor Jim Johnston and Professor Sally Brooker.

Meanwhile, one of the Institute's Associate Investigators, Professor Sally Davenport of VUW, was named Fellow of the International Society of Professional Innovation Management in 2012. She is Professor of Management in the Victoria Business School but, with a background in the physical sciences, her research interests include growth of high-tech firms especially in the biotechnology sector, commercialisation processes in research organisations, business models in high-tech firms, and policy issues in science and innovation.

Professor Shaun Hendy

Professor Keith Gordon

Professor Juliet Gerrard

Distinguished visitor

Professor Michael Kelly, who is Prince Phillip Professor of Technology at the University of Cambridge and a member of the International Advisory Board, spent eight months on sabbatical at VUW between August 2012 and March 2013 supported in part by the MacDiarmid Institute. During his time here he gave lectures and seminars to students and to special interest groups such as the New Zealand Manufacturers and Exporters Association, the Māori Trust and New Zealand Tourism.

Professor Kelly also spent time discussing end-user research in New Zealand. This included acting as an adviser to researchers at Callaghan Innovation (formerly IRL and a partner in the Institute), which came in to being on 1 March 2013 to serve the research needs of the high-value manufacturing sector and carry out research that can open up new opportunities for New Zealand in high-tech industries. He was involved in setting up a similar organisation, the Advanced Technology Institute at the University of Surrey in 2000 and worked closely with the prestigious US research university, MIT on research for economic impact. He says the MIT approach has lessons for New Zealand.

"A key aspect of MIT's international success is the way it gets end-users inspired to support research projects by committing to trial prototypes and as an initial customer of new technologies and products.

"With a wealth of technology-push research going on in New Zealand, such a response from end-users in New Zealand would be a welcome addition to the country's capability."

He also shared his 20 years experience in commercialising research with the MacDiarmid Institute.

Professor Kelly was a speaker at the sixth MacDiarmid Institute Advanced Materials and Nanotechnology Conference held in Auckland early in 2013. His subject there was one of his areas of expertise: the extent to which there is a clear distinction to be made between what is, and what is not, manufacturable so that money is not wasted in the vain pursuit of ideas that have no chance of being produced economically.

Prizewinners in 2012

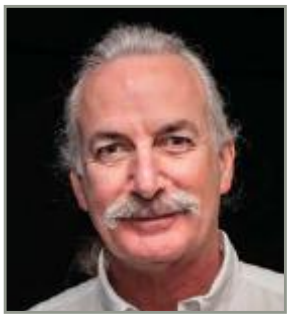
- Associate Professor Richard Tilley: Principal Investigator, VUW, received the New Zealand Institute of Chemistry Maurice Wilkins Centre Prize for research published during the previous five years that has made a significant contribution to any branch of chemistry.
- Dr Justin Hodgkiss: Principal Investigator, VUW received the Asian and Oceanian Photochemistry Association Young Scientist Prize awarded every two years to photochemists below the age of 40 in the Asia/Oceania region.
- Dr Dmitri Schebarchov, previous PhD student, won the RSNZ Hatherton Award for the best paper in physical, earth or maths and information sciences by a New Zealand University PhD.
- James Eldridge: PhD student IRL/VUW won best poster prize in the Nanobio section at the 2012 International Conference on Nanoscience and Technology in Paris.
- Professor David Williams, Principal Investigator, University of Auckland was awarded the RSNZ Pickering Medal for his contribution to the development of biomedical and gas sensors, which have been commercialised.
- Associate Professor Shane Telfer, Principal Investigator at Massey University received the Distinguished Lectureship Award at the 91st Annual Meeting of the Chemical Society of Japan.
- Professor Shaun Hendy, Principal Investigator, VUW/IRL received the 2012 Prime Minister's Science Media Communication Award and the RSNZ Callaghan Medal

International Advisory Board

The MacDiarmid Institute International Advisory Board, advises the Institute Board. Its members include some of the world's leading scientists in the fields of research represented by the MacDiarmid Institute. Professor Sir Paul Callaghan chaired the panel until his death in March 2012 and the position has remained vacant during 2012 pending a decision at the next meeting in February 2013. As at 31 December 2012, the members were:

Professor Haroon Ahmed, ScD FREng
Microelectronics Research Centre, Cavendish Laboratory
University of Cambridge, UK
Advisor on higher education to the Pakistan Government
Ministry of Education, Pakistan
Nanoengineered devices

Professor Neil Ashcroft, Member US Academy of Sciences
Horace White Professor Physics, Laboratory of Atomic and Solid State Physics
Department of Physics, Cornell University, Ithaca, US Materials science



Dr Don Eigler
Director & Fellow
The Wetnose Institute for Advanced Pelagic Studies, Auckland, New Zealand & California, USA
Nanoscience

Professor Sir Richard Friend
Cavendish Professor of Physics
University of Cambridge, UK
Optoelectronics

Professor Hiroshi Mizuta
Professor of Nanoelectronics, School of Electronics and Computer Science
University of Southampton, UK
Nanoengineered electronic devices

Professor Daniel Nocera
The Henry Dreyfus Professor of Energy and Professor of Chemistry
Massachusetts Institute of Technology, USA
Catalysis, energy

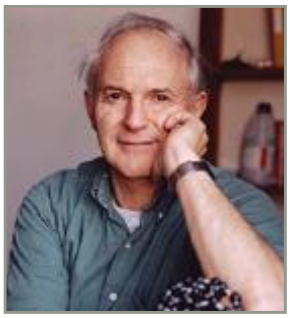
Professor Michelle Simmons
Director
Australian Research Council Centre of Excellence for Quantum Computation & Communication Technology
Federation Fellow and Professor of Physics
University of New South Wales, Australia
Atomic electronics

Professor Mark Warner
Theory of Condensed Matter Group
Cavendish Laboratory,
University of Cambridge, UK
Soft materials

Professor Lynn Gladden, OBE, FRS
Department of Chemical Engineering
University of Cambridge, UK
Chemical engineering and porous media

Professor Henry Smith
Keithley Professor of Electronic Engineering & Head of NanoStructures Laboratory
Massachusetts Institute of Technology, US
Nanofabrication

Professor Michael Kelly, FRS, FEng
Prince Phillip Professor of Technology
University of Cambridge, UK
Electro-optic materials and devices



Professor Sir Harry Kroto, FRS, FRSC
Dept of Chemistry and Biochemistry
Florida State University, US
Spectroscopy, radio astronomy, nanoscience

Dr David Williams
Senior Research Scientist
Hitachi Cambridge Laboratory, Cavendish Laboratory, *University of Cambridge, UK*
Nanoengineered electronic devices

Professor Chennupati Jagadish *
Federation Fellow, Electronic Materials Engineering
Research School of Physical Sciences and Engineering, ANU
Compound semiconductor optoelectronics and nanotechnology

Professor Ed Samulski *
Cary C. Boshamer Professor of Chemistry and Jefferson Fellow
UNC-Chapel Hill, USA
Structure and dynamics of liquid and polymer crystals

Dr Lim Khiang Wee *
Executive Director
Institute of Materials Research and Engineering, Singapore

* Board members who stood down in November 2012.

Excellent science

Finding needles in haystacks

The MacDiarmid Institute has strong international contacts, not only through its International Advisory Board of leading scientists in the nanotechnology and advanced materials field, but also in research initiatives.

One collaboration – between Principal Investigator Dr Geoff Willmott and researchers at University College Dublin - has produced important work in developing a new way of detecting specific molecules at very low concentrations. They have found a way to bind the target molecules to the surfaces of magnetic nanoparticles in the shape of rods. The molecules, when they are captured, in effect glue the rods together on contact. The molecules could then be detected at exceptionally low concentrations using a process known as resistive pulse sensing. The researchers have found this approach works for the great majority of molecules and can see exciting opportunities for its application. In medicine, it could be used at the patient's bedside to detect infections, but there are also applications in border biosecurity and in food production, all areas where being able to reliably detect contaminants or potentially hazardous diseases is currently a huge challenge.

Incidentally, the instrument used for the resistive pulse sensing of the captured molecules is an example of New Zealand know-how and technical expertise. It was manufactured by Christchurch-based company, Izon Science. The diagram below illustrates the process.

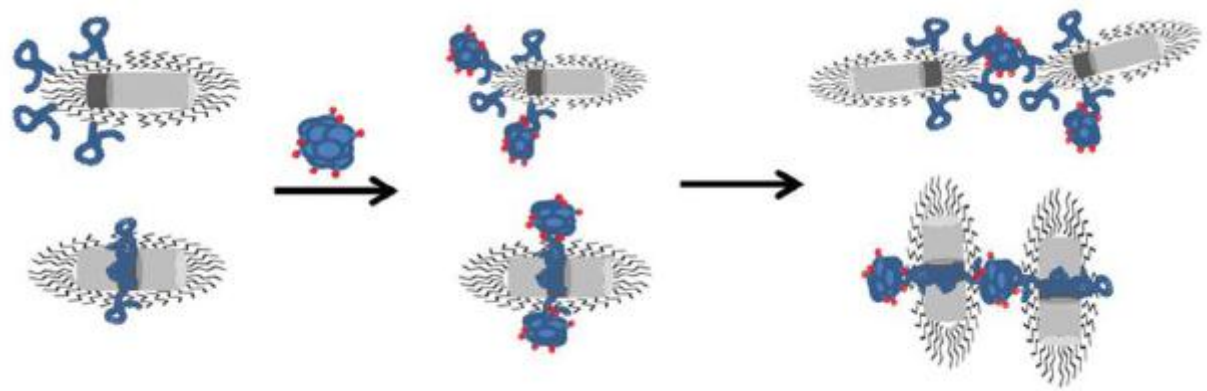
Locating the hidden signal

Spectroscopy studies the emission of light and radiation from matter and is widely used, both in fundamental research in the physical sciences as well as in astronomy, medicine where it is an important imaging tool) and in remote sensing systems, to name only a few.

