ANNUAL REPORT **2013**

The MacDiarmid Institute

for Advanced Materials and Nanotechnology

The MacDiarmid Institute
of Advanced Materials and Nanotechnology

PO Box 600
Wellington
New Zealand

macdiarmid-institute@vuw.ac.nz
www.macdiarmid.ac.nz

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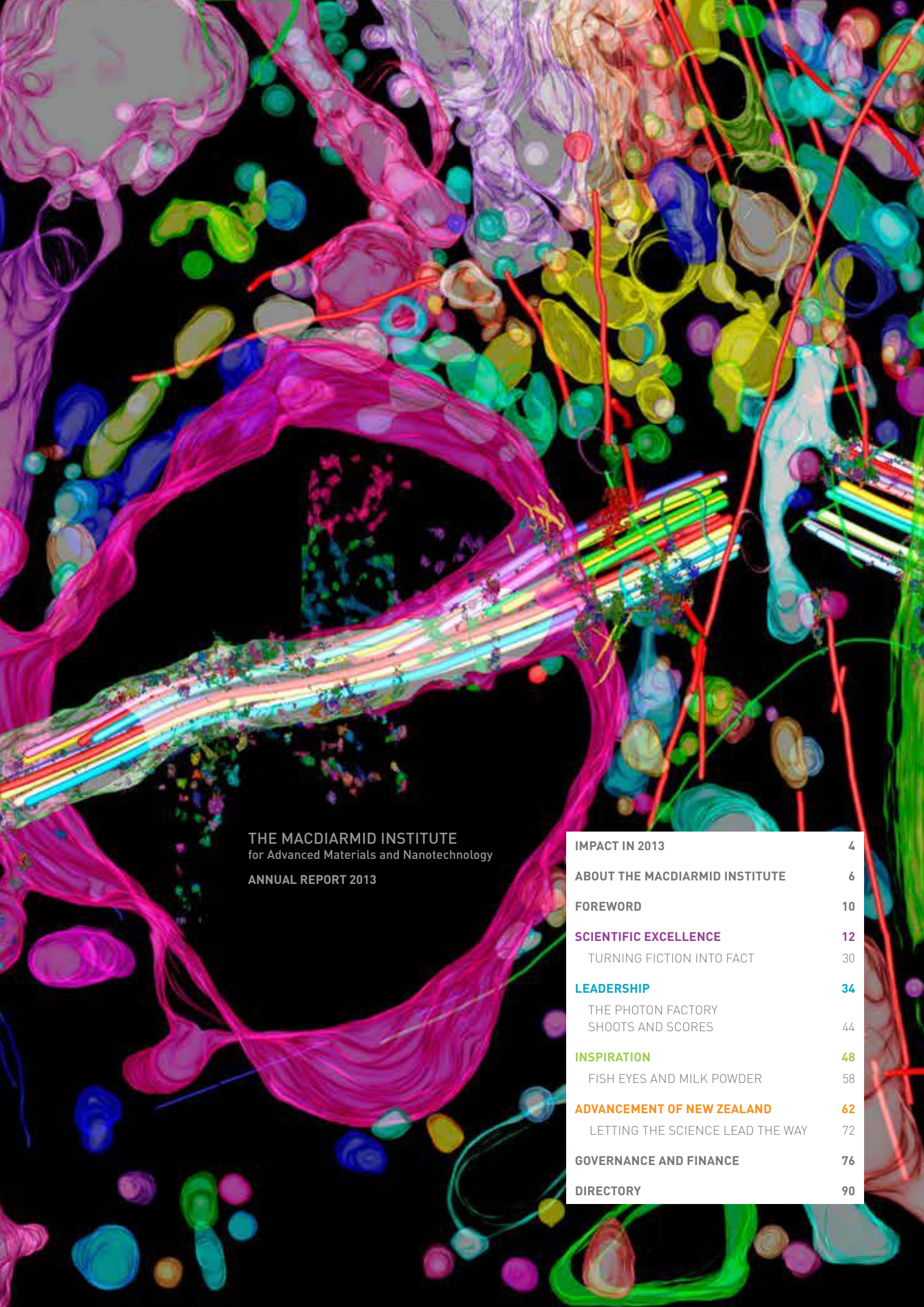
A note about the title: *Making the Invisible, Visible.*

This year's report title references a successful nanotechnology public art exhibition called Art of the Invisible hosted by the Institute in 2013. It also plays on the idea that MacDiarmid Institute scientists frequently explore and investigate (and make visible) matter and objects that are so small, they seem invisible.



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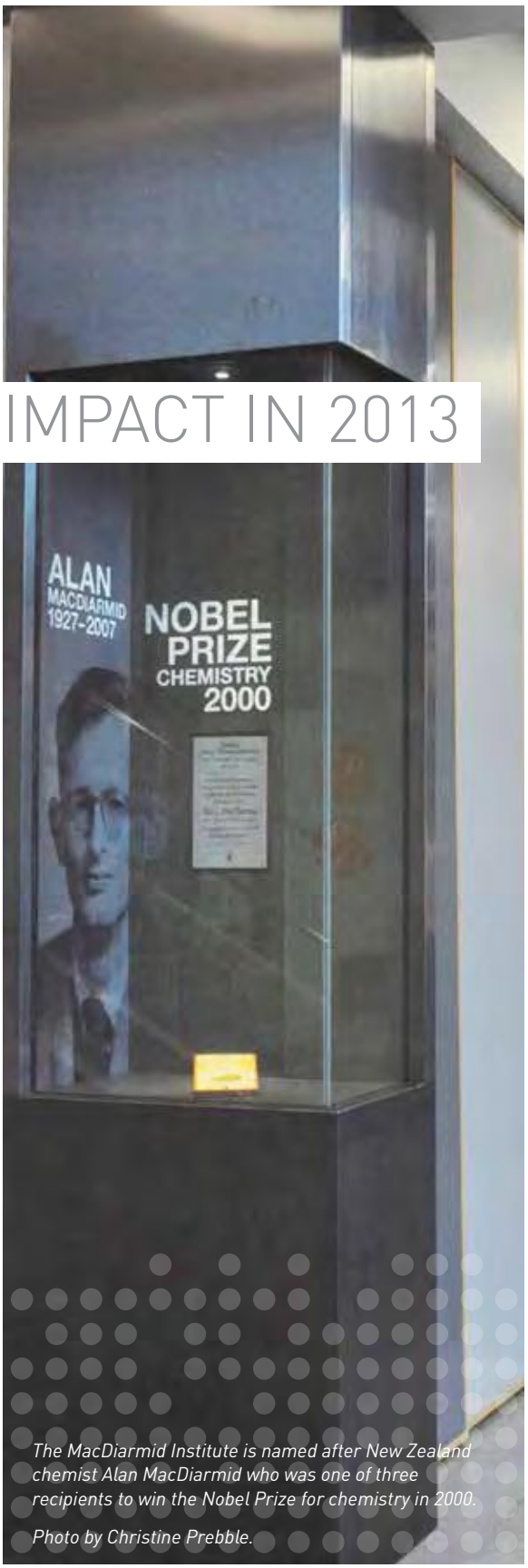


The MacDiarmid Institute is named after New Zealand chemist Alan MacDiarmid who was one of three recipients to win the Nobel Prize for chemistry in 2000.

Photo by Christine Prebble.

IMPACT IN 2013

MACDIARMID INSTITUTE HIGHLIGHTS

The MacDiarmid Institute's strategic plan is implemented

Scientific leadership and collaboration results in successful grant applications, ground-breaking research, commercialisation opportunities and outcomes and research awards

ENGAGEMENT WITH MĀORI AND PASIFIKA COMMUNITIES INCREASES

THE MACDIARMID INSTITUTE'S SCIENTISTS ACCESS STATE-OF-THE ART TECHNOLOGY & EQUIPMENT

The MacDiarmid Institute's stories and vision is conveyed through channels such as the mainstream and social media

Scientific excellence is recognised externally in reports such as the latest CoRE report

Leading scientists from New Zealand and throughout the world are supported through a range of new and existing initiatives

CONTRIBUTION TO THE ADVANCEMENT OF NEW ZEALAND IS REALISED THROUGH SCIENCE COMMERCIALISATION AND INDUSTRY INITIATIVES

THE BENEFITS OF SCIENCE AND INNOVATION ARE PROMOTED THROUGH A RANGE OF OUTREACH AND COMMUNITY INITIATIVES AND PARTNERSHIPS

THE WORK OF THE MACDIARMID INSTITUTE SHOWCASED TO THE PUBLIC IN NEW WAYS

SCIENCE HIGHLIGHTS

WORLD-LEADING DEVELOPMENTS IN RARE-EARTH NITRIDES

INSIGHTS INTO MAKING COMPUTER CHIPS SMALLER THAN EVER BEFORE

CONTINUITY OF WELL-ESTABLISHED SURFACE-ENHANCED RAMAN SPECTROSCOPY SERS RESEARCH

Discovery of a low-cost fabrication technique for producing solar cells

Proof-of-concept achieved for research into the assembly of protein nanostructures

Ground-breaking bionano-technology and soft matter research into genetic makeup and cell behaviour; insights into the effects of material properties and structure on cell behaviour

Insights into a new procedure for computed tomography imaging used in cancer treatment

New findings about the holes in field-effect transistors with magnetic doping

New materials research published showing how smart device energy storage and conversion could be improved

NEW INSIGHTS INTO THE OPTICAL PROPERTIES OF SPHEROIDAL PARTICLES

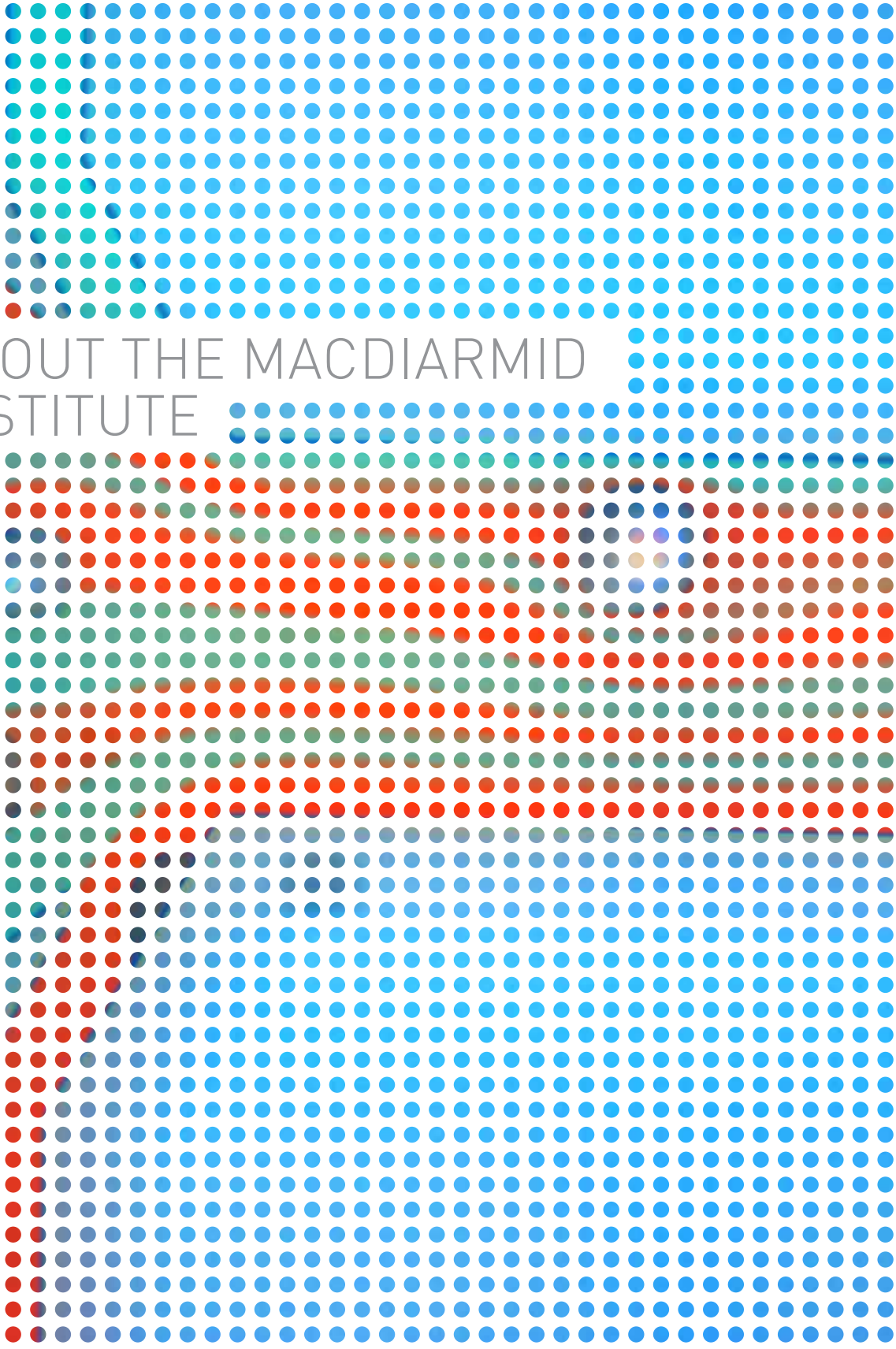
New understanding of the thermoelectric power generation potential of therm-oelectric fabric