A common issue, however, is that the target signal may be very weak and can be lost in the broad background of "noise" from a variety of other sources. These can be anything from stray-light contributions to backgrounds produced by fluorescent probes. A MacDiarmid research team has been working on devices that can be used to identify and extract the underlying signal.

Their approach involves using what is known as charge-coupled device (CCD) detectors in conjunction with standard spectrometers and has had success in identifying weak features against a background of fluorescence which is a million times stronger!

The potential applications of the technique include the detection of faint signals in resonant Raman spectroscopy (a holy grail for many years), as well as the detection of extremely small absorptions by gases in the visible range. These are the so-called "Fraunhofer lines", which are detected by atmospheric physicists and astronomers using interferometers that are kilometres in size. The MacDiarmid group can now obtain the same sensitivity on a bench-top instrument a few metres in size. Being able to detect one photon in every million as coming from a specific optical effect opens new doors in the accuracy and type of optical spectroscopy that can be used in the future. It also opens up a whole new range of applications.



Schematic showing (left) two rod barcode structures with blue antibodies, which (middle) capture the target molecule and (right) form two-rod aggregates in either end-to-end (upper) or side-by-side (lower) orientation (from *Small* 8: 2436).

Collaborating across the CoREs

MacDiarmid Institute researchers are working with colleagues at the Riddet Institute – another CoRE, in this case specialising in food science and nutrition – in a project to understand the mesocule. This can be defined as the intermediate states between the single molecule and the groupings they make to form the real-world mass and form of everyday objects as demonstrated below. MacDiarmid Principal Investigator, Associate Professor Bill Williams is based at Massey University – home base for the Riddet, and is leading the project to study the mesocule in order to better understand the properties of the material itself.

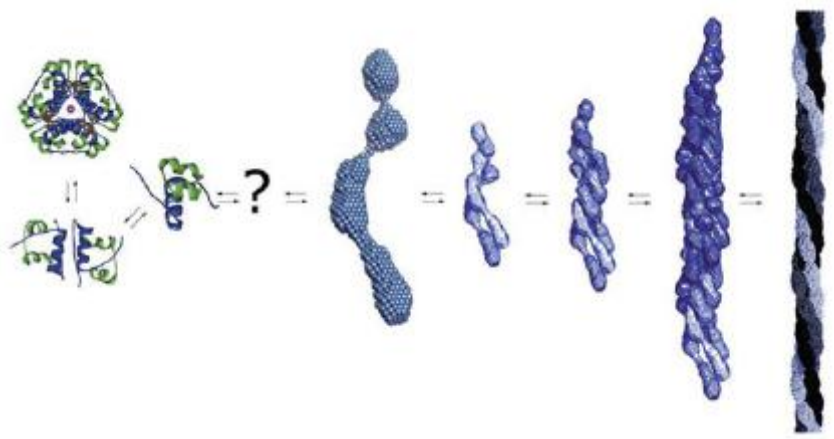
"The biomaterials field has looked at the properties of individual polymers as well as the properties of the bulk materials, but the area of the intermediate states remains a tad fuzzy," he says. "Just because you know the molecule doesn't mean you're going to understand the properties of the material."

The research will focus on what are known as soft materials – those that feature long chains of molecules that make cellulose fibres, the dairy-based casein micelles in milk and protein filaments in hair or foods.

Gaining a greater understanding of the mesocule states could be the key to ensuring we make the most of the desired properties of biomaterials and being able to greatly improve their use in medical applications such as artificial joints, or in foods with improved taste and texture and more environmentally friendly ways to extract oil.

It is a project that requires a broad range of expertise and hence the cooperation between the two institutes. Other investigators include: Dr Juliet Gerrard, Professor of Biochemistry at the University of Canterbury and co-director of the Biomolecular Interaction Centre and also a Principal Investigator at both CoREs; and MacDiarmid Institute Director Dr Kathryn McGrath, Professor of Chemistry at VUW. The collaboration also opens up to the team the highly sophisticated equipment needed to carry out the project.

Insulin forms fibrils of 7-10 nm in diameter, however lengths of fibrils vary hugely due to the complex nature of the fibril mechanism. This complexity is typical of mesocules.



2

Leadership

> To forge New Zealand's future leaders

Leadership

The MacDiarmid Institute supports and develops leadership throughout the organisation by:

- Establishing an integrated community of students and alumni.
- Providing the optimal learning environment that extends beyond the laboratory bench to produce well-rounded, scientifically astute, entrepreneurial and socially aware leaders.
- Demonstrating leadership in science and wider society.

MacDiarmid PI named as Marsden Fund chair

During the year, Principal Investigator Professor Juliet Gerrard was named as the new chair of the Marsden Fund Council. She is based at the University of Canterbury where she is director of the Biomolecular Interaction Centre (BIC) and works with the Institute under Theme 6: The intersection of nanoscience and biology. Professor Gerrard specialises in protein physical biochemistry and her current research focuses on how amyloid fibrils form and their subsequent self-assembly.

Her appointment, which came into effect in March 2013, was announced by the Minister of Science and Innovation, Steven Joyce. In her position, she will be responsible for chairing the 11-strong Marsden Fund council, whose role is to set the strategic direction of the Marsden Fund and the selection of proposals to be funded.

Another Principal Investigator, Professor John Evans of the University of Otago, has been selected to be a member of the Health Research Council of New Zealand's College of Experts. The Council is the main funding body for health research in New Zealand and the College of Experts is made up of committees that assess applications for research grants. His appointment is for a term of three years. Professor Evans research expertise is in the physiology of cells and he is currently investigating the nano and microenvironment of cells – research which is at the confluence of engineering and biology.

Recognition for MacDiarmid Deputy Director's science communication

MacDiarmid Institute Deputy Director Professor Shaun Hendy's role in highlighting the links between science and technology and economic prosperity won him the 2012 Prime Minister's Science Media Communication Prize. The prize is awarded annually to a practising scientist who is an effective communicator, to further develop their knowledge of science media communication. Professor Hendy, who was chosen by the late Sir Paul Callaghan to continue his writing on innovation, received a prize of $50,000 with another $50,000 allocated for further developing his science media communication skills.

His skills and influence in science communication were also recognised when he was awarded the RSNZ 2012 Callaghan Medal, which is awarded for an outstanding contribution to science communication, in particular raising public awareness of the value of science to human progress. In Professor Hendy's case, the citation says, for raising public awareness of science and its role in increasing economic prosperity.

His blog, *A Measure of Science*, attracts a monthly audience of more than 1,000 readers many of whom are policy makers in New Zealand's innovation sector. Some of Professor Hendy's posts, including one on the Fukushima nuclear disaster, have been syndicated by leading newspapers and read by a large international audience.

He is also physics commentator on Radio New Zealand's *Nights* programme and regularly talks about his work at public events or conferences for policy makers.

His work is credited with changing attitudes and behaviours in both government and business and his approach to understanding innovation has been used in major New Zealand companies in the development (R&D) of their research and development strategies, in New Zealand Trade and Enterprise's analysis of New Zealand's high technology sector, and by Business New Zealand to encourage a collaborative approach to exporting to Asia.

From left: Hannah Ng (Future Scientist), Hon. Steven Joyce Minister of Science & Innovation, Mr Peter Stewart (Science Teacher Prize), Dr James Russell (MacDiarmid Emerging Scientist), Professor Shaun Hendy (Science Media Communication Prize), the Prime Minister the Rt. Hon. John Key, Professor Paul Moughan (Science Prize, Riddet Institute, Massey University) and Mrs Anne Singh on behalf of Professor Harjinder Singh (Science Prize, Riddet Institute, Massey University).

Rutherford Discovery Fellowships

Two of our Principal Investigators, Dr Geoff Willmott (IRL) and Dr Martin Allen (University of Canterbury) were awarded two of the ten Rutherford Discovery Fellowships given in 2012.

The government-funded Fellowships are awarded annually to develop and foster the future leaders in the New Zealand science and innovation system and provide financial support of $160,000 a year for five years, enabling the Fellows to establish a track record for future research leadership.

Dr Allen was awarded a Fellowship for his research into the properties of, and applications for, transparent metal oxide semiconductors for use in sold-state lighting, next-generation optical displays such as smart windows, electronic paper and transparent electrodes for wide-area solar cells. The research also has potential applications in public health, including a new generation of epidemiological tools to study the risks and benefits of UV radiation to human health.

Dr Willmott's Fellowship will further his research work in developing tools to manipulate fluids at the nanoscale. At present the range of tools available to researchers wanting to manipulate fluids at the nanoscale are limited since there are technological roadblocks because of the way fluids behave at this scale. One area of study is producing a tunable nanopore that could sense nanoparticles suspended in a solution, accurately measure their concentration, size and surface change and hence allow the analysis of a wide range of particle types, including gold and magnetic particles, viruses, platelets and large molecules.

Another line of this research is studying the capillary-driven uptake of small water droplets, even in materials such as Teflon, where water would generally simply roll off

MacDiarmid Emerging Scientists Association

The MacDiarmid Emerging Scientists Association (MESA) was formed in 2010 to expand the opportunities available to MacDiarmid Institute PhD students and postdoctoral researchers. It works to improve networking among them and establish a sense of community. MESA, which is supported financially by the Institute, is involved in organising the MacDiarmid Institute annual symposium for students and the postdoctoral cohort.

In 2012 it organised the first intensive course for emerging scientists on electrochemistry. This was held in April at Huia Bay, north of Auckland and was attended by 24 post-doc students from around New Zealand. Three of New

The MacDiarmid Emerging Scientists Association (MESA)

Zealand's top electrochemistry researchers presented at the bootcamp, including Professor David Williams, who in 2013 took up a position as Deputy Director of the MacDiarmid Institute, replacing Professor Shaun Hendy.

Professor Williams is a strong supporter of the bootcamp approach to passing on knowledge to the new generation of scientists.

"Huia Bay was a good venue – just the right touch of bootishness and remoteness and wonderfully organised by MESA," he says. "There was terrific energy and enthusiasm among those who attended and from a teacher's viewpoint, I found it much more fun than teaching in the rather more formal environment of a lecture hall. I'm looking forward to the next one."

MESA was also a leading force in the establishment of Chiasma Wellington, which aims to establish a greater range of job opportunities for students after graduation.

Student and postdoctoral symposium

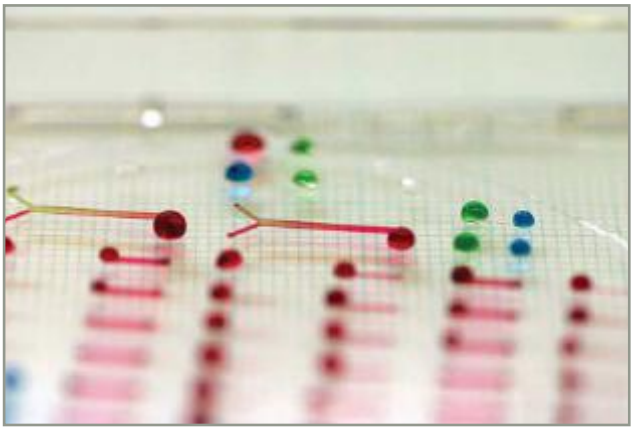
The student and postdoctoral fellow symposium is held annually to provide MacDiarmid Institute emerging researchers with an opportunity to focus on the skills they will need as they prepare to take the next steps in their research career. The 2012 symposium was held in Christchurch in November and included presentations by four recipients of MacDiarmid Research Commercialisation Fellowships on their scoping work investigating the commercial potential of MacDiarmid Institute research.

Australia/New Zealand microfluidics symposium

In April 2012, the MacDiarmid Institute supported the third Australia/New Zealand Microfluidics symposium held in Wellington. Fifty researchers from throughout Australasia and Singapore took part in a two-day symposium, which was the first one to be held in New Zealand.

The plenary speaker was Associate Professor Saif Khan of the National University of Singapore and other sessions discussed a range of topics from cellular science to device development and theoretical modelling work.

A prize for the best and most enthusiastic student presentation was presented to James Eldridge of IRL and the MacDiarmid Institute.



Leading science

Computers that don't forget

Most of the electronic devices we rely on are based on semiconductors like silicon, because these materials allow the precise control of electric currents. By contrast, data storage on computer hard disks relies on magnetic materials, and most magnets are made of metallic substances like iron or nickel. Now a team of MacDiarmid Institute researchers are looking to materials that combine both those qualities in one in the quest for the computer that can retain its memory when switched off. The result would be an end to the ritual coffee machine visit while the computer boots up and a welcome to the world of instant start-up.

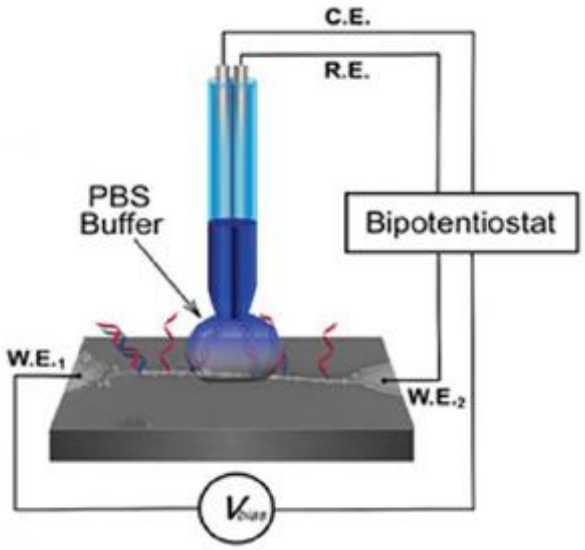
That rare combination of semiconducting and magnetic qualities is found in rare-earth nitrides and the team has been working to understand why these two properties are able to co-exist in them and to attempt to control them so that they could be engineered into proof-of-concept electronic devices able to control electric currents using magnetic fields.

One of the students working on the team, Victoria University honours student Harry Warring recently made an important breakthrough when he succeeded in fabricating a so-called field-effect transistor from a very thin rare-earth nitride layer grown on a silicon wafer. By applying a voltage to the device Harry was able to change the ability of the rare-earth nitride layer to conduct electricity, and then to show how this influences the magnetism. This represents a key step towards our goal of producing devices that control currents through magnetism. A manuscript detailing the results is presently under consideration at the prestigious journal *Applied Physics Letters*. Work is now proceeding on more complex structures that we expect will give us further control of the electrical and magnetic properties of these novel materials.

Better, cheaper DNA sequencing

DNA sequencing has become ubiquitous in the modern world. It is used in clinical diagnostics, in forensics and in food quality analysis. Currently, most DNA sequencing is done using fluorescence but MacDiarmid Institute scientists are working on a potential new way of direct electrical DNA sensing to rival fluorescence-based techniques, one that would be fast, portable, highly sensitive and selective, and yet economic.

The research team has successfully fabricated single conducting polymer nanowires that can be used as transducers for biosensing. An oligonucleotide (a short, single-stranded DNA or RNA molecule) specific to human breast and ovarian cancer cells was then incorporated into the device, which indicated the presence of cells through a change in resistance. The sensor proved to be highly sensitive, detecting the target cancer cells at infinitesimal concentrations.



Innovation ecology

One research paper produced by MacDiarmid Institute authors during 2012 had particularly broad appeal. The paper, by Principal Investigator and Institute Deputy director, Shaun Hendy and IRL Research Scientist Dion O'Neale, was entitled *'Power Law Distributions of patents as indicators of innovation'* and was published in the on-line peer-reviewed, open access scientific publication *PloS ONE*[1]. The paper demonstrates that the distribution of intellectual property amongst companies in national ecosystems is very similar to the distribution of biomass in natural ecosystems and illustrates the importance of lifting R&D spending and increasing the diversity of knowledge-intensive products that are exported by an economy. The findings have important lessons for New Zealand as it debates how best to diversify the economy into high-tech manufacturing and other new technology sectors to ensure the country's financial sustainability in the 21st century.

Rewriting the book on electrostatics

A research paper by MacDiarmid Institute Emeritus Investigator John Lekner is rousing much interest internationally with its findings that challenge the current understanding of electrostatics.

The paper, published in Nature News in May 2012[2], outlines how, under certain circumstances, two positively charged spheres might actually attract one another rather than being repelled.

It outlines the team's research that proved two charged conducting spheres will almost always attract each other at close approach, even when they have charges that are alike. The one exception is when the two spheres have the same charge ratio that they would obtain by being brought into contact. In that case they repel each other and the paper explains the forces behind the reactions and gives formulae to express them.

The findings were also outlined on the Royal Society's mathematical, physical and engineering sciences Proceedings website and hard copy publication where it reached number two on the Royal Society's list of the top ten most downloaded and cited articles on that site .

1 D. R. J. O'Neale & S. C. Hendy, (2012). 'Power Law Distributions of Patents as Indicators of Innovation', *PLoS ONE 7(12):* e49501 (2012).

2 Lekner, J.Proc. R. Soc. A http://dx.doi.org/10.1098/rspa.2012.0133 (2012). 'Like attracts like?'(Nature News, 23 May 2012).


Transit of Venus
Kōpū Ki Uawa 2012

3

Inspiration

> To inspire New Zealanders

Inspiration

The MacDiarmid Institute works to inspire people about science and innovation by:

- Stimulating community discussion on the benefits of science and innovation.
- Engaging with the public and private sector and Government to establish a shared vision of the role science and innovation should play in the future of New Zealand.
- Showcasing science, both MacDiarmid Institute science and science in general.
- Engaging with the Mäori and Pasifika communities to generate opportunities and lift the ambitions of young people to take up science.

Transit of Venus forum

Before his death in March 2012, MacDiarmid Institute founder Sir Paul Callaghan – with the backing of the MacDiarmid Institute – came up with the idea of a national forum about science and the economy to coincide with excitement around the rare event of the transit of the planet Venus across the sun on 6 June 2012. The forum turned out to be a unique event in New Zealand. It brought together local iwi, politicians, scientists, artists, economists, academics and students to first observe the transit of Venus at Tolaga Bay and then spend two days in Gisborne reflecting on our shared past and looking towards the future. There was a strong contingent from the MacDiarmid Institute with 17 representatives attending, including Investigators.

The forum attracted more than 280 delegates, drawn to hear a panel of New Zealand speakers that echoed the diversity of the audience. They included: Sam Johnson, organiser of Christchurch's post-earthquakes student army; Peter Chrisp, head of New Zealand Trade and Enterprise; Tamaki College principal Soana Pamaka; *Listener* journalist Toby Manhire, entrepreneur Derek Handley; Forest & Bird advocate Nicola Toki; and, young Mäori banker, Kristen Kohere-Soutar. Topics discussed included science and the economy, the Mäori economy, land use, environmental restoration, communications and human development. The forum also generated three public panel discussions broadcast by Radio New Zealand National.