New ways to measure jelly-like materials discovered

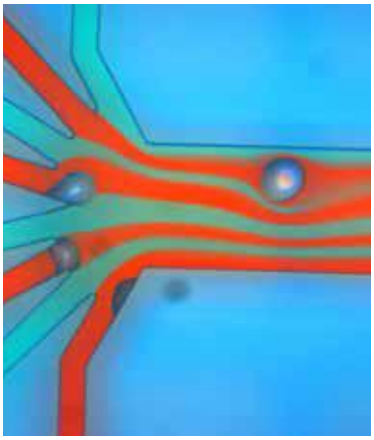
INSIGHTS INTO THE BINDING EFFECT OF LIGANDS ON GOLD CLUSTERS UNCOVERED

Subwavelength patterning research used commercially

ABOUT THE MACDIARMID INSTITUTE



BACKGROUND



This image, Microfluidic Bubbles by Volker Nock, is nanotechnology presented as artwork. Art of the Invisible, 2013.

The MacDiarmid Institute for Advanced Materials and Nanotechnology is a partnership between five universities and a Crown Research Institute and a Crown entity. Our leading-edge researchers are based in Auckland, Palmerston North, Wellington, Christchurch and Dunedin.

OUR UNIVERSITY PARTNERS:

The University of Auckland

The University of Canterbury

Massey University

University of Otago

Victoria University of Wellington.

OUR CROWN RESEARCH INSTITUTE AND CROWN ENTITY PARTNERS:

Callaghan Innovation

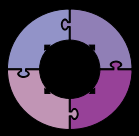
GNS Science.

OUR STRATEGY

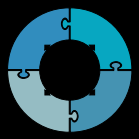
OUR **VISION** IS

SCIENTIFIC EXCELLENCE
+
LEADERSHIP
+
INSPIRATION
=
ADVANCEMENT OF NEW ZEALAND

OUR **MISSION** IS TO:



DELIVER EXCELLENT SCIENTIFIC RESEARCH AND EDUCATION — creative, ambitious, innovative research in advanced materials and nanotechnology.



FORGE NEW ZEALAND'S FUTURE LEADERS — scientifically astute, entrepreneurial and socially aware leaders.

INSPIRE NEW ZEALANDERS — engendering passion for science and innovation across society.

ADVANCE A NEW FUTURE FOR NEW ZEALAND — deliver and support responsible economic development.

OUR **VALUES** ARE:

EXCELLENCE • COLLABORATION • ENTREPRENEURSHIP • INTEGRITY • CREATIVITY • COMMITMENT • COLLEGIALITY

OUR PEOPLE

In 2013, we were a team of:

1 Director

2 Deputy Directors

1 centre manager

1 team of centre staff

1 science executive (of 11 members)

1 board of Directors (of 16 members)

1 international science advisory board (of 13 members)

2 Emeritus Investigators

42 Associate Investigators, including 9 new appointments

37 Principal Investigators, including 6 new appointments

2 honorary investigators

200 PhD students

34 postdoctoral fellows

6 research fellows and technical assistants

12 members of The MacDiarmid Emerging Scientist Association

2 innovation agents

341 alumni

1 industry advisory group (of 6 companies).

THE SCIENCE

In 2013, our scientific research was divided into four themes.

NANOFABRICATION AND DEVICES

ELECTRONIC AND OPTICAL MATERIALS

MOLECULAR MATERIALS

NANOBIO/BIONANO AND SOFT MATTER.

DIRECTOR & CHAIR FOREWORD

Tēnā koutou

It is our pleasure to introduce the 2013 MacDiarmid Institute annual report—the first ever to report against the Institute's strategic plan (launched in 2012) and only the second annual report published by The MacDiarmid Institute.

Readers will find the document reflects the layout of the Institute's strategic plan and reports against the four key areas of the plan—scientific excellence, leadership, inspiration: advancement of New Zealand.

They will also see it features four major case studies profiling an aspect of our work relevant to each of the four themes.

The report represents a good overview of the year's work, the outstanding scientists and students involved and begins to set the scene for what will be achieved in the next few years.

For The MacDiarmid Institute, the ultimate goal of our work is the advancement of New Zealand.

We know that to achieve this goal we must have scientific excellence, leadership among our people and that we must inspire others to want a similar goal and to believe in it enough to join us on the journey.

These ideas are articulated in the strategic plan and very much encompass the late Sir Paul Callaghan's original view of the what The MacDiarmid Institute could be.

Sir Paul understood the transformative power of science and technology and he understood that power could be increased exponentially when supported by a population engaged and interested in an innovative science-led economy and society.

This broader vision is what The MacDiarmid Institute sought to realise in 2013.

We sought to achieve scientific excellence through the creative, ambitious and innovative research of more than 80 investigators, 200 PhD students and 34 postdoctoral fellows.

Our research discoveries, the collaborative work and partnerships our people achieved and the work they published in 2013 is testament to that.

Within The MacDiarmid Institute itself, we sought to provide for our investigators, PhD students and postdoctoral fellows an environment in which they had the support they needed to develop their leadership skills and become the scientifically-astute, entrepreneurial and socially-aware leaders we want them to be.

Again, their achievements speak for themselves. In 2013, our people achieved four Marsden grants, took home the prestigious Hector and Tuck medals, represented The MacDiarmid Institute on numerous councils, committees and forums and were invited to speak to, literally, hundreds of conference audiences here and overseas.

> We know partnership is the key to achieving this vision of the future. That's why we will continue to build on our formal and informal relationships across all sectors of society

In 2013, we also looked for ways to inspire others and to share the benefits of science and innovation more widely through stimulating debate and discussion and being more engaged with the public.

There's plenty more to do in this area, but we're undoubtedly headed in the right direction through our increased engagement with the media, with schools, teachers and students and with industry.

We are particularly pleased to have secured Memoranda of Understanding with industry partners such as Callaghan Innovation, new start up Publons, KiwiNet and the union for the early childhood education and primary school sector—New Zealand Education Institute Te Riu Roa (NZEI).

Achieving a record number of Discovery Awards aimed at getting more Māori and Pasifika secondary students enrolled in science at the tertiary level was another 2013 highlight.

Finally, in the crucial area of advancing New Zealand, we made some important inroads.

MacDiarmid Institute scientists successfully commercialised their research, our alumni went on to head new start up enterprises and the research work of our people attracted all-important pre-seed funding.

We were able to share our commercialisation success stories in the media and convey our vision more widely through symposia and sponsorships focused on the commercial potential of science.

At this point, it is important to take stock of these milestones and think about where to next.

For the organisation as a whole and for the board, the science of advanced materials and nanotechnology is central to our future. It remains the foundation of what we do and gives us a platform for achieving our strategic goals.

We know and understand the importance of our science and what we are achieving in the four key areas of nanofabrication and devices; electronic and optical materials; molecular materials; and nanobio/bionano and soft matter.

Looking ahead, perhaps the bigger challenge is making New Zealanders and the world more aware of this too. It's about taking what we do out of the lab and into society.

It's about creating a future where individuals, organisations and New Zealand as a whole understand the value in the Institution's work and see the benefits of working more closely together to achieve better outcomes with greater benefits.

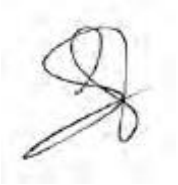
We know partnership is the key to achieving this vision of the future. That's why we will continue to build on our formal and informal relationships across all sectors of society. It's also why we will keep up our endeavours to upskill and support industry-literate graduates with the ability to actively and directly participate in strengthening, deepening and expanding New Zealand's economic base.

It is through this engagement with society that we will achieve research outcomes that can be commercialised, continue to answer the really hard and important research questions of today's modern societies and encourage and nurture tomorrow's scientists to excel at school, at university and as high-quality, commercially-focused researchers.

These are ambitious outcomes to strive for. They require teamwork and a hunger to create a better future, making the most of the resources we have been provided by the New Zealand public.

Yet they are achievable too—particularly if we are able to work together, collaborate and see scientific-excellence as a collective endeavour.

Ngā mihi

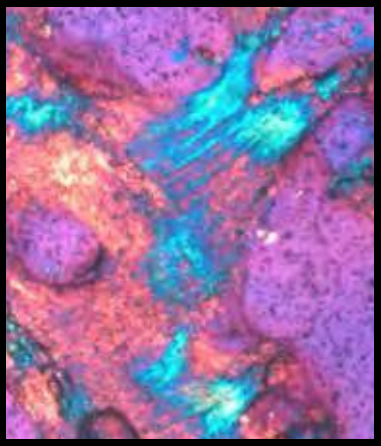


KATHRYN MCGRATH
Director
MacDiarmid Institute

STEVE THOMPSON
Chair
MacDiarmid Institute Board


SCIENTIFIC EXCELLENCE

TO DELIVER EXCELLENT SCIENTIFIC RESEARCH AND EDUCATION



This image, Biomineral Skeleton by Riyad M Mucadam, is nanotechnology presented as artwork. Art of the Invisible, 2013.

VISION

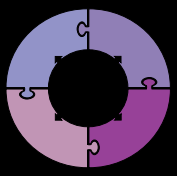
SCIENTIFIC EXCELLENCE

LEADERSHIP

INSPIRATION

ADVANCEMENT OF NEW ZEALAND

MISSION



SCIENTIFIC LEADERSHIP & IMPACT

RECOGNISING & SUPPORTING EXCELLENCE

ENSURING EXCELLENCE

SCIENTIFIC COLLABORATIONS

Creative, ambitious, innovative research in advanced materials and nanotechnology

SCIENTIFIC COLLABORATIONS

In 2013, The MacDiarmid Institute continued to explore different ways to enhance collaboration within the Institute and the wider community. It continued to make use of face-to-face forum such as meetings, symposia and conferences, as well as exploring the opportunities available through digital media, formal partnerships and research projects.