A follow-up event is currently in the planning stages to capitalise on the enthusiasm engendered by the forum.

The MacDiarmid Institute was also involved in other events to mark the transit of Venus. These included sponsorship of a documentary film – *Venus: A Quest* – about the transit event. It was publicly released in November 2012 with screenings in Tolaga Bay, Gisborne, Auckland, Wellington, Christchurch and Dunedin. The Institute also sponsored an art exhibition entitled Dark Sky mounted at the Adam Art Gallery at VUW.

Nanocamp

Each year, one of the MacDiarmid Institute's six partner organisations hosts a Nanocamp for the top year 12 and 13 science students from around New Zealand. In 2012 it was the turn of VUW, The event attracted 15 high-performing students from Auckland, Hamilton, Gisborne, Nelson, Christchurch, Dunedin, and the Wellington region. They were chosen from a total of 55 applications. The students

attended daily interactive sessions that focused on cutting-edge research topics in nanoscience and nanotechnology. They also saw demonstrations of modern nanofabrication methods and state-of-the-art equipment. These sessions were facilitated by MacDiarmid Institute Principal Investigators, assisted by PhD students and postdoctoral fellows.

Professor Uli Zuelicke, who organised the 2012 Nanocamp says the interaction between the visiting students and researchers is stimulating to both. "Thinking of ways to describe to bright high-school students how we approach our science quite often provides a new angle for how we academics view very fundamental issues," he says.

One of the participants, Gabrielle Young from Chilton St James school in Lower Hutt found the Nanocamp a good chance to find out what a career in science would be like: "It's given me a more realistic view of what it's all about. It's not just white coats and labs all the time."

As well as seeing the facilities at Victoria, the students also visited the Gracefield sites of IRL (now Callaghan Innovation) and GNS Science.

The full and varied science programme was matched by an equally exciting schedule of social evening activities organised by local members of MESA.

Discovery Awards

The Discovery Awards is a programme offered by the MacDiarmid Institute to year 12 and 13 Mäori and Pasifika secondary students who have demonstrated their interest in science. It gives them the opportunity to work alongside scientists and their postgraduate students (who act as day-to-day mentors) in the research laboratories of one of our six partner organisations.

In 2012, seven students from Christchurch, Nelson and the Wellington region attended a two-day introduction session at VUW during which Howard Lukefahr and James Eldridge took them through some interactive science sessions. They then spent two weeks working individually in laboratories at Victoria and the Universities of Auckland and Otago.

The aim of the programme is to nurture the Mäori and Pasifika students' interest in science, expose them to possible career options and encourage them to enroll in a science degree programme at tertiary level. The programme also gives them an opportunity to develop a network of contacts that could be invaluable in their future career. While academic achievement is an important part of the selection process for the Discovery Awards, the students' goals and personal and financial circumstances are also taken into account.

The successful students in 2012 were Isaiah and Tre Ratahi (who are identical twins), Nadine Houia-Ashwell and Hoani Hotene – all from the Wellington region - Sophie Barron and Kristie-Lee Thomas from Christchurch and Rere Pope from Nelson.

The MacDiarmid Institute also sponsors Te Röpü Äwhina Whänau, an initiative by the Faculties of Science, Engineering, Architecture and Design at VUW to support Mäori and Pasifika students enrolled in their courses.

Reaching out to schools

The MacDiarmid Institute actively supports programmes that see scientists talking about their work in schools.

This includes the FutureIntech initiative of the Institute of Professional Engineers New Zealand (IPENZ). The feedback from teachers is enthusiastic.

For example, PhD student and MESA executive member Elf Eldridge is a regular visitor to colleges in the Wellington area to talk about science and as one teacher reported after a session:

"I have heard kids (and their teachers) buzzing in the corridors and judging from the eager beavers who stayed behind to ask those huge curly questions after each spell, his ideas and his personal story have really hit the spot."

Another FutureIntech ambassador was Associate Investigator Franck Natali who talked to several schools about his work with light-emitting diodes or LED. His first-ever visit was to St Michael's School in Taita, where he spoke to 75 students mainly from the Mäori and Pasifika communities. He found it a stimulating experience to see the students relate the scientific research to everyday life.

"One of the highlights of the morning session was to see these enthusiastic kids playing with the LEDs and the batteries I had brought in. Observing the little 8 year-old girls who were scared of touching the sparkling bulb to the oldest boy thinking he can use it in his new PlayStation, it was a great journey for me!"

PhD student Andrea Kolb (pictured above)– whose research is in wool research and nanogold science – is another FutureIntech ambassador and she finds the experience a very useful discipline.

"I had to rise to the challenge of using 'scientific talk for non-scientists' which was even harder due to the need to adjust adult language to children's vocabulary."

Nanotechnology – learning from the experts

Over any year, hundreds of school students visit MacDiarmid Institute laboratories around the country to learn more about basic chemistry and physics. In August 2012, however, a group of 20 Year 12 science students from Westmount High School in Hamilton visited to find out more about the groundbreaking science of nanotechnology. They had chosen nanotechnology as an elective and the programme presented to them during their day-long visit concentrated on introducing them to the basics of the subject. Institute Director Professor Kathryn McGrath talked about the research carried out by MacDiarmid Institute Investigators and the role it plays in the New Zealand context while PhD student Elf Eldridge introduced them to the basics of bionanotechnology and Professor Uri Zuelicke to nanoelectronics.

Elf Eldrige talks to Westmount High School students.

The Hub

In 2012, the MacDiarmid Institute began developing The Hub – an online resource for science teachers and students. The site contains news and events of interest to secondary school students and their teachers as well as links to resources for teachers.

It incorporates the New Zealand Physics Teachers' Resource Bank, which was set up in 2004 to provide teachers with ideas for demonstrations and activities to enhance their classroom teaching.

The Hub is one of a number of initiatives the Institute is considering as an aid to teachers of the physical sciences and to enthuse and inspire students about science.

MacDiarmid Institute science on TV

During the year, TV3's weekend current affairs show The Nation featured MacDiarmid Institute researchers and collaborators in a special feature on nanotechnology and its applications in New Zealand.

The programme featured interviews with Principal Investigators Ben Ruck (VUW), Richard Tilley (VUW) and Geoff Willmott (IRL) and alumni Dmitri Schebarchov about their work. It also highlighted the work of four companies that the Institute works closely with - Aeroqual, Magritek, IZON and Nuenz.

Inspirational science

In pursuit of nanoscale manufacturing

Scientists at the MacDiarmid Institute, University of Canterbury, have discovered a new way of controlling the formation of nanoscale structures – a development that is essential if industrial-scale manufacturing at the atomic level is ever going to be a reality. The new method allows the structures to self-assemble, and has potential applications in a range of areas, including new computer memory components and new laser technologies.

The construction of nanosized structures is currently painstakingly slow since the atoms that are the building blocks of these structures have to be manipulated individually – meaning it is a very expensive process as well. The new method of assembling nanostructures uses one of the principles of quantum mechanics – the world of the atom where things act rather differently than they do in the world we can observe with the naked eye.

Anyone who has played a woodwind or brass instrument, or simply blown across the open end of a bottle or a pipe, knows that the musical note produced varies according to the length of the instrument – in scientific terms the length of the pipe matches the wavelength of the note required. The MacDiarmid team has found that the exact opposite process comes in to play at the nanoscale, where the structure 'tunes' its size to match the wavelength of the electron waves inside it. Structures with sizes that match the wavelength of the electrons turn out to be more stable, and are therefore preferred. This opens the way to tuning the sizes of many nanostructures by first tuning the wavelengths of their electrons.

The experimental work was done by postdoctoral researcher Pawel Kowalczyk and PhD student Ojas Mahapatra in Professor Simon Brown's group at the University of Canterbury and was largely funded by the MacDiarmid Institute. However, the project was an international one involving researchers in the United States and China and Professor Brown says that proved to be crucial to developing a detailed understanding of the mechanisms of self-assembly.

"What made this work really complicated was that there are several different electronic effects happening at the same time. The collaboration with Professor Tai Chiang's group at the University of Illinois at Urbana Champaign, who were able to calculate the electron's behaviour, was what allowed us to understand this complex puzzle."

The findings have recently been published in the prestigious international journal *Nano Letters*[3].

3 P. J. Kowalczyk, O. Mahapatra, S. A. Brown, G. Bian, X. Wang, and T.-C. Chiang, 'Electronic Size Effects in Three-Dimensional Nanostructures', Nano Letters 13, 43 (2013)

Smallest and deepest patterns

Ever since the 1950s the semiconductor industry has given us better, faster computer chips by scaling the wiring in their circuits to ever smaller dimensions. In modern chips the wire widths are now at the nanoscale (smaller than 100nm) and still shrinking.

Research at the MacDiarmid Institute is contributing to this shrinkage. Using simple, optical methods, they have printed ever-smaller patterns and the researchers have concluded that there are no fundamental limits to how small those patterns can be made.