SCIENTIFIC COLLABORATION AMONG RESEARCHERS

Increasing opportunities for scientific collaboration among MacDiarmid Institute scientists remained a focus in 2013. Initiatives included a boot camp, workshops, seminars, mentoring and commercialisation programmes for PhD students and postdoctoral fellows. In 2013, a symposium was held in Wellington for PhD and postdoctoral fellows, a LinkedIn group was set up for alumni and three investigator meetings were hosted, with one specifically focused on research networking and collaboration.

SCIENTIFIC COLLABORATION **A YEAR IN NUMBERS**

- 23 PhD students and postdoctoral fellows attended boot camp coordinated by The MacDiarmid Emerging Scientists Association (MESA).
- 92 PhD students and postdoctoral fellows attended a face-to-face symposium.
- 47 investigators attended annual investigator meeting.
- 94 alumni signed up to a new LinkedIn group.
- 4 Memoranda of Understanding (MoUs) signed with industry partners (Callaghan Innovation, KiwiNet, Publons and the New Zealand Educational Institute, Te Riu Roa).
- 1 industry advisory group set up, with representatives from Rakon, Fisher and Paykel Healthcare, TIN100, Scott Technology, Everedge IP and consultant Simon Arnold.
- 9 Principal Investigators invited to participate in overseas research.

CO-LAB

Co-Lab is The MacDiarmid Institute's own online collaboration platform set up to give investigators a secure location to discuss and share information. It features a dashboard (summarising the latest activity), forum, news and updates. Scientists also use Co-Lab to share and work on documents together. In 2013, Co-Lab became a primary collaboration tool (alongside a three-day planning meeting) for debating and deciding on the strategic direction of The MacDiarmid Institute's science.

SCIENTIFIC COLLABORATION WITH SCIENTISTS AND INDUSTRY PARTNERS

None of The MacDiarmid Institute's scientific research is done in isolation. It all depends on collaboration, whether that involves the Institute's Principal Investigators working together and with outside collaborators to successfully bid for and achieve government science grants or working closely with industry partners to realise the commercial potential of The MacDiarmid Institute's science.

MBIE GRANT—AN EXERCISE IN TEAMWORK AND COLLABORATION

In 2013, the collaborative work of the Institute resulted in a significant $1.8m grant from the Ministry of Business Innovation and Employment. The grant will be used to carry out a multidisciplinary project focused on large-scale electrical energy storage. MacDiarmid Institute scientists will examine optimal materials and electrolytes and explore new aluminium smelter turndown technology, with the aim of improving the efficiency of the New Zealand national grid.

Jeff Tallon

PROFILE OF A SCIENTIFIC COLLABORATOR

MacDiarmid Institute Principal Investigator Jeff Tallon is perhaps best known for his work in high temperature superconductivity. In 1988, Jeff's breakthrough research showed it was possible to create superconductive materials that could conduct electricity with zero electrical resistance (ie. 100% efficiency) at temperatures above the boiling point of liquid nitrogen. Through Jeff's commercial collaboration, his findings have been used commercially throughout the world. Overseas, they have improved power transmission efficiency and Magnetic Resonance Imaging (MRI) scanning. In New Zealand, a firm called Scott Technology has used Jeff's science to become a world leader in the fabrication and application of high-temperature super-conductors. In 2013, Jeff took his scientific collaboration efforts in a new direction, becoming chair of The MacDiarmid Institute's International Advisory Board, a 12-person board responsible for bringing a globally-strategic perspective to The MacDiarmid Institute's research programme.

EXPLORATION OF RARE-EARTH NITRIDES—A KIWI-FRANCE COLLABORATION

By collaborating with scientists in France and using the European Synchrotron Radiation Facility in Grenoble in 2013, a team of MacDiarmid Institute scientists were able to make break-through discoveries about the possible commercial use and application of rare-earth nitrides. The team, led by Principal Investigator Ben Ruck, further explored the combined magnetic and semiconducting nature of rare-earth nitrides, a novel class of materials with potential to transform the way electronic devices are commercially produced. In 2013, their collaborative efforts led to the discovery of a new way to fabricate electronic devices using rare-earth nitrides, which they have since patented. The team also identified and patented a new way to manipulate the electrical properties of rare-earth nitrides. In 2013, their work attracted a Marsden Grant worth more than $780,000 over three years.

SCIENTIFIC COLLABORATION **2013 OUTCOMES IN BRIEF**

- Subwavelength patterning research by MacDiarmid Institute researchers Richard Blaikie, Maan Alkaisi and Cather Simpson was commercialised by AeroQual and IZON Science and used to improve their products and services.

- A team led by Principal Investigator Bill Williams developed a new way to measure jelly-like materials, using innovative light scattering techniques.

- Insights into the binding effect of ligands on gold clusters by Principal Investigator Nicola Gaston was found to have potential use in the study of super atomic semiconductors and led to new partnerships with Victoria University and Japanese scientists.

- PhD students Lynn Murray and Li Hui (Tiffany) Tan contributed to ground-breaking bionanotechnology and soft matter research suggesting genetic makeup was not the sole determinant of cell behaviour.

SCIENTIFIC LEADERSHIP AND IMPACT

In 2013, The MacDiarmid Institute showed leadership and was recognised at home and overseas for the impact of its work in a range of ways. MacDiarmid Institute scientists were successfully promoted to roles of national significance and awarded prizes. Institute scientists were sought out to attend international conferences and to represent the very best in the fields of advance materials and nanotechnology. Their published research and papers continued to have an impact within New Zealand and internationally, with a record number of citations in 2013.

INTERNATIONAL LEADERSHIP

Principal investigator Uli Zuelicke's invitation to join the prestigious three-week international research programme *Spintronics: Progress in Theory, Materials and Devices* was another example of the recognition achieved by the Institute's scientists in 2013. Uli joined a group of 30 international participants handpicked by the University of California's Kavli Institute for Theoretical Physics. He presented research findings and since has embarked on new spintronics projects.

MARSDEN GRANTS REWARD SCIENTIFIC LEADERSHIP

In 2013, MacDiarmid Institute scientists were awarded an impressive four Marsden grants in recognition of the outstanding scientists leading the work. Marsden funding is contestable government funding for excellent fundamental research administered by the Royal Society of New Zealand (on behalf of the Marsden Fund Council). It is awarded to investigator-initiated research that benefits New Zealand society as a whole in the areas of science, engineering and maths, social sciences and the humanities.

MARSDEN GRANTS IN 2013

- $782,609, over three years for 'Semiconductor-based spintronics: can rare-earth nitrides and group III-nitrides get it together?' by Franck Natali, Ben Ruck, Simon Granville, Natalie Plank and Joe Trodahl (Victoria University), Stéphane Vezian and Benjamin Damilano (Centre National de la Recherche Scientifique, Valbonne).

- $739,100, over three years for 'Designer spin crossover: towards nanoswitches, sensors and display' by Sally Brooker, Geoff Jameson and Carla Meledandri (University of Otago).

- $695,652, over three years for 'Dipoles of charge or spin—what is the pairing mechanism in HTS cuprates?' by Neil Ashcroft (Cornell University), Jeff Tallon, Suresh Narayanaswamy and James Storey (Victoria University).

- $739,130, over three years for 'Graphene supercapacitators: transforming energy storage solutions' by Alison Downard, Paula Brooksby (University of Canterbury), Ronald Fawcett (University of California) and Scott Donne (University of Newcastle).

AMN6:

A SHOWCASE OF SCIENTIFIC LEADERSHIP AND IMPACT

In 2013, The MacDiarmid Institute hosted the biennial international conference on advanced materials and nanotechnology (AMN6) in Auckland, with a record number registrations achieved (more than 500). The sixth event of its kind, it showcased scientific leadership and impact by presenting some of the latest ideas in physical phenomena, biological interface, nanoscale structures, molecular materials and engineered nanosystems. More than 40 countries were represented at this year's event, with 26 distinguished plenary speakers and five international keynote speakers including 1981 Nobel Laureate for Chemistry professor Roald Hoffmann from Cornell University, professor Daniel Nocera and professor Joanna Aizenberg from Harvard University, professor Don Eigler, the Kavli Prize Laureate for Nanoscience in 2010 and professor Krzysztof Matyjaszewski of Carnegie Mellon University. More than 200 oral and written presentations were made at the conference, with many conference articles published in a special edition of the International Journal of Nanotechnology.

2013 LEADERSHIP AND IMPACT **HIGHLIGHTS**

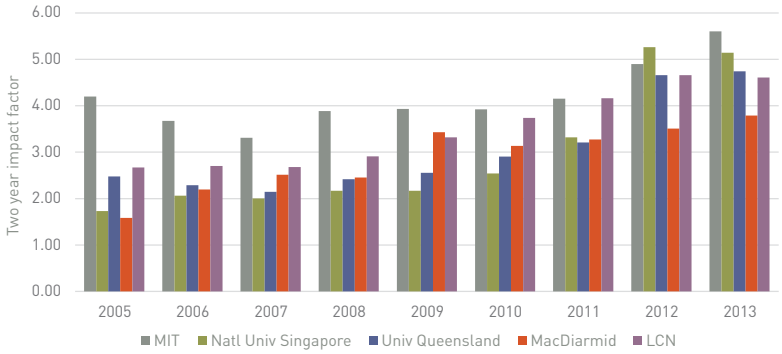
- Principal investigator David Williams is The MacDiarmid Institute's most cited author, with 683 citations in 2013.

- *Surface enhanced Raman scattering enhancement factors: A comprehensive study* by Pablo Etchegoin and Eric Le Ru (MacDiarmid Principal Investigators) published in 2007 in the *Journal of Physical Chemistry* with PhD students Evan Blakie and Matthias Meyer, continues to be The MacDiarmid Institute's most highly cited paper in 2013.

- *A new precursor for conducting polymer-based brush interfaces with electroactivity in aqueous solution* by Principal Investigators David Williams, Jadranka Travas-Sejdic, Associate Investigator Margaret Brimble and postdoctoral fellow Jenny Malmstrom is the most cited paper published in 2013.

- MacDiarmid Institute scientists awarded four Marsden grants, the Hector Medal (for outstanding work for physical science) and the Tuck Medal (for contribution to applied mathematics).

Comparison of The MacDiarmid Institute's impact, 2005 – 2013

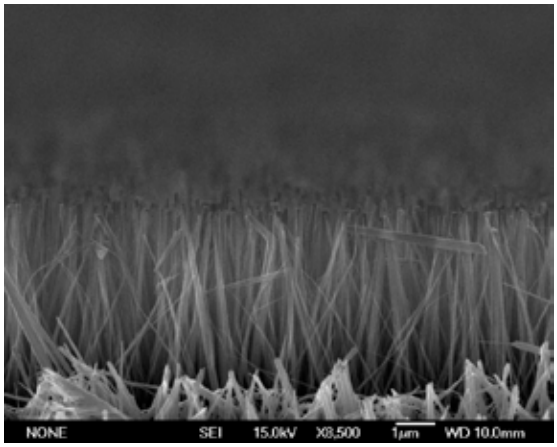


Impact of The MacDiarmid Institute's publications compared to that of leading international institutions with strong materials science and nanotechnology focus

(Source: Thomson Reuters Web of Science, Search Terms: MacDiarmid Institute; New Zealand

RECOGNISING AND SUPPORTING EXCELLENCE

In 2013, The MacDiarmid Institute focused on four scientific research themes, ensuring its research programme was aligned with its five-year strategic plan, while ultimately being determined by the Institute's investigators.



This image shows ZnO NWs made by hydrothermal synthesis.

THE MACDIARMID'S INSTITUTE'S FOUR SCIENTIFIC RESEARCH THEMES

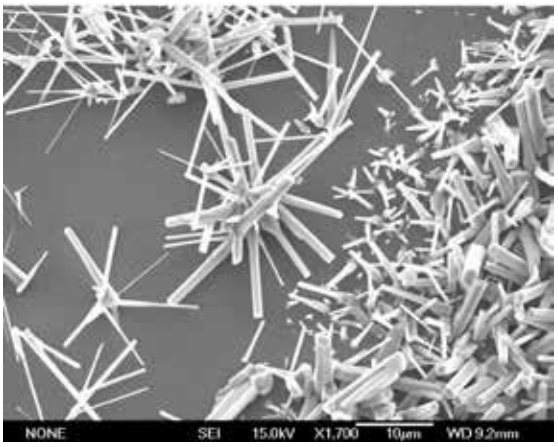
NANOFABRICATION AND DEVICES

This theme explored the devices or machinery involved in nanofabrication, as well as the methods of nanofabrication itself. In 2013, The MacDiarmid Institute's work programme involved scientists from the University of Auckland, University of Canterbury, University of Otago, GNS Science and Victoria University of Wellington.

They were:

- 10 Principal Investigators
- 2 Associate Investigators
- 9 postdoctoral fellows
- 35 PhD students
- 5 Masters degree students.

The team's work programme primarily focused on subwavelength patterning with evanescent interference lithography and high-power femtosecond laser pulses; atomic and molecular-scale self-assembly for future nanodevices; next generation semiconductor materials and devices and the theory and modelling of new functionality at the nanoscale.



This image shows nanostructures of ZnO fabricated by vapour phase synthesis.

In 2013, this team published 40 papers within this theme, wrote several book chapters and contributed to more than 13 conference proceedings. Members of this team were keynote and invited speakers at more than 23 national and international conferences and events and successfully achieved several grants related to research work occurring within this theme.

ELECTRONIC AND OPTICAL MATERIALS

This theme looked at the electronic and optical properties of materials and the way those properties assemble and behave. In 2013, The MacDiarmid Institute's work programme involved scientists from the University of Auckland, University of Canterbury, Callaghan Innovation, GNS Science, Macquarie University in New South Wales, Australia, and Victoria University of Wellington.

They were:

- 1 Emeritus Investigator
- 9 Principal Investigators
- 16 Associate Investigators
- 6 postdoctoral fellows
- 44 PhD students.

The team's work programme primarily focused on understanding structural, electronic and optical properties of nanoparticles and nanostructures; optoelectronic properties of nanoscale and advanced materials; and superconducting and spin-dependent properties of novel materials.

In 2013, they published 56 papers within this theme, presented keynote speeches to three overseas conferences and were invited to speak at 20 conferences at home and around the world. The team were successfully awarded five grants for their work and had significant involvement with industry through either providing advice and consultation or hands-on development work.

MOLECULAR MATERIALS

This theme explored the properties and functions of molecular materials. In 2013, The MacDiarmid Institute's work programme involved scientists from the University of Auckland, University of Canterbury, Callaghan Innovation, Massey University, University of Otago and Victoria University of Wellington.

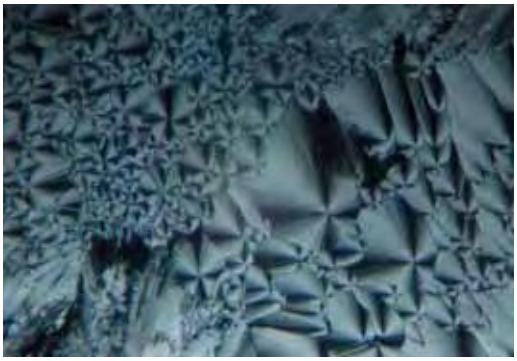
They were:

- 1 Emeritus Investigator
- 9 Principal Investigators
- 6 Associate Investigators
- 7 postdoctoral fellows
- 55 PhD students
- 16 Masters and Honours degree students.

The team's work programme primarily focused on functionalised surfaces; identifying the role of delocalisation in primary excitations of conjugated polymers via spectroscopy and computational chemistry; and metallosupramolecular materials.

In 2013, 80 papers were published within this theme, and members of the team presented at 12 conferences in New Zealand and the United States. They achieved a patent for battery zinc electrode composition and were invited to speak at 29 national and international conferences. They successfully achieved 15 new grants and communicated about their work through a range of media.

This image shows the defect formation of a liquid crystals is probed using polarising optical microscopy.



NANOBIO/BIONANO AND SOFT MATTER

This theme looked at the molecules and materials found in biology to understand the potential for scientific experimentation and application.

In 2013, The MacDiarmid Institute's work programme involved scientists from the University of Auckland, University of Canterbury, Callaghan Innovation, Massey University, the University of Otago, Tsinghua University, Beijing, China and Victoria University of Wellington.

They were:

- 8 Principal Investigators
- 12 Associate Investigators
- 12 postdoctoral fellows
- 50 PhD students
- 4 Masters degree students.

The team's work programme primarily focused on bottom-up soft engineering; interacting with the animate; transport in the nanoworld; biology on-the-fly and nanomaterials for biological applications.

In 2013, the team published 54 papers within this theme, wrote four book chapters, presented two keynote speeches and were invited to speak at 30 conferences In New Zealand and overseas. They successfully achieved eight grants for their work and had significant input into government policy and four industry projects.

HIGHLIGHTS FROM THE 2013 RESEARCH PROGRAMME

- MacDiarmid Institute's new laser-based patterning techniques were commercially applied by two New Zealand companies.
- Breakthrough discovery of a low-cost fabrication technique for producing solar cells.
- Insights into a new procedure for computed tomography imaging used in cancer treatment.
- New understanding of the thermoelectric power generation potential of thermoelectric fabric.
- New materials research published showing how smart device energy storage and conversion could be improved.
- New insights into the effects of material properties and structure on cell behaviour.

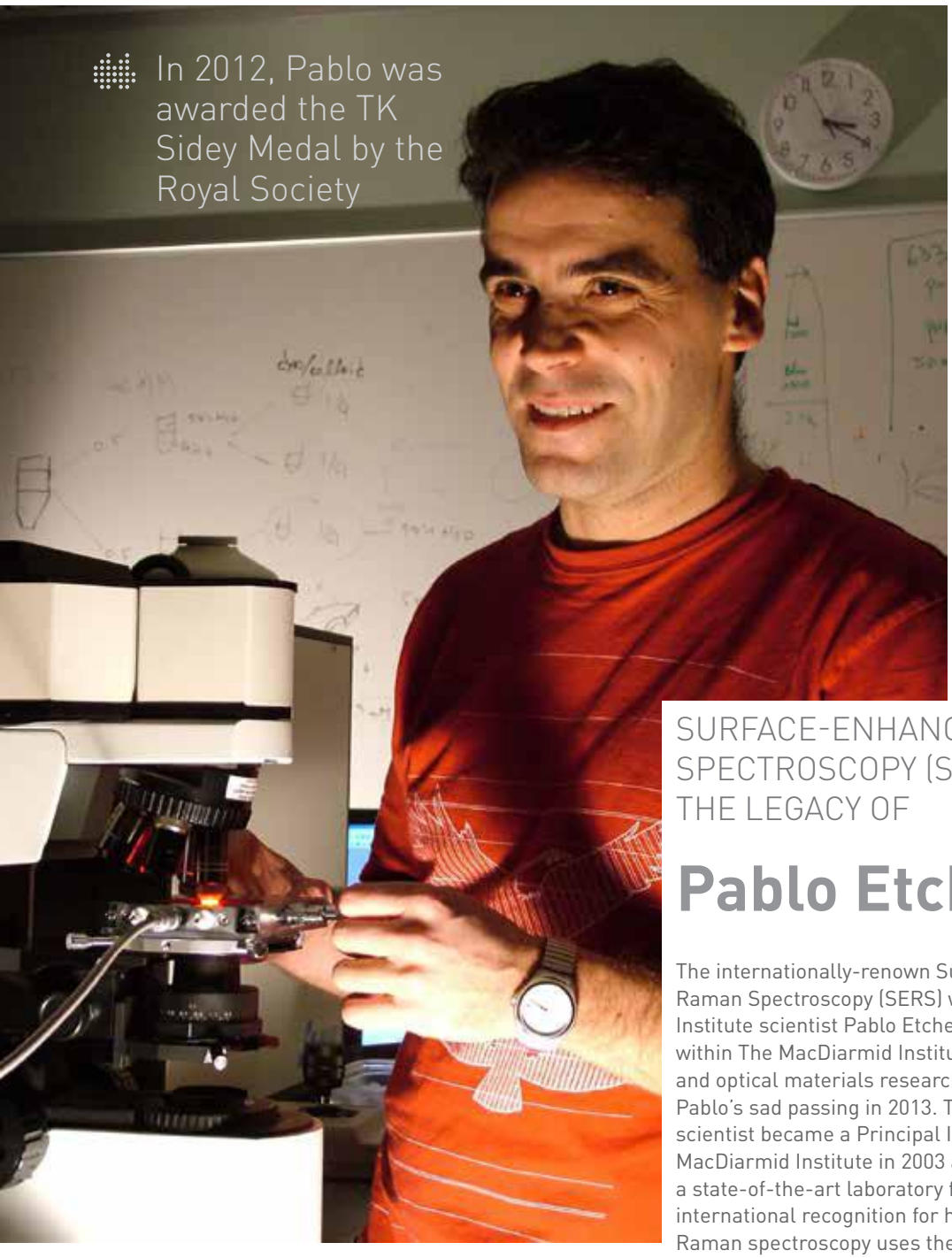
STRIKING A BALANCE BETWEEN OLD AND NEW

In 2013, The MacDiarmid Institute continued to maintain a balance between supporting well-established research and nurturing and developing new research ideas. The internationally-recognised Surface-Enhanced Raman Spectoscopy (SERS) work of MacDiarmid Institute Principal Investigator Pablo Etchegoin was an example of the well-established research that continued in 2013, while the work of Principal Investigators Eric Le Ru and Maan Alkaisi were examples of research that broke new ground in 2013.

RESEARCH ON PARTICLE PROPERTIES AND BIOLOGICAL CELLS BREAKS NEW GROUND

MacDiarmid Institute research into the optical properties of spheroidal particles was an example of high-quality research that broke new ground in 2013 and that was likely to have a long-lasting impact on the fields of climate science and astronomy. In 2013, Principal Investigator Eric Le Ru and his team developed a new algorithm for calculating the optical properties of spheroidal particles. Spheroidal particles are found in dust and the atmosphere. Until now, computers had limited means for measuring them accurately.

The biological cell research of MacDiarmid Institute Principal Investigator Maan Alkaisi and his team provided new insight into the influence of a cell's physical environment on its ability to grow and spread. Maan's experiments, carried out under the research theme for nanobio/bionano and soft matter, at Canterbury and Otago Universities, used bioimprinted substrates to explore the role of surface shape and topography on a cell's response. It found cells cultured directly on bioimprinted substrates showed remarkable growth, compared to those that were not cultured that way—findings likely to have significant implications for future cancer cell research.



SURFACE-ENHANCED RAMAN SPECTROSCOPY (SERS)—AND THE LEGACY OF

Pablo Etchegoin

The internationally-renown Surface-Enhanced Raman Spectroscopy (SERS) work of MacDiarmid Institute scientist Pablo Etchegoin is set to continue within The MacDiarmid Institute under the electronic and optical materials research theme, despite Pablo's sad passing in 2013. The South American scientist became a Principal Investigator for The MacDiarmid Institute in 2003 and went on to build a state-of-the-art laboratory for SERS, gaining international recognition for his SERS methodology. Raman spectroscopy uses the light scattered by laser beams to learn about materials. Pablo's surface-enhanced technique made significant improvements to standard Raman spectroscopy and has become the basis of numerous research projects carried out by The MacDiarmid Institute. In 2012, Pablo was awarded the TK Sidey Medal by the Royal Society of New Zealand for outstanding scientific research related to electromagnetic radiation and was elected Fellow of the Society.