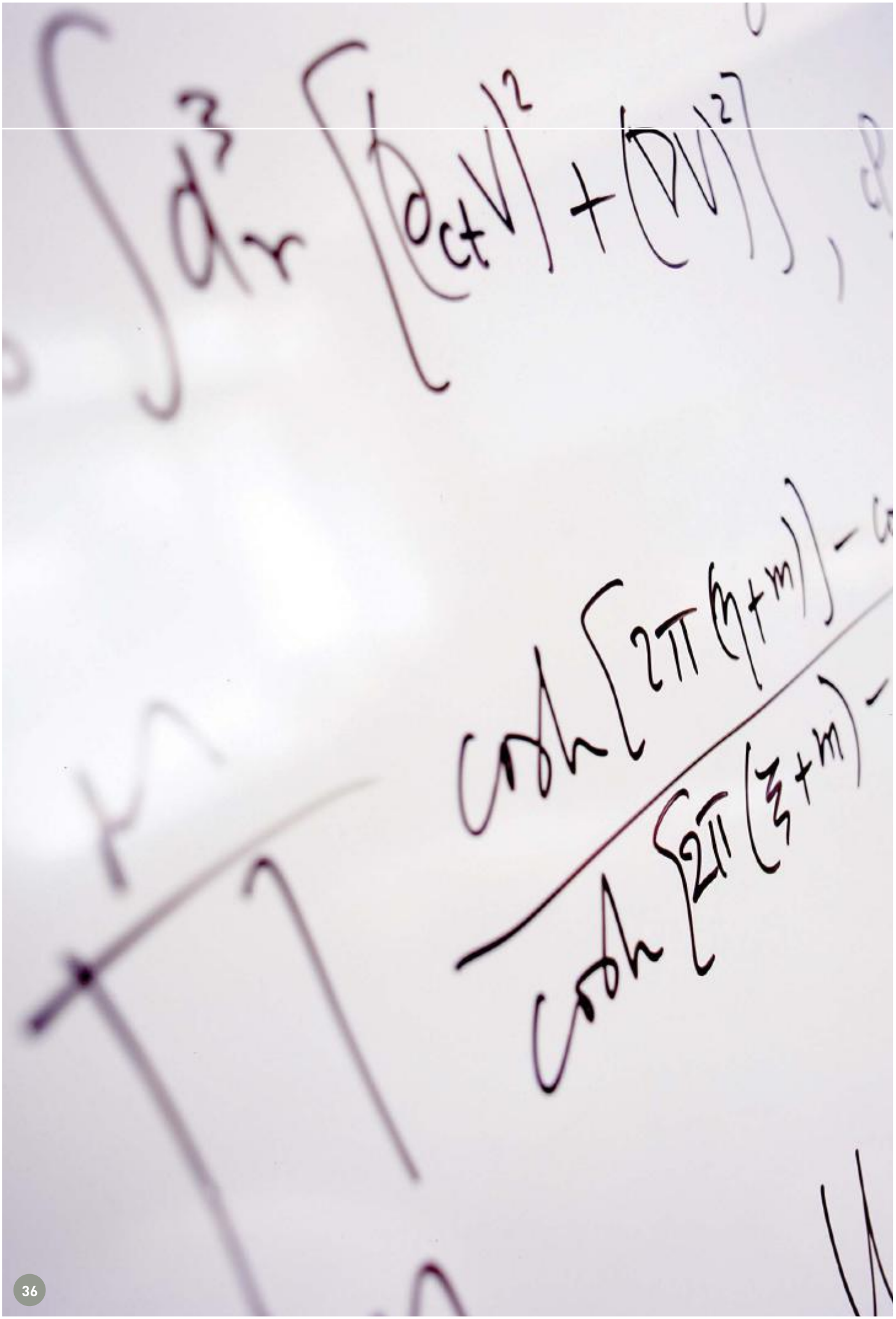
However, this comes at a cost if conventional methods are used because, while the patterns might be smaller, they are also shallower and depth is an important factor if these methods are to be used for manufacturing.

As a result, the MacDiarmid team has been exploring ways to overcome this difficulty. Their answer is a novel approach they call "effective gain medium" which has allowed them to etch patterns that are both small and deep using ultraviolet light at the wavelength set as the industry standard for semiconductor manufacturing.

The research will contribute to understanding of how smaller and deeper can be patterned for use in computer chip manufacturing and the development of new chemical and biomedical sensors.

Nanotechnology meets fashion

Chemists Kerstin Lucas and Fern Kelly – PhD apprentices to Professor Jim Johnston mastered the secret art of bonding gold and silver nanoparticles to merino wool and then linked up with Massey fashion students in 2011 to explore how the luxurious fabrics could be turned into garments fit for the catwalk. A start-up company, Noble Bond Ltd, has now been set up to commercialise the high-tech fabrics.



4

Advancement of New Zealand

> To advance a new future for New Zealand

Advancement of New Zealand

The MacDiarmid Institute's goals of scientific excellence, leadership and inspiration all contribute to our objective of the advancement of New Zealand. We work to achieve that by:

- Establishing collaborative networks with applied R&D organisations and New Zealand companies to ensure we understand the market demands of local industry.
- Producing scientists and engineers who make a leading contribution to New Zealand's prosperity.
- Commercialising our research, as appropriate, to ensure the greatest possible benefit to New Zealand, its people and its economy.
- Sharing and realising our vision for adaptable and sustainable economic growth based on a high-technology export sector.

Implementing a strategic commercialisation plan

In 2012, the Institute began implementing the strategic commercialisation plan adopted at the end of 2011 and aimed at reaping the benefits of science and innovation to New Zealand through generating intellectual property (IP) and new businesses.

The plan sets up a process for identifying, at an early stage, research programmes and projects with commercial potential. Small teams consisting of a research student, commercial mentor and team coordinator undertake an initial scoping project to review and understand how the technology or service they have developed might be applied. Those projects identified as having significant market potential are then subject to in-depth evaluation. During the year, 17 research projects within the Institute were considered for their commercial potential and six were chosen for fuller evaluation. A number of MacDiarmid Research Commercialisation Fellowships are available for postgraduate and emerging scientists interested in carrying out either scoping or in-depth evaluation projects. Money is also available through MacDiarmid's Bright Ideas fund to allow students to scope the commercial potential of their research.

Two commercialistation coordinators, one based in the North Island and the other in the South Island, have been appointed to help with the process.

Another important part of the strategy is to provide a range of opportunities for MacDiarmid researchers and students to learn more about the commercialisation process. Seven workshops were held during the year, often through or in collaboration with, other organisations and were open to all MacDiarmid Investigators and emerging scientists. As well, the Institute sponsored two students to attend an IP workshop in Auckland and three others to attend a commercialisation exercise at the University of Canterbury.

The Institute has also established a partnership with Wellington business incubator Creative HQ to work with them to commercialise innovative R&D.

New start-up companies

Three start-up companies were launched during 2012 to commercialise research coming out of the MacDiarmid Institute.

Associate Professor Cather Simpson of the University of Auckland, with funding by Pacific Channel investors and Auckland UniServices, set up Engender Scientific – a company that offers a new approach to sorting bovine sperm according to sex. An effective method for identifying sperm carrying the female chromosome offers a major advance for the dairy industry, which largely relies on artificial insemination for its breeding programmes and where the preference is for producing as many female offspring as possible. The company is at an early stage of development as patents are pending on the technology.

Another company to come out of MacDiarmid Institute research in 2012 has been BoutiQ Nanoparticle Solutions, which was founded by MacDiarmid Principal Investigator, Associate Professor Richard Tilley and Associate Investigator Dr John Watt. The company came out of Richard Tilley's research at VUW into the synthesis of nanocrystals in their liquid phase to control the properties, shape and structure of the resulting nanoparticles. BoutiQ sells customised nanoparticles for scientists and engineers internationally. There has been particular interest from the US, Japan, Australia and New Zealand and in its first six months of trading the company has returned a profit.

Noble Bond Ltd is the start-up company set up by Professor Jim Johnston and Dr Kerstin Lucas to commercialise a range of luxury textiles that blend nanoparticles of gold and silver with merino wool and other New Zealand natural fibres. The company produces a boutique range of naturally coloured wool textiles called Aulana, where the exact colour depends on the size of the gold particle. Using the same technology, Noble Bond has developed a process to chemically bind minute particles of silver and silver compounds to natural fibres, providing a durable, environmentally low-impact antimicrobial product suitable for use in the mass public transport markets and for medical textiles. Noble Bond Ltd will manufacture Aulana yarns in New Zealand for international markets and implement and licence the antimicrobial Silverwool technology internationally.

Entering the Dragon's Den

As part of its strategy to encourage postgraduate students to be more aware of the commercialisation potential of their research, the MacDiarmid Institute sponsored three students to attend a one-week Dragon's Den programme in conjunction with the Masters of Engineering Management programme at the University of Canterbury.

Two of the MacDiarmid Institute's products presented to the Dragons were for nanocoatings. Yiwen Pei was part of a team assessing the potential of polymer carbon nanoparticles to be used as coatings in the development of microfluidic and lab-on-a-chip devices – an idea that has come from Professor David William's group at the University of Auckland. Benjamin Wylie-van Eerd's team presented a proposal from Professor Alison Downard's group at the University of Canterbury on producing nanocoatings for latex gloves to minimise allergic reactions. Alec La Grow's team presented a market validation for the use of a wet-air oxidation process to transform the organic sludge produced during waste-water treatment into useful products – a process developed in Professor Jim Johnson's laboratory at VUW.

All three agreed it had been an eye-opening experience to work with the Canterbury students.

"Working together in a team of people who've been learning about commercialisation all year was a really unique experience, says Benjamin. "It makes you realise how much work it is for these people to gain the skills and knowledge needed to make a new technology into a successful business."

MESA chair wins Chiasma prize

The Chair of MESA, PhD student Cosmin Laslau of the University of Auckland won the 2012 Chiasma Prize in the Spark Entrepreneurship Ideas Challenge.