ENSURING EXCELLENCE

The MacDiarmid Institute uses several key methods to measure its performance and ensure excellence. Within the Institute, there is a rigorous and regular process for reviewing the science team and their work, with the aim of keeping the research programme targeted, fresh and responsive. The Institute also uses a range of tools to benchmark its performance—for example, data showing the Institute's published outputs over time and external reviews such as the one published in 2013 by the Ministry of Education, *CoREs and Effect*.

MINISTRY OF EDUCATION STUDY OF CENTRES OF RESEARCH EXCELLENCE (CORES)

In 2013, the Ministry of Education published an evaluative analysis on the performance of the country's Centres of Research Excellence (CoRE) since 2002. The MacDiarmid Institute was one of the seven CoREs reviewed by the Ministry.

Key findings

- The work of the CoREs has had wide-ranging impacts on New Zealand's society and economy.
- The nature of the impact varies between CoREs and ranges from commercialisation of the results of CoRE research to public health initiatives, improved biosecurity, better management of New Zealand's natural environment and social change.
- The quantity and quality of research outputs in each CoRE have increased, evidenced by improvements in bibliometric measures.
- Collaboration between researchers has increased as evidenced by coauthorship networks.
- Public outreach programmes that go beyond those normally undertaken by universities have lifted the profile of and interest in science among young people and have influenced national debates.

FINDINGS ON THE MACDIARMID INSTITUTE'S SCIENCE AND TECHNOLOGY CONTRIBUTION

The Ministry's study, called *CoREs and Effect*, found The MacDiarmid Institute was contributing to New Zealand economically and socially through its research, the commercialisation of its findings, its outreach activities and the training of entrepreneurial graduate students who had the ability to communicate well.

It highlighted the following internationally-important areas of work.

- New method for maintaining the structural integrity of materials, called metal organic frameworks, that have the potential to change the way gas is stored and catalysed (MacDiarmid Institute scientists at Massey University).

- New techniques (Rheo-NMR and multidimensional diffusion NMR) now widely used for investigating complex materials such as cheese, porous oil-laden rocks and polymer systems (MacDiarmid Institute scientists at Victoria University).

- New approaches to surface modification and patterning that control the nanoscale films of surfaces, which are now being applied in the sensor design and molecular electronics industries (MacDiarmid Institute scientists at the University of Canterbury).

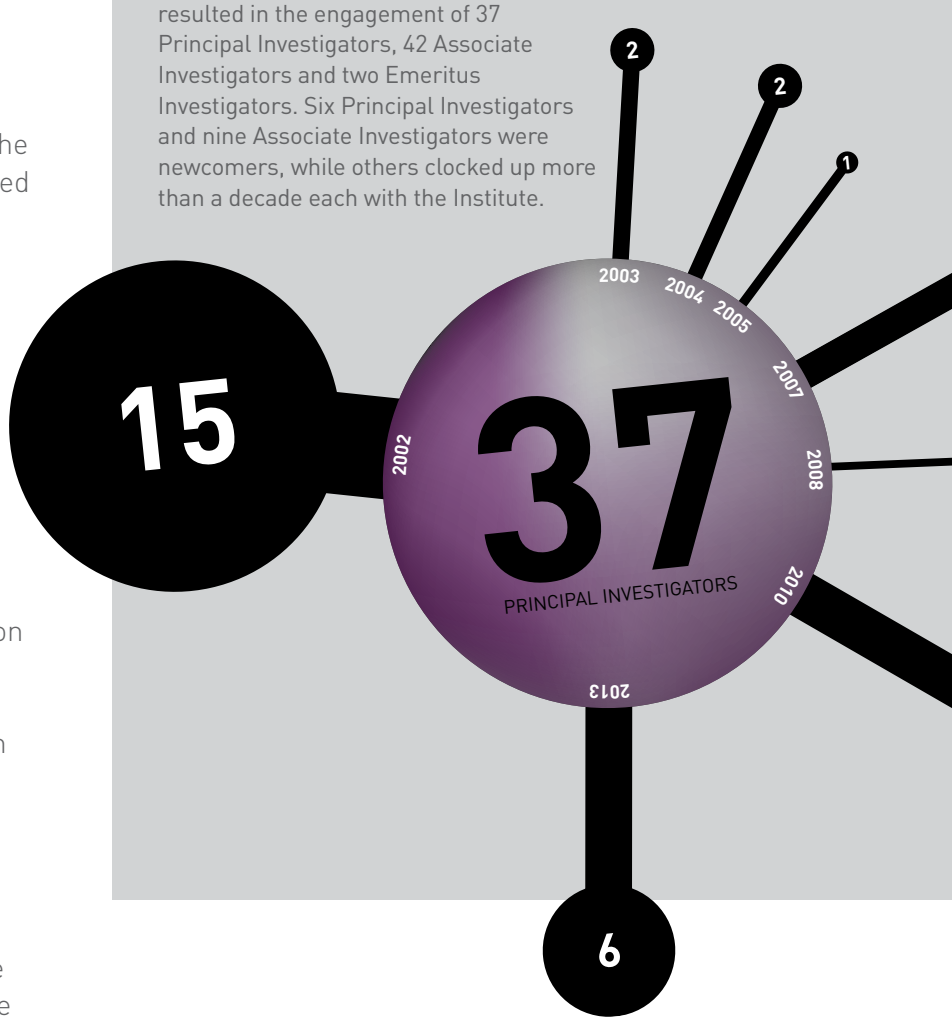
- New science on the behaviour of single molecule magnets, enabling the deeper exploration of high temperature switching (MacDiarmid Institute scientists at the University of Otago).

To read the full report, go to:
www.educationcounts.govt.nz

MACDIARMID INSTITUTE COMPLETES

Investigator review

In 2013, changes to The MacDiarmid Institute's investigator team took effect following a review in 2012. The review resulted in the engagement of 37 Principal Investigators, 42 Associate Investigators and two Emeritus Investigators. Six Principal Investigators and nine Associate Investigators were newcomers, while others clocked up more than a decade each with the Institute.



LONGSTANDING INVESTIGATORS IN PROFILE

KEITH GORDON,
PRINCIPAL INVESTIGATOR

RESEARCH SPECIALTY: Spectroscopy of molecular materials.

QUALIFICATIONS: PhD in laser spectroscopy of solar energy compounds from Queens University, Belfast, United Kingdom.

YEARS WITH THE MACDIARMID INSTITUTE: 11 (since 2002).

DAY JOB: Professor of chemistry, Otago University.

CURRENT RESEARCH: Identifying the role of delocalisation in primary excitations of conjugated polymers through spectroscopy and computational chemistry.

2

ALISON DOWNARD,
PRINCIPAL INVESTIGATOR

RESEARCH SPECIALITY: Electrochemistry, nanotechnology and surface science.

QUALIFICATIONS: BSC Hons and PhD in synthetic chemistry from Otago University.

YEARS WITH THE MACDIARMID INSTITUTE: 11.

DAY JOB: Professor of chemistry, University of Canterbury.

CURRENT RESEARCH: Surface engineering, giving new properties to a surface while maintaining the usual properties of the bulk material. Also developing strategies to control the growth of the layers and applications of surface functionalisation in energy storage and conversion.

3

KEN MACKENZIE,
EMERITUS INVESTIGATOR

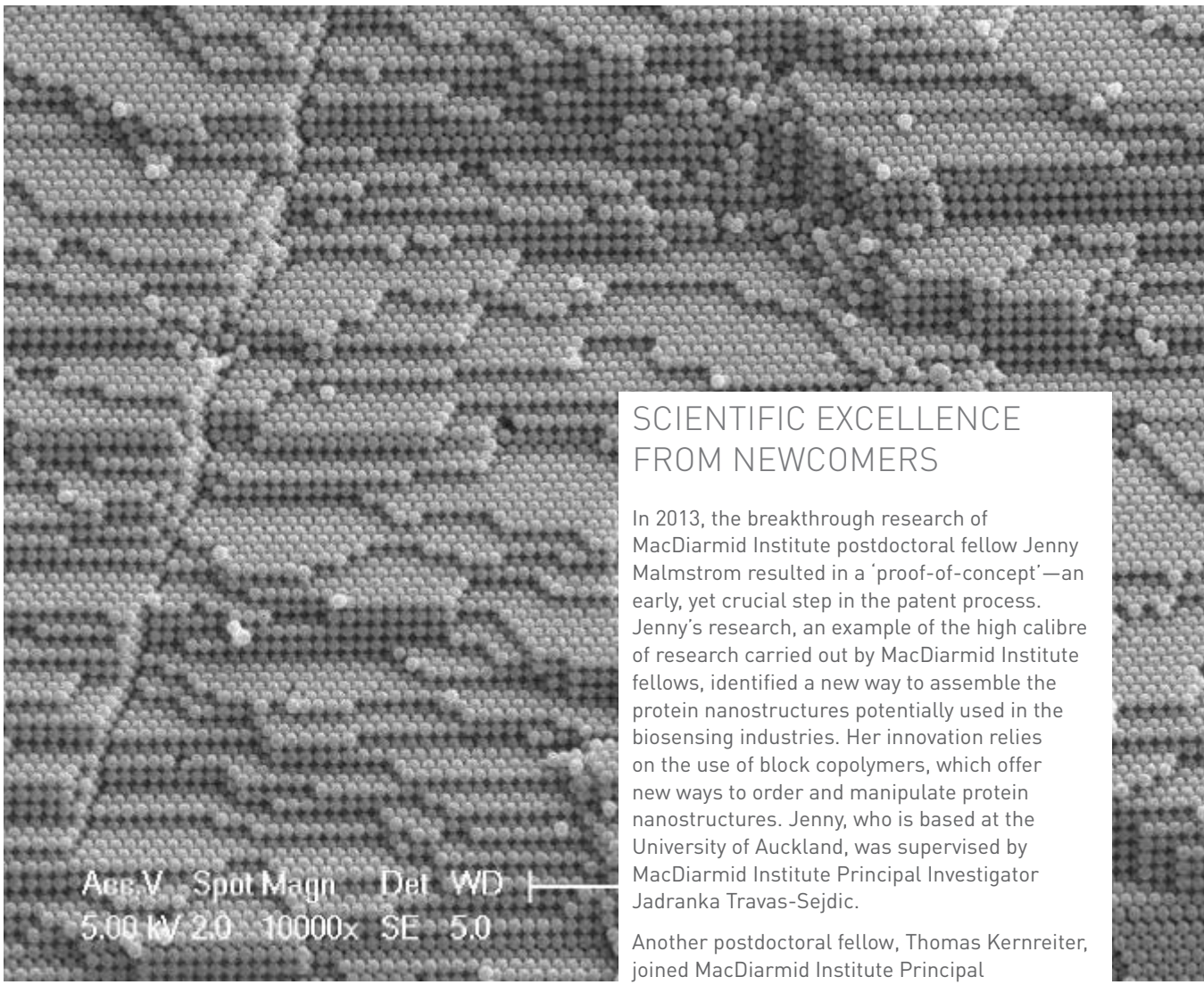
RESEARCH SPECIALITY: Advanced inorganic materials (ceramics, cements, glasses, inorganic polymers), specialising in the development of new inorganic materials and their structural investigation by multinuclear solid-state nuclear magnetic resonance (NMR).

QUALIFICATIONS: PHD, DSC, FRSNZ, FRIC, FICeram.

YEARS WITH THE MACDIARMID INSTITUTE: new to the role in 2013, but started with The MacDiarmid Institute in 2002 as a Principal Investigator.