The award of $2000 will allow him to commercialise a nanopipette system that the judges ruled was the best research idea with potential biotech applications entered in the competition. Cosmin designed and built a prototype of the system during the course of his PhD research.

Cosmin says he was greatly assisted by Dr Anne Barnett of the MacDiarmid Institute Commercialisation Programme and acknowledged the contribution to the project of Professors David E Williams and Jadranka Travas-Sejdic and Mike Nelson.

"We now plan to enter the Spark $100,000 challenge," he says, "and also pitch the idea before the Return on Science committee for funding to enable us to develop a customer-ready prototype."

More details on Cosmin's scanned nanopipette system are available www.picoion.com/

Callaghan Fellowships

To mark Sir Paul Callaghan's death and his huge contribution to science and society in New Zealand, the MacDiarmid Institute in 2012 announced new fellowships named in his honour. The Sir Paul Callaghan Innovation Fellowships recognise Sir Paul's passion for taking research from the laboratory bench to the market place by giving academics an opportunity to pursue commercialisation opportunities. Two Fellowships will be awarded annually to allow the Fellows to develop a business plan or business idea and the first of them was awarded to Associate Professor Cather Simpson of the University of Auckland for her work in photochemistry at ultra fast speeds.

The criteria for judging the awards is the potential of the idea to lead to the formation of a new business or commercial venture – including licensing of a technology – and potential economic impact.

The Institute's Deputy Director Commercialisation and Industry Engagement, Professor Simon Brown, says many academic researchers would like to commercialise the ideas that come out of their work but the biggest impediment is time.

"These Fellowships will allow researchers to put aside teaching and administration and focus on commercialisation for three solid months. We believe this will allow more projects to reach the stage where external partners will be willing to fund them".

Director of the MacDiarmid Institute Professor Kathryn McGrath believes the Fellowship initiative to play a crucial role in the Institute's goal of commercialising research to ensure the greatest possible benefit to New Zealand, its people and its economy.

"I am sure this initiative will lead to many new start-up companies and license deals, as well as greater participation in existing commercialisation funding schemes, such as the Pre-Seed Accelerator Fund and the New Zealand Venture Investment Fund".

Chiasma launched in Wellington

The MacDiarmid Institute was one of the sponsors of the launch in March 2012 of Chiasma Wellington - a student-led organisation aimed at increasing engagement with the high-tech industrial sector in the Wellington region. About 200 people attended the launch, including CEOs of high tech companies, students, scientists, industry representatives, investors and academics.

The Wellington organisation grew out of the concerns of MacDiarmid PhD students Ben Mallet and James Eldridge that students needed a greater range of options at the end of their studies. Ben, who is now CEO of Chiasma Wellington, says they were concerned that science, engineering and design graduates were not being retained in the region.

With the support of the MacDiarmid Institute, along with IRL and Grow Wellington, the two spent six months talking to companies and students about this problem and what could be done to tackle it. The result was Chiasma Wellington, which takes its inspiration from the University of Auckland's highly successful biotechnology engagement programme of the same name.

"Particularly in science and engineering, students are often groomed for academic jobs which simply don't exist in abundance in New Zealand," Ben says. "So, on completion of their degree, most of them turn their sights overseas where the academic market is perceived to be much easier. On the other side of the coin, local technology companies often clamour for reliable, skilled employees. Chiasma simply connects these two groups together."

Chiasma's programme for 2012 included workshops on cutting-edge science for design students, entrepreneurship think tanks, and an introduction to Wellington's high-tech industries at an industry expo held in August.

Chiasma
The link in Biotech enterprise

Award for innovative health research

MacDiarmid Institute Director Professor Kathryn McGrath and her research assistant Natasha Munro were recognised for their R&D on hard tissue implant technologies, winning the *Lead Innovation for 2012 award* in the Grow Wellington *Innovating for Health Challenge.*

Their submission was one of 40 from the Wellington region submitted to the challenge and the award comes with $50,000 of development funding from Grow Wellington.

Professor McGrath's project focused on the development of non-toxic composite materials - using hydrogel technologies - that mimic the materials that make up the body's hard tissues. Successful development of these materials would lead to new breakthroughs in hard tissue implants such as bone grafts, with a drastic reduction in rejection rates, increased mechanical compatibility, and a longer lifespan.

Research by another MacDiarmid Institute scientist, Dr Grant Williams, to develop instruments using fibre light to measure radiation remotely was one of five other submissions identified by the judges as showing great potential for future development and recognised as 'leading innovations' in the region.

The *Innovating for Health Challenge* was conceived by Grow Wellington to showcase and support the breadth of research and commercial activity in the Wellington region in the biomedical sector. The judging panel included experts from the biotech industry, the Ministry of Business Innovation and Employment, health services researchers, and an industry entrepreneur and investor.

Science advancing New Zealand

Commercialisation of protein science

In 2012, MacDiarmid Principal Investigator Professor Juliet Gerrard was named an IRL Industry and Outreach Fellow to undertake joint research on protein science involving scientists from IRL and from the Biomolecular Interaction Centre (BIC) at the University of Canterbury, of which she is Director. The research team, which is led by Dr Andrew Muscroft-Taylor of IRL (now Callaghan Innovation), will be based at BIC.

The goal of the programme is to develop IRL capability in protein science and engineering and come up with technologies for use by New Zealand companies, in particular those in the Canterbury area. Businesses that are involved to date include biotechnology company Canterbury Scientific Ltd, Gelita – a gelatin manufacturer, pharmaceuticals manufacturer New Zealand Pharmaceuticals, and Anagenix, which sells functional and natural food and beverage ingredients globally.

Understanding how surface modification affects plastics

A group of MacDiarmid Institute researchers at the University of Canterbury have been successful in coming up with a new understanding of why protective coatings may act to modify the surface of polymer materials such as plastic and rubber.

Any protective coating, while keeping the surface of the material safe from contamination, must not affect its desirable properties. It is also a major advantage if it lasts and is robust enough to withstand chipping and flaking. Paint is a good example of the pros and cons. Used on steel, it stops the metal rusting but does not affect the strength and integrity of the steel. The problem is, however, that paint does not last forever and can be quite easily chipped. That means the object needs to be regularly repainted or the metal will be vulnerable to rust.

The MacDiarmid research project, led by Professor Alison Downard, has succeeded, with its coatings for polymers, to come up with products that meet two of the requirements. The researchers turned to organic compounds that are very strongly bonded to the target surface so that they cannot chip or flake off. They are also extremely thin – measuring a few nanometres only – and are invisible to the naked eye.

In the latest phase of the research, PhD student Brad Simons has been studying how these coatings react with the surface of the materials they are used on and has identified a previously unknown reaction pathway that helps to explain why the modification reaction can sometimes be irreproducible and difficult to control. These findings will be particularly valuable to the international community of researchers who are exploring practical applications of the methodology.

Professor Downard is currently working with the MacDiarmid Institute Commercialisation Coordinator Bill Swallow to identify commercial opportunities in New Zealand. One local company sees potential in applying what has been learned to add to its product by modifying the surface. Initial experiments have produced promising results.

Harnessing ions for super coatings

Diamond-like carbon (DLC) coatings are of increasing interest to industry for products that require smooth, durable surfaces that are low friction. They are particularly sought after for products using titanium-based alloys, which are widely used in modern industry, including the aerospace industry, in medical protheses and implants, and mobile phones.

MacDiarmid Institute Principal Investigator Dr Andreas Markwitz of GNS Science, in a project funded by the Ministry of Business, Innovation and Employment and industry partners, has developed a novel way of producing these coatings by manipulating ions. The films produced meet the requirements of industry in that they are of extreme hardness and low friction, meaning they are long-wearing and very smooth. They are also chemically inert, are compatible with biological tissues, and provide electrical insulation.

In developing the new coating method, Dr Markwitz worked with GNS Science's triple beam line ion implanter to slow down the target ions and then developed an ion deposition system to produce the film coating.

He is now working with industry partners on a commercial system that will allow the coatings to be applied at room temperature.

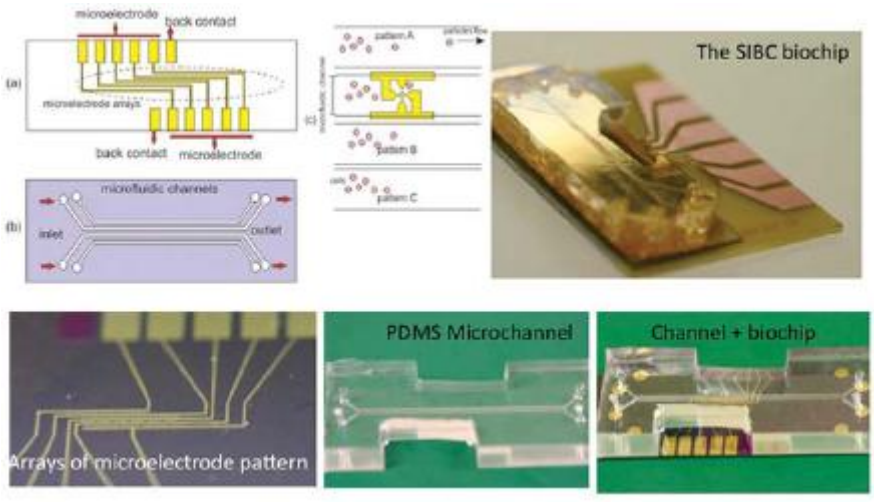
Developing a biochip

Speedy diagnosis of infections and disease is often the key to a patient's recovery but waits for the laboratory test results to come back can mean the most appropriate treatment may be delayed.