DAY JOB: Professor of materials chemistry at Victoria University.

CURRENT RESEARCH: Synthesis and structural characterisation of new inorganic polymers and inorganic/organic hybrid materials for engineering, electronic and biological applications. Development of new energy-efficient methods for producing advanced ceramic materials, including mechanochemical processing. Application of multinuclear solid-state MAS NMR techniques to the study of inorganic materials (in conjunction with Warwick University).

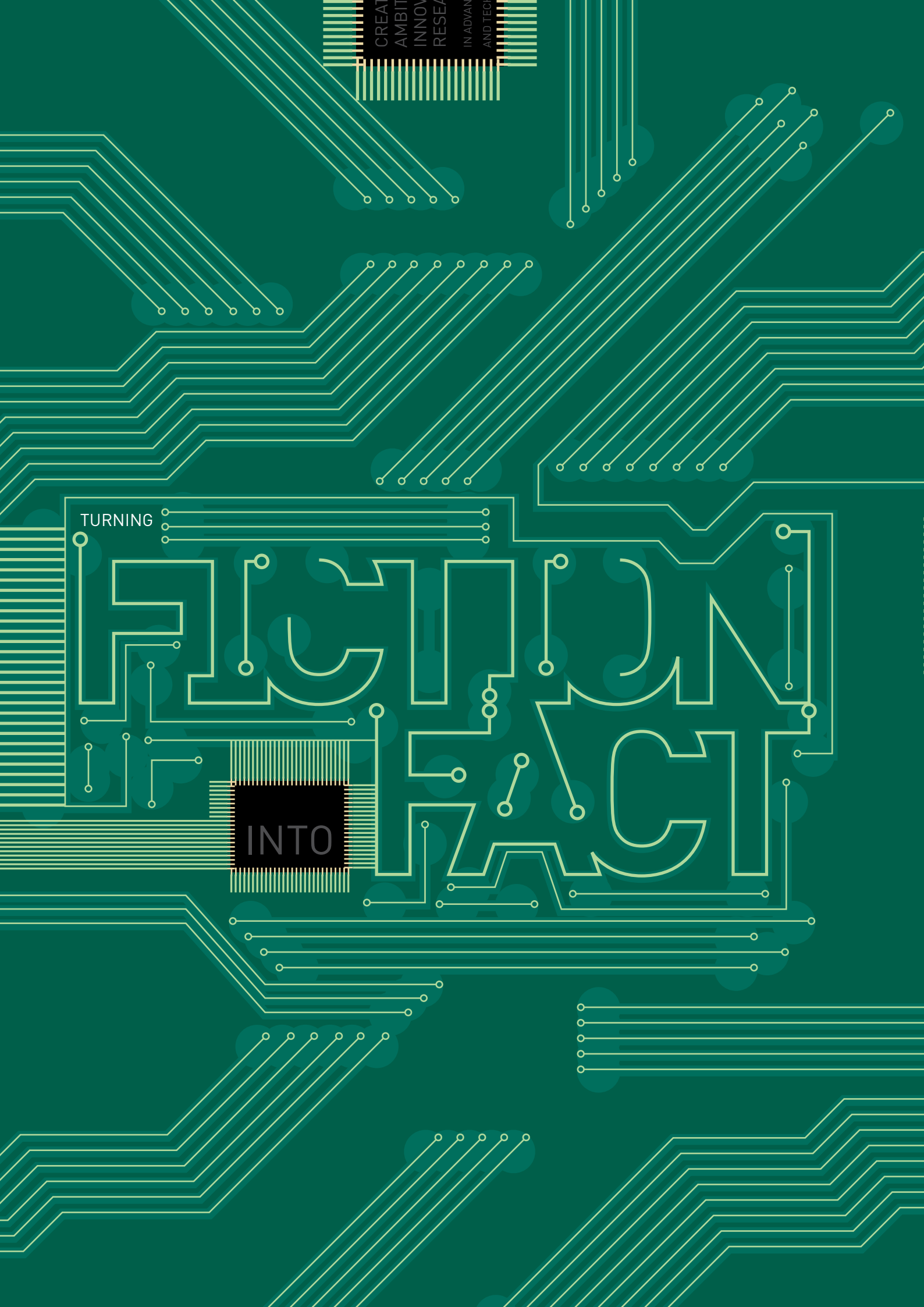


SECOND PLACE, ART OF THE INVISIBLE
"Titania Colloidal Crystal" by MSc student Zhaojie Geng

SCIENTIFIC EXCELLENCE FROM NEWCOMERS

In 2013, the breakthrough research of MacDiarmid Institute postdoctoral fellow Jenny Malmstrom resulted in a 'proof-of-concept'—an early, yet crucial step in the patent process. Jenny's research, an example of the high calibre of research carried out by MacDiarmid Institute fellows, identified a new way to assemble the protein nanostructures potentially used in the biosensing industries. Her innovation relies on the use of block copolymers, which offer new ways to order and manipulate protein nanostructures. Jenny, who is based at the University of Auckland, was supervised by MacDiarmid Institute Principal Investigator Jadranka Travas-Sejdic.

Another postdoctoral fellow, Thomas Kernreiter, joined MacDiarmid Institute Principal Investigators Michele Governale and Ulrich Zuelicke to examine the behaviour of holes in field-effect transistors with magnetic doping. The team's work discovered the holes had properties that could open up new ways to design magneto-electronic devices. In 2013, they published their findings in physics journal *Physical Review Letters* and continued to explore the application of their findings in the area of quantum information processing.


TURNING
FICTION
INTO
FACT

We are working at the forefront of technology here. It's big bold research because of the number of unknowns.

Professor Richard Blaikie is showing computer chips can be made tinier than ever thought possible. That's big news in a world constantly demanding smaller, faster technology where more fits into less space.

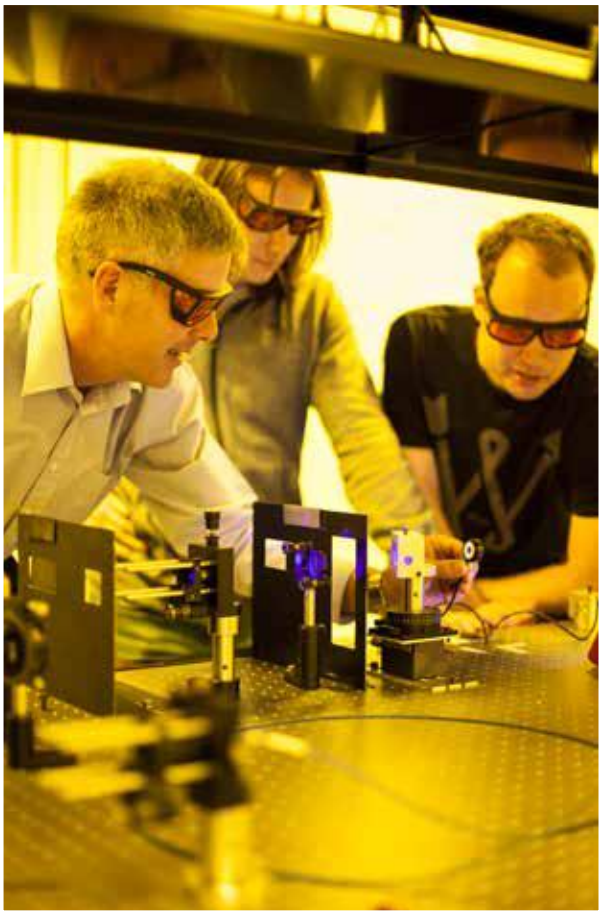
The University of Otago deputy vice chancellor (Research and Enterprise), Principal Investigator and former Director of The MacDiarmid Institute says he "tries to fit light into tiny spaces".

Last year he was awarded the Royal Society of New Zealand's Hector Medal for the advancement of physical sciences, for his world-first demonstration of the silver superlens, which does exactly that.

Blaikie works in the area of near-field optical lithography, using light to transfer tiny patterns, which can be used in manufacturing circuits on computer chips.

"We've got hugely powerful computer chips in our cell phones and wristwatches now. You can only get 16 gigabytes of data on something the size of your thumbnail if the area for each bit of information is incredibly small. At this stage it's just a few tens of nanometres," he says.

"To understand the magic of the scale we work on, think about a metre and a millimetre. That scale is understandable to us, even though they are 1,000 times different. If you take that



millimetre and divide it 1,000 times again, you get a micrometre, about the size of our cells. If we divide 1,000 times again, we are getting into the nanometre range.

"But after a certain point, you can't just keep seeing smaller and smaller. You get to the point where the wavelength of the light becomes important.

"So we are trying to see if we can manipulate things at a scale smaller than that wavelength, to see if we can make even smaller things."

Blaikie says one of the biggest benefits of his research is seeing his graduate students successfully move into industry and business in New Zealand and around the world.

"First and foremost out of basic research, we can guarantee that we produce very good people who make a really valuable economic contribution.

"We are working at the forefront of technology here. It's big bold research because of the number of unknowns.

"In industry it's the other way round, there's often many known principles and a small area of science that needs to be done to develop a specific application. Our students are comfortable with that too."

He is still motivated by finding the answer to his original basic questions.

"I want to know what's the smallest you can see, resolve, manipulate, move and image with light? Can we go to one twentieth or one fortieth of the wavelength? And what price would we have to pay to do that, what limitations do we have and how can we apply it?

"As long as there are still areas where this is relevant, then it is still a worthwhile area to be working in."

THE SILVER SUPER LENS

Professor Richard Blaikie won the Hector Medal for his fundamental and wide-ranging contributions to the field of nano-optics, showing that light can be manipulated at scales much smaller than its wavelength and providing a world-first demonstration of a controversial superlens system using subwavelength techniques.

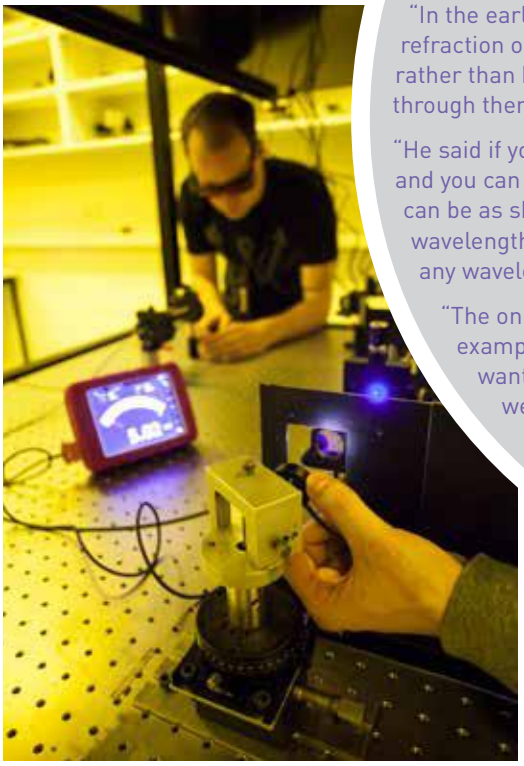
"We've known for a long time that as light goes into water or between glass and air it bends. But it bends gently, it never bends back on itself," he says.

"In the early 2000s professor John Pendry came up with the idea of negative refraction or light bending backwards. He looked at fictional materials, which rather than being normal in terms of their refractive index where light travels through them, light travels backwards.

"He said if you make a lens from this kind of material, the light will bend backwards and you can make it come to a nice sharp focus. It's called a perfect focus and can be as sharp as you like one tenth, one hundredth or one millionth of the wavelength, so potentially you have the ability to image anything at any scale with any wavelength.