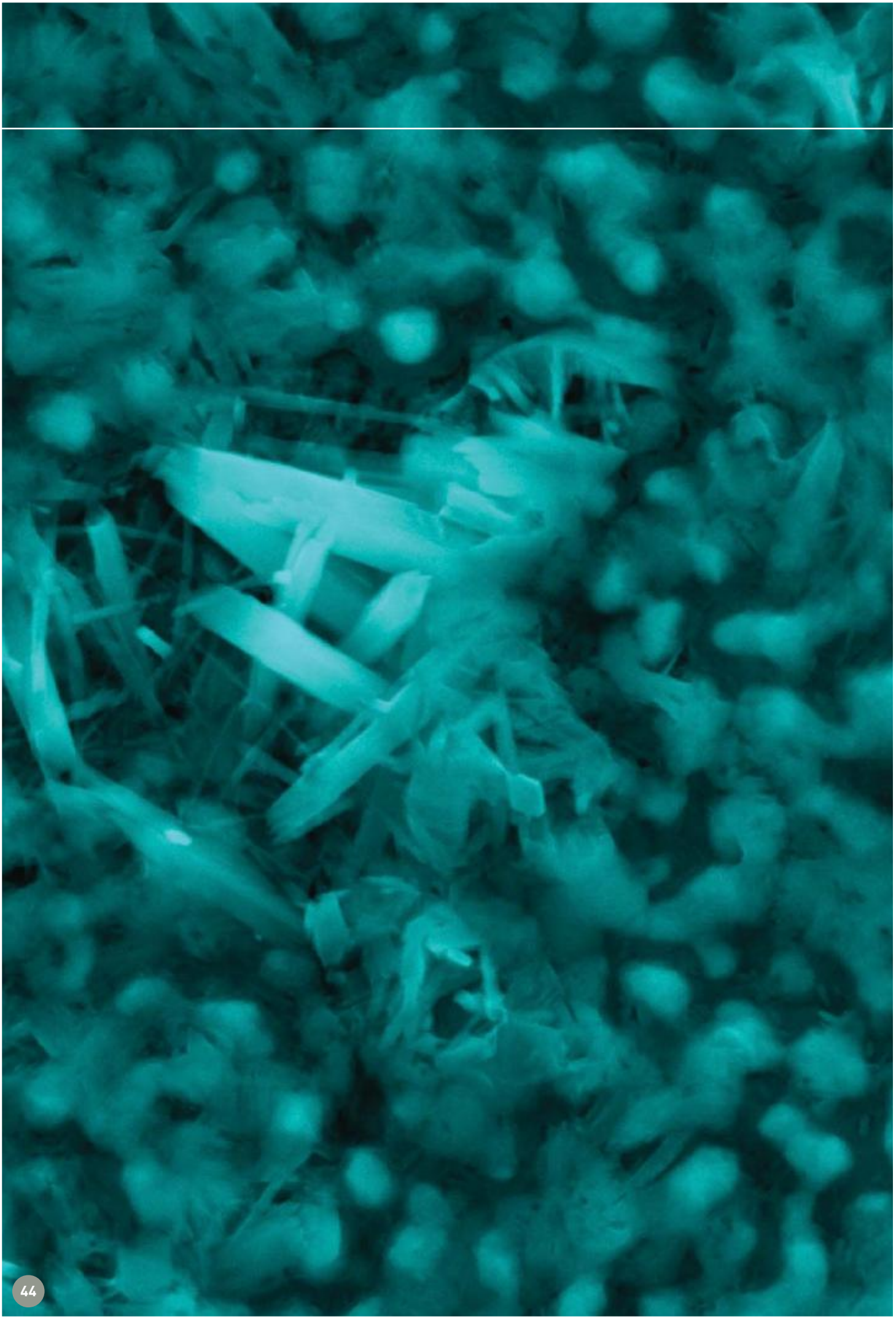
Researchers at the MacDiarmid Institute have developed and constructed a device – known as a biochip – that is capable of trapping and sorting single biological cells. The chip is combined with microfluidic channels to provide a very small and portable Bio microelectromechanical (BioMEM) device that is in essence a Lab-on-a-Chip (see diagram below).

Using it, cells can be isolated, stimulated and analysed. It is capable of identifying viruses and also has potential application in DNA sequencing

The work could provide the basis for a new high-tech industry in New Zealand in manufacturing BioMEMs for the healthcare sector and the life sciences, a market that is expected to grow in value from $1.6 billion currently to $6.6 billion over the next five years.



Design of the BioChip showing arrays of microelectrodes and cell trapping cavities.
Design of microfluidics channels to facilitate cells and media flow.
The fabricated BioChip showing the Au microelectrodes and PDMS microfluidics.



5

Governance and finance

Governance

Science Executive

The Board is advised by the Science Executive, which represents the views of the Investigators and contributes to the leadership of the organisation.

Professor Simon Brown *
Theme Leader, Nanofabrication and Devices
Deputy Director of the MacDiarmid Institute
University of Canterbury

Dr Nicola Gaston
Theme Leader, Electronic and Optical Materials *(to September 2012)*
Industrial Research Ltd

Associate Professor Eric Le Ru
Theme Leader, Electronic and Optical Materials
(from September 2012)
Victoria University of Wellington

Professor Alison Downard
Theme Leader, Molecular Materials
University of Canterbury

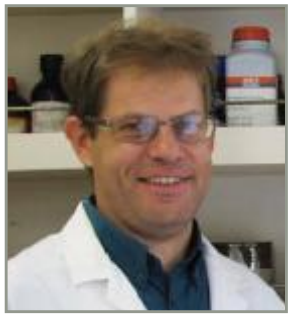
Juliet Gerrard
Across-theme representative
(from September 2012)
University of Canterbury

Ian Brown
Across-theme representative *(to September 2012)*
Industrial Research Ltd.

Cosmin Laslau
Chair, MESA
University of Auckland

Emily Sullivan
Centre Manager
VIctoria University of Wellington

Associate Professor Bill Williams
Theme Leader, Soft Materials
Massey University



Dr Tim Kemmitt
Theme Leader, Inorganic Hybrid Materials
Industrial Research Ltd

Dr Geoff Willmott
Theme Leader,
The Intersection of Nanoscience and Biology
Industrial Research Ltd

Professor David Williams
Across-theme representative
University of Auckland

Professor Kathryn McGrath *
Director MacDiarmid Institute

Professor Shaun Hendy *
Deputy Director
MacDiarmid Institute

Dr Steve Thompson *
Chair, MacDiarmid Board

* Ex-officio members

MacDiarmid Institute Board

The MacDiarmid Institute is governed by a Board whose members are drawn largely from our partner organisations. At 31 December 2012, the Board members were:

Dr Steve Thompson
Chair from January 2010
Science & Innovation Promoter, British High Commission

Professor David Bibby, DSc
From July 2002
Pro Vice-Chancellor & Dean of Science, Architecture & Design, Victoria University of Wellington

Dr Robert Buckley, FRSNZ
From 2004
Manager, Materials Technologies Group, Industrial Research Limited (Callaghan Innovation as of 1 March 2013)

Professor Don Cleland, FIPENZ, FASHRAE, FNZIFST, FIRHACE, HonMAIRAH
From 2010
Head of School & Professor of Process Engineering, Massey University

Dr Roger Ridley, BSC (Hons), MSc, PhD (Monash, Australia)
From 2011
General Manager Strategy and Evaluation, Science, Engineering and Technology Delivery, Industrial Research Ltd (Callaghan Innovation as of 1 March 2013)
(replacing Shaun Coffey, CEO, IRL)

Mr Fred Samandari
From April 2012
Director, Wireless and Spatial Engineering Research Centres, University of Canterbury

Professor Vernon Squire
From January 2010
Deputy Vice-Chancellor, Academic & International, University of Otago

Dr Geoff Todd
From September 2010
Managing Director VicLink, Victoria University of Wellington

Professor Charles Daugherty, ONZM, PhD (Mont)
From April 2009
Associate Vice-Chancellor Research, Victoria University of Wellington

Professor Jan Evans-Freeman, FInstP
From 2010
Pro Vice-Chancellor Engineering, University of Canterbury

Dr Ian Graham
From July 2012
General Manager Research, GNS Science
(replacing Dr Frank Bruhn, Director of the National Isotope Centre, GNS Science)

Distinguished Professor Jane Harding, ONZM MBChB DPhil FRACP FRSNZ
From June 2012 (New member appointed as part of MacDiarmid/UoA partnership)
Deputy Vice-Chancellor Research, University of Auckland

Professor Kathryn McGrath, BSc(Hons), PhD(ANU) *
From July 2011
Director of the MacDiarmid Institute
Victoria University of Wellington

Professor Shaun Hendy, BSc(Hons) Massey, PhD Alberta *
From March 2008
Deputy Director of the MacDiarmid Institute
Industrial Research Ltd (Callaghan Innovation as of 1 March 2013 / Victoria University of Wellington

Professor Simon Brown, BSc(Hons) Well PhD(Camb) *
From March 2010
Deputy Director of the MacDiarmid Institute
University of Canterbury

* Ex-officio members

Strategic plan in place

The MacDiarmid Institute undertook a major exercise during late 2011 and in 2012 to clearly articulate its purpose and strategy for the future.

The new Strategic Plan was signed off by the Board in November 2012 following intensive consultation which included with Board and science executive members as well as the whole science cohort.

It was then formally presented to Investigators at a special meeting which discussed incorporating the Plan into practice and its implications for the Institute's future science activities and structure.