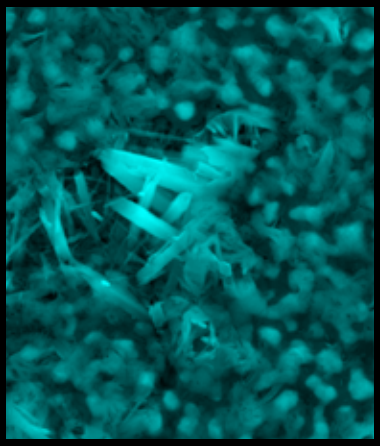
"The only problem is the materials are fictional. But he gave the practical example of using silver as a poor man's lens. It wouldn't work if you wanted to look out at the stars, but it would work in the range where we were doing our photolithograpy experiments.

"We were one of two groups in the mid 2000s that demonstrated John Pendry wasn't completely mad. The work could be shown to be experimentally sound."



LEADERSHIP

TO FORGE NEW ZEALAND'S FUTURE LEADERS



This image, Film of Lead Clusters by Amol Nande, is nanotechnology presented as artwork. Art of the Invisible, 2013.

VISION

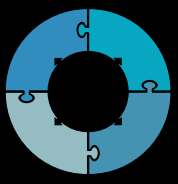
SCIENTIFIC EXCELLENCE

LEADERSHIP

INSPIRATION

ADVANCEMENT OF NEW ZEALAND

MISSION



INTEGRATED COMMUNITY

OPTIMAL LEARNING ENVIRONMENT

SCIENTIFIC COLLABORATIONS

LEADERSHIP IN SCIENCE & SOCIETY

Scientifically astute, entrepreneurial and socially aware leaders

LEADERSHIP DEVELOPMENT

In 2013, The MacDiarmid Institute continued to develop and foster leadership at all levels of the organisation. The Institute achieved this strategic objective by providing scientists with a range of development, training, mentoring and formal leadership opportunities and through continued support of The MacDiarmid Emerging Scientist Association (MESA), the Institute's student arm.

ASSOCIATION FOR EMERGING SCIENTISTS CELEBRATES THIRD YEAR

The MacDiarmid Emerging Scientist Association (MESA) celebrated its third year in 2013. MESA is the Institute's student arm, chaired by Victoria University and MacDiarmid PhD student Alex Barker. MESA provides emerging scientists with leadership development through general information and advice, access to workshop and seminars, career and networking opportunities and the opportunity to participate in the Institute's outreach (or public interest) activities.

CHEMISTRY STUDENT REPRESENTS MACDIARMID IN THE USA

In 2013, chemistry PhD student Andrea Kolb represented the Institute at the Future Leaders in Chemistry programme run by the American Chemicals Society. The 10-day programme held in the United States was open to only 15 PhD students and postdoctoral fellows worldwide and gave participants the opportunity to share ideas, network and learn about the latest research.

POSTDOCTORAL FELLOW CONTRIBUTES TO INDUSTRY R&D

A new method for controlling the position of surface molecules that could be applied to the smart device industry was explored by MacDiarmid Institute postdoctoral fellow Andrew Gross in 2013. Andrew, who was assisted by MacDiarmid Institute Associate Investigator Dr Volker Nock (a microfluidics expert) and synthetics expert Matthew Polson, published his research as an abstract in the United States National Library of Medicine. As part of his PhD, Andrew came up with a way to strongly and irreversibly bond molecules to a surface. He also developed a new low-tech, easy-to-implement method of nanoscale patterning. Through his work, Andrew was able to gain significant leadership experience, while contributing to The MacDiarmid Institute's research base and the development of smart devices occurring worldwide.

FROM EMERGING SCIENTIST TO INVESTIGATOR

In 2013, the exceptional research work and leadership potential of MacDiarmid Institute emerging scientists were rewarded with career opportunities and advancement. Emerging scientist Natalie Plank, the first-ever chair and founding member of The MacDiarmid Emerging Scientist Association (MESA), became a Principal Investigator for her outstanding contribution to the bionano/nanobio and soft matter fields, while Suresh Narayanaswamy was appointed to the role of Associate Investigator for his work in the field of electronic and optical properties of materials.

IN PROFILE

NATALIE PLANK,
PRINCIPAL INVESTIGATOR

RESEARCH SPECIALITY: The use of zinc oxide and carbon nanotubes in nanodevice applications.

QUALIFICATIONS: PhD in microelectronics, University of Edinburgh.

DAY JOB: Lecturer in physics in the School of Chemical and Physical Sciences at Victoria University of Wellington.

YEARS WITH THE MACDIARMID INSTITUTE: 3 (two as an emerging scientist and one as a Principal Investigator).

OTHER RESEARCH POSITIONS: Former postdoctoral fellow, Cambridge University Nanoscience Centre. First-ever chair and founder of The MacDiarmid Emerging Scientist Association (MESA).

RECENT INDEPENDENT RESEARCH GRANTS: 2010 Marsden Fast Start Award from the Royal Society of New Zealand. Foundation of Research, Science and Technology (FRST) postdoctoral research fellowship.

CURRENT RESEARCH: Design of new transistor-based platforms used in biosensing.

"The MacDiarmid Institute has been a real lifeline to me as an early career researcher. There's the close interaction you get with such a broad network of scientists within New Zealand. This is so important starting out. Being able to get advice from others in Canterbury and Auckland, as well as my colleagues at Victoria University has been brilliant. Then there's the research funds and having access to excellent PhD students. I've been able to offer a scholarship to an excellent local student, Conor Burke-Govey."

SURESH NARAYANASWAMY,
ASSOCIATE INVESTIGATOR

RESEARCH SPECIALITY: High-pressure science and techniques, specialising in the instrumentation engineering for sciences at extreme conditions.

QUALIFICATIONS: BSc and MSc in physics from Madurai Kamaraj University, India. PhD in shockwave research from University of Mumbai, India.

DAY JOB: Experimental physicist, Robinson Research Institute.

YEARS WITH THE MACDIARMID INSTITUTE: 5.

OTHER RESEARCH POSITIONS: Scientist at the Bhabha Atomic Research Centre. Research fellow at the Centre for Science at Extreme Conditions, University of Edinburgh.

CURRENT RESEARCH: Subject materials (such as superconductors and nanomaterials) to extreme conditions, using techniques developed to investigate underlying physics.

INTEGRATED COMMUNITY

Progress towards achieving a strong integrated community of students and alumni continued in 2013, with the development of new networks for students, alumni and industry representatives.

INTEGRATED SCIENTIFIC COMMUNITY—**PROGRESS IN 2013**

- 1 new alumni network developed.
- MacDiarmid Institute initiates project to identify, track and link with MacDiarmid alumni.
- 250 alumni identified to work with The MacDiarmid Institute's PhD students and postdoctoral fellows.

OPTIMAL LEARNING ENVIRONMENT

In 2013, The MacDiarmid Institute continued to focus on providing an outstanding learning environment for the Institute's students. Opportunities included providing access to state-of-the-art technology, developing a strong culture of participation and innovation and resourcing The MacDiarmid Emerging Scientist Association (MESA) to train and upskill the Institute's emerging students.

NEW LAB PROVES IDEAL FOR LITHOGRAPHY EXPERIMENTATION AND RESEARCH

Having access to state-of-the-art technology and equipment is crucial for high-quality research in the fields of nanotechnology and advanced materials science, particularly in the area of nanofabrication and devices research.

In 2013, MacDiarmid Institute investigators were able to make use of the newly-upgraded Solid-Immersion Lloyd's Mirror Interference Lithography (SILMIL) laboratory at the University of Otago to achieve some of the Institute's nanofabrication and device research objectives.

The experiments of MacDiarmid Institute's Principal Investigator Richard Blaikie, PhD student Levi Bourke and Otago university's Dr Sam Lowery explored subwavelength patterning, using evanescent interference lithography and high-power femtosecond laser pulses. The team were able to test the setup of the new laboratory, explore new ways to apply the laboratory's optical system and demonstrate the pattern-transfer of SILMIL-exposed features, using lift-off metalisation.

Another team of MacDiarmid Institute investigators used the SILMIL laboratory to gain insights into the use of nano-pyramid structures for enhanced light harvesting and the application of silicon and gold nanoparticles in light trapping and absorption in silicon solar cells. Their findings led to a greater understanding of how to fabricate silicon-based solar cells textured with nano pyramids and coated with nanoparticles. Their work was also published as two journal articles and formed the basis of an invited presentation at the Nanotechnology for Next Generation High Efficiency Photovoltaics Conference in France.

THE MACDIARMID INSTITUTE CLOCKS UP MORE THAN 100 PHDS

The number of PhD students funded by The MacDiarmid Institute reached 114 in 2013, marking a significant milestone in the Institute's commitment to building a strong culture of participation and innovation amongst its students. Since its inception in 2002, The MacDiarmid Institute has funded PhDs covering all aspects of nanotechnology and advanced materials research. PhD study completed in 2013 by students funded, or partially funded, by The MacDiarmid Institute focused on a wide range of topics, from studies of bismuth nanostructures [Ojas Mahapatra, University of Canterbury] and computational and spectroscopic studies of donor-acceptor polymers and nonlinear optical materials [Matthew Reish, University of Otago] through to ion size effects In high temperature superconducting cuprates [Ben Mallet, Victoria University of Wellington].

BIOSENSING BOOTCAMP A HIT: Student Rory Gardner, part-way through a master's degree in science at the University of Auckland, attended bootcamp to find out if biosensing was relevant to his research into the bioactive components of manuka honey and manuka flower nectar.

BIOSENSING BOOT CAMP FOR MESA STUDENTS

Biosensing was the central theme of the 2013 MESA boot camp held in Otaki. The four-day training and upskilling event, MESA's second-ever boot camp, introduced attendees to the basics of biosensing with presentations covering topics such as biosensing test design, commercialisation opportunities and the role of advanced materials and nanotechnology in biosensing. Twenty-three MESA students and MacDiarmid Institute investigators from throughout New Zealand attended this year's event.

STUDENT SYMPOSIUM BOOSTS COMMUNICATION SKILLS

In 2013, MESA hosted the ninth annual student and postdoctoral symposium in Wellington. The theme was science communication, specifically selected to boost the confidence and skills of MacDiarmid Institute students. All students were expected to practice their communication skills at the event and participate in a communication competition to select the best student communicator. Keynote speakers included Christchurch geologist Mark Quigley, winner of the 2011 Prime Minister's Prize for Science Communication, Hilary Hamnett, an expert in the field of science publishing and senior lecturer from Victoria University's School of Design, Ross Stevens, who talked about innovative ways to communicate science. Gerry le Roux from ScienceLens, another keynote, talked to students about science photography. This year's symposium featured a panel discussion on communicating science through the media and round table discussions between The MacDiarmid Institute's Principal Investigators and students.

HANYUE (HANNAH) ZHENG WINS PRIZE FOR BEST STUDENT TALK

In 2013, MacDiarmid Institute PhD student Hanyue (Hannah) Zheng won a prize for best student talk called 'A sensor platform based on carbon nanotube thin film field effect transistors'. Hanyue, who is studying at Victoria University in Wellington, won the prize for an oral presentation given at the Conference on Frontiers of Polymers and Advanced Materials in Auckland.

LEADERSHIP IN SCIENCE AND SOCIETY

In 2013, The MacDiarmid Institute continued to support its scientists to demonstrate active leadership in science and wider society. It achieved this strategic objective by encouraging the Institute's scientists to participate and present at national and international conferences, communicate widely about their science research, achieve science prizes and awards and take on leadership roles on national and international boards and committees.