The strategy content strongly reflects the vision Sir Paul Callaghan had for the Institute at its inception, stressing the role the Institute sees, not just in engaging in excellent research, but also in promoting science in society, in providing leadership within the science sector and beyond, and meeting the imperative to add value for New Zealand through commercialisation of research and closer links with the end-users of science.

It is, however, the first time these aspirations have been formally expressed and the Strategy also lays out some specific milestones and initiatives to achieve the goals and assigns a budget, over and above the research budget, to fund these activities.

Management team

From left: Professor Simon Brown, Deputy Director Commercialisation and Industrial Engagement, Professor Kathryn McGrath, Director, Professor Shaun Hendy, Deputy Director Stakeholder Engagement, Sarah Dadley, Senior Administrator, Emily Sullivan, Centre Manager, Rebekah Hunt, Administrator

Budget and financial reporting

The MacDiarmid Institute ended the 2012 calendar year in a sound financial position.

We continue to enjoy strong support from our host and partner institutions, as well as from like-minded industry and research-sector organisations (for example, RSNZ) and so have been able to achieve excellent leverage from the expenditure we make.

The accumulated unexpended grant has grown slightly through 2012 by $400,000 to $4.8m. The sign-off of the Strategic Plan in November 2012 has formalised the strategic initiatives developed in 2011 to complement our core activities and make the best use of these funds. These include: two new and significant research projects; a detailed commercialisation programme aimed at arming our staff and alumni with greater knowledge and skills around the commercialisation process and entrepreneurship; an operational plan to engage with and inspire New Zealand on the topic of science and technology; and, improving our communication channels, including the redevelopment of our website. Money was set aside to assist our people in Canterbury with earthquake recovery. These reserves will also be used to offset inflation that occurs during the term of the contract.

The 2012 statement of financial position for the MacDiarmid Institute is summarised below.

The MacDiarmid Institute
Special Purpose - Statement of Financial Performance for the 12 months ended 31 December 2012

Revenue	*$ 000*
Operational Receipts	6,708
Interest Income	186
Other Income	99
Total Revenue	6,993
Expenditure	
People Costs	2,004
Overheads	1,373
Direct Project Costs	1,100
Travel	539
Postgraduate Students	1,377
Depreciation on CoRE Equipment	600
Subcontractors	-
Extraordinary Items	-
Total Expenditure	6,993
Surplus for the year	-
(All Quoted Excl of GST)	

The MacDiarmid Institute
Special Purpose - Statement of Financial Performance
for the period ended 31 December 2012

	Note	Victoria University	Canterbury University	Massey University	University of Otago	University of Auckland	IRL	GNS	Consolidated
		$ 000	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000
Revenue									
Operational Receipts		3,421	1,337	514	520	388	468	60	6,708
Interest Income	1	186	-	-	-	-	-	-	186
Other Income	2	10	70	-	-	-	19	-	99
Total Revenue		3,617	1,407	514	520	388	487	60	6,993
Expenditure									
People Costs		826	459	146	220	147	164	42	2,004
Overheads		580	267	129	134	54	209	-	1,373
Direct Project Costs		815	147	47	24	30	32	5	1,100
Travel		283	88	16	30	27	82	13	539
Postgraduate Students		793	237	126	91	130	-	-	1,377
Depreciation on CoRE Eqpt	3	320	209	50	21	-	-	-	600
Subcontractors		-	-	-	-	-	-	-	-
Extraordinary Items		-	-	-	-	-	-	-	-
Total Expenditure		3,617	1,407	514	520	388	487	60	6,993
Surplus for the year		-	-	-	-	-	-	-	-

Statement of Movements in Equity
for the period ended 31 December 2012

	Note	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000
Surplus for the year		-	-	-	-	-	-	-	-
Capital Funds received from Government		-	-	-	-	-	-	-	-
Total changes in Equity		-	-	-	-	-	-	-	-
Opening Equity		10,320	7,087	1,652	564	-	-	-	19,623
Closing Equity		10,320	7,087	1,652	564	-	-	-	19,623

The MacDiarmid Institute
Special Purpose - Statement of Financial Position
as at 31 December 2012

	Victoria University	Canterbury University	Massey University	University of Otago	University of Auckland	IRL	GNS	Consolidated
	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000	$ 000
Current Assets								
Cash at Bank/Short Term Investments	6,055	1,893	1,192	115	190	(15)	48	9,478
Accounts Receivable & Prepayments	-	-	-	-	-	-	-	-
Total Current Assets	6,055	1,893	1,192	115	190	(15)	48	9,478
Non-Current Assets								
Plant & Equipment	8,234	5,488	674	600	-	-	-	14,996
Construction in Progress	-	-	-	-	-	-	-	-
Total Non-Current Assets	8,234	5,488	674	600	-	-	-	14,996
Total Assets	**14,289**	**7,381**	**1,866**	**715**	**190**	**(15)**	**48**	**24,474**
Current Liabilities								
Accounts Payable and Accruals	-	-	-	-	-	-	-	-
Research Grants Unexpended	3,969	294	214	151	190	(15)	48	4,851
Total Current Liabilities	3,969	294	214	151	190	(15)	48	4,851
Total Net Assets	**10,320**	**7,087**	**1,652**	**564**	**-**	**-**	**-**	**19,623**

The MacDiarmid Institute
Special Purpose - Statement of Cash Flows
as at 31 December 2012

	Victoria University	Canterbury University	Massey University	University of Otago	University of Auckland	IRL	GNS	Consolidated
	Actual $ 000	Actual $ 000	Actual $ 000	Actual $ 000	Actual $ 000	Actual $ 000	Actual $ 000	Actual $ 000
Operating Activities								
Cash was provided from:								
Royal Society New Zealand	4,188	1,131	432	492	471	342	62	7,118
Interest income on funds held	186	-	-	-	-	-		186
Other sources	10	70	-	-	-	19		99
	4,384	1,201	432	492	471	361	62	7,403
Cash was applied to:								
Employees and Suppliers	(3,298)	(1,198)	**(464)**	**(499)**	**(388)**	(487)	(60)	(6,394)
	(3,298)	(1,198)	(464)	(499)	(388)	(487)	(60)	(6,394)
Net Cash Flows from Operating	**1,086**	**3**	**(32)**	**(7)**	**83**	**(126)**	**2**	**1,009**
Investing Activities								
Cash was provided from:	-	-	-	-	-	-	-	-
Cash was applied to:								
Property, Plant & Equipment	-	(171)	-	-	-	-	-	(171)
Net Cash Flows from Investing	-	(171)	-	-	-	-	-	(171)
Financing Activities								
Cash was provided from:								
Funds from TEC	-	-	-	-	-	-	-	-
Net Cash Flows from Financing	-	-	-	-	-	-	-	-
Net Cash Flows for the year	1,086	(168)	(32)	(7)	83	(126)	2	838
Add Cash at start of year	4,969	2,061	1,224	122	107	111	46	8,640
Cash at end of the year	**6,055**	**1,893**	**1,192**	**115**	**190**	**(15)**	**48**	**9,478**
Cash at end of the year comprises:								
Cash at Bank/Short Term Investments	6,055	1,893	1,192	115	190	(15)	48	9,478
Cash at end of the year	**6,055**	**1,893**	**1,192**	**115**	**190**	**(15)**	**48**	**9,478**

The MacDiarmid Institute
Notes to the Special Purpose Financial Statements
for the period ended 31 Dec 2012

Note 1 Interest Income

Revenue generated from investment of CoRE funds by Victoria University Wellington

Note 2 Other Income

Revenue generated from donations, commercial income and sponsorship

Note 3 Depreciation

The Fixed Asset Registers of all partners will show a depreciation balance higher than that reported here. The partner universities have been required to subsidise CoRE activities by meeting the depreciation shortfall.

The MacDiarmid Institute
Statement of Accounting Policies
for the period ended 31 December 2012

The Reporting Entity

The MacDiarmid Institute is a collaboration between Victoria University Wellington, University of Canterbury, Massey University, University of Otago, University of Auckland, GNS Science and Industrial Research Limited to undertake research on a project funded by the Ministry of Education (MoE) via the Tertiary Education Commission (TEC). The terms of this collaboration is set out in the Memorandum of Understanding agreed by the partners in July 2008, amended in 2012 to formally include the University of Auckland.

Measurement Base

The accounting principles recognised as appropriate for the measurement and reporting of financial performance and financial position are on a historical cost basis.

Specific Accounting Policies

Consolidated Special Purpose Financial Statements

These comprise the returns from each university. The consolidation excludes inter-entity entries.

Revenue Recognition

Funds received from TEC were held in a Research Grants Unexpended account. Once costs were incurred, an amount sufficient to cover the expenditure was recognised as revenue

Financial Instruments

These are recognised in the Statement of Financial Position. These financial instruments include bank accounts, accounts receivable, short-term deposits and accounts payable. Revenue and costs in relation to all financial instruments are recognised in the Statement of Financial Performance.

Goods and Services (GST)

The Special Purpose Financial Statements are prepared on a GST exclusive basis

Plant & Equipment

All items of plant and equipment are initially recorded at cost, including costs directly attributable to bringing the asset to its working condition. Depreciation has been charged to this project following application of the TEC guidelines of 3% (45% of a 6.67%) Straight Line annual asset charge, excluding the super-computer. This project is charged for this particular asset at 11.25% (45% of a 25%) Straight Line basis. All are in compliance with the CoRE Budget approved by the TEC. TAMU guidance, received 5th September 2003 via TEC, enables the partners to retain project funds to cover depreciation of CoRE assets when TEC funding has ended. This is included in the Research Grants Unexpended value