LEADERSHIP IN SCIENCE AND SOCIETY—**2013 HIGHLIGHTS**

HECTOR MEDAL

Professor Richard Blaikie (former MacDiarmid Institute Director) was awarded Hector Medal for outstanding work for physical science by a researcher in New Zealand. Richard was recognised for his contribution to the field of nano-optics and his manipulation of light at a scale much smaller than its wavelength. Richard was also recognised for his world-first demonstration of a superlens system using subwavelength techniques.

TUCK MEDAL

MacDiarmid Institute Principal Investigator and former Deputy Director Shaun Hendy was awarded the Tuck Medal for his contribution to applied mathematics. The Tuck Medal, from ANZIAM, the professional association for industrial and applied mathematics in Australia and New Zealand, recognises the work of leading scientists.

In 2013, the association recognised Shaun's achievements in science communication, leadership, research (particularly in the areas of mathematical modelling in nanotechnology in New Zealand), scientific discovery (including the identification of solid-liquid phase behaviour that can occur in nanoparticles and classifying the novel recoil behaviour of nanoparticles) and a recent pioneering study showing how innovation develops in space and time (using international patent databases and Google Earth).

GOVERNMENT SCIENCE BOARD APPOINTMENT

Professor David Williams (MacDiarmid Institute board member) was appointed to the science board of government agency, the Ministry of Business Innovation and Employment (MBIE).

RECOGNITION AS A DISTINGUISHED ALUMNI

Professor Jeff Tallon (MacDiarmid Institute Principal Investigator) was recognised by Victoria University of Wellington (where he gained his PhD in 1977) as a distinguished alumni.

HIGH SCHOOL HALL OF FAME

Professor Justin Hodgkiss (MacDiarmid Institute Principal Investigator and past pupil of Rotorua Boys' High School) was inducted into the Rotorua Boys' High School hall of fame in recognition of his contribution to science.

RECOGNITION FROM CITY COUNCIL

MacDiarmid Institute Director Kathryn McGrath was recognised in 2013, with the Inspire Wellington Award from the Wellington City Council. Kathryn, who set up a master's programme in Advanced Technology Enterprise at Victoria University of Wellington, was recognised as a scientist, educator and mentor for combining scientific innovation with entrepreneurship to help transform the New Zealand economy.

In 2013, Kathryn and her team embarked on a science research project aiming to revolutionise joint replacement surgery. The researchers are replicating the process of biomineralisation (or molecular self-assembly) found in nature. Their aim is to use the process of 3D printing to develop materials mimicking nature that are stronger and friendlier to the body than those currently used in procedures such as hip replacements. The team is also keen to develop a material that will help broken bones to repair and grow, slowly degrading and disappearing to be replaced by bone over time.

Jim Metson

PROFILE OF A SCIENTIFIC LEADER

In 2013, MacDiarmid Institute Principal Investigator Jim Metson was offered a two-year, part-time post with the Ministry of Business, Innovation and Employment (MBIE), becoming its first-ever chief science advisor. The appointment recognises Jim as a stand-out leader in his scientific field of metal surfaces, and his connections with the broader science community. Jim, a deputy dean of science at The University of Auckland, is also Associate Director of the Light Metals Research Centre, councillor for the Australian Institute of Nuclear Science and Engineering, a member of The Australian Synchronton's Science Advisory Committee and former chair of the Research Infrastructure Advisory Group for MBIE. In 2014, he will continue as an Emeritus Investigator with The MacDiarmid Institute.

PEOPLE ON PANELS

A SNAPSHOT OF INVESTIGATOR INVOLVEMENT

NEW ZEALAND

2020 Vision for eResearch in New Zealand (1 advisory group member).

Gravida, Centre of Research Excellence for biomedical, clinical and animal science (1 board member).

International Conference on Physical Organic Chemistry (1 national advisory committee position).

Manawatu Chemical Education Trust Awards (1 convenor).

Marsden Fund (2 panel members, 1 council member, 1 council chair).

Ministry of Business Innovation and Employment (1 science advisory position, 1 science board position, 1 smart ideas panel position, 1 minerals and energy research grant applications assessment panel position, 1 Taki Ao, early-mid career researchers committee position).

National Science Challenge 10 (1 steering group member).

New Zealand Chemistry Olympiad (1 trustee position).

New Zealand Committee on Crystalography (1 committee member).

New Zealand eScience Infrastructure Access Policy (1 advisory board member).

New Zealand Institute of Physics (2 council members).

Plant and Food Research (1 Director).

Polymer Electronics Research Centre (1 Director).

Royal Society of New Zealand Rutherford Discovery Fellowships (2 panel positions).

INTERNATIONAL

Asian Nano Forum (1 executive member).

Australian Research Council (1 referee, 1 assessor panel position).

Australian Nuclear Science and Technology Organisation (1 international advisory team member, 1 international advisory team chair position).

Australian Synchrotron Scientific Advisory Committee (1 member).

Austrian Science Fund (1 grant reviewer).

Centre for Nanoscale Materials, United States (1 proposal evaluation board member).

Czech Science Foundation (1 grant reviewer).

Deutsche Forschungsgemeinschaft German Science Foundation (1 grant reviewer)

Engineering and Physical Sciences Research Council, United Kingdom (1 grant reviewer)

European Theoretical Spectroscopy Facility (1 advisory board member).

Foundation for Fundamental Research on Matter, Netherlands (1 grant reviewer).

Foundation for Polish Science (1 grant reviewer).

International Society of Electrochemistry (1 chair of the analytical electrochemistry division).

International Union for Pure and Applied Biophysics Council (1 member).

International Union of Crystallography (1 consultant position, 1 member).

IZA Metal-Organic Framework Commission (1 commission member).

Netherlands Foundation for Fundamental Research on Matter (1 assessor panel position).

National Research Council, United States (1 referee).

National Science Foundation, United States (1 grant reviewer).

THE PHOTON FACTORY

SHOOTS AND SCORES

Professor Cather Simpson is winning awards for passing her scientific vision on to the next generation. In basketball terms, she sees herself as 'a natural point guard'.

It's her job to lead the play and make sure the ball gets to the right players at the right time.

As Director of the University of Auckland's Photon Factory, The MacDiarmid Institute Principal Investigator heads a team of 25 staff and students delivering solutions to over 15 companies worldwide.

"The Photon Factory is a multi-use laser facility and part of its core business is helping other scientists succeed. I get great satisfaction from passing the ball to other people to set them up to score," she says.

Simpson led a team of scientists to win a four-year $7.8 million grant from the Ministry of Business, Innovation and Employment that helps them do this, by working on ways to make laser micromachining and microfabrication more economically viable for New Zealand industry.

Her passion for teaching science students to come up with creative answers was rewarded last year, when she won Ako Aotearoa's Sustained Excellence in Tertiary Teaching Award. Her success followed faculty and university awards in 2012.

Simpson also increasingly steps outside the university, sharing her enthusiasm for science with primary and secondary teachers and students. She has a particular focus on encouraging girls and Māori and Pasifika students to become confident in the field.

"Turning young minds on to science is important. They are the generation that will solve problems like global climate change, renewable energy and clean drinking water.

"The people I am reaching are not just tomorrow's scientists; they will be its doctors, lawyers, politicians and school teachers. It's about ensuring that they too know the science they need to do their jobs.

"Being able to construct logical arguments from observations and to recognise underlying principles and apply them is relevant to everyone."

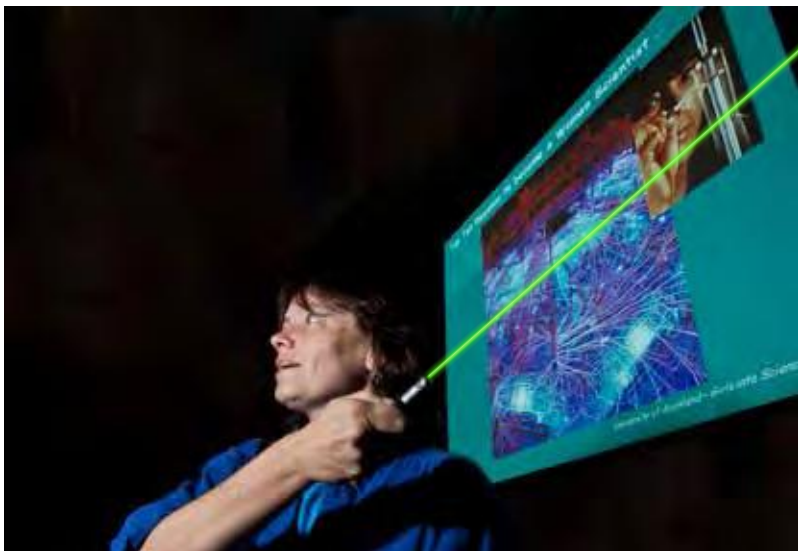
She teams this approach with commercial success at The Photon Factory, which has established a reputation for excellent science and innovation.

"Often someone will ask us to solve a particular problem and we can do it quite easily because we have the expertise."

That was the case with The Photon Factory's first big commercial win in 2011, one year after launch.

"NextWindow was having trouble with the 'touch' function on their touch screens. They were developing technology for customers to do things like play the piano on the screen, and we were able to help them with a critical step."

At the other end of the scale there are cutting-edge developments, providing the opportunity to learn, and to solve bigger less well-formed problems.



A highlight has been resolving an issue facing the dairy industry, leading to the development of spin-off company Engender Technologies in 2011. It filed its first international patent last year.

"We came up with an alternative technology for sperm sorting for the agricultural sector. It's designed to be less expensive, require less technical expertise to run and the sperm are healthier at the end of it."

A partnership with a US company that makes the world's leading robotic surgical platform, is yet another example.

"Laser surgery has been around for decades. However, there are certain types of tissues that burn when you cut them with standard lasers. It turns out that femtosecond pulses do a kind of cold-cutting process and we are employing that in our work with Intuitive Surgical.

"So when people ask me 'Do university scientists and students really improve people's daily lives?' My answer is an emphatic yes! That's the goal of our game plan in the Photon Factory."

THE PHOTON FACTORY

The idea that maths is the language of science and nature, it just fires my rockets

Professor Cather Simpson had almost completed her PhD in Medical Sciences, when she encountered quantum mechanics for the first time. She knew she had a slam-dunk.

"The idea that maths is the language of science and nature, it just fires my rockets. When we are discovering new things about nature and harnessing our lasers to solve important problems, underpinning all of that is some very beautiful mathematics."

She established the multi-user Photon Factory at the University of Auckland in 2010. Her appointment is held jointly in Chemistry and Physics.

"At the Photon Factory, the PhD research we do is about understanding how electrons and nuclei communicate with one another. When you excite a molecule with light, what does it decide to do with that light? We study how molecules convert light to useful energy.

She and her students use the high-tech laser pulses for everything from discovering fundamental knowledge to manufacturing on a microscopic scale.

"We have a variety of different laser pulses to play with, from a nanosecond to a femtosecond (one millionth of a nanosecond).

"Because the pulses are so short, they provide extremely high intensities for cutting and shaping many materials, from glass to plastic to metals. We use those laser pulses for micromachining projects for scientists all over the world."

INSPIRATION

TO INSPIRE NEW ZEALANDERS

This image, Vanadium Oxide Crystals by Surayya Mukhtar, is nanotechnology presented as artwork. Art of the Invisible, 2013.

VISION

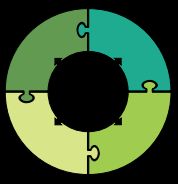
SCIENTIFIC EXCELLENCE

LEADERSHIP

INSPIRATION

ADVANCEMENT OF NEW ZEALAND

MISSION



ROLE OF SCIENCE & INNOVATION

SHOWCASE

MĀORI & PASIFIKA

BENEFITS OF SCIENCE & INNOVATION

Engendering passion for science and innovation across society.

BENEFITS OF SCIENCE AND INNOVATION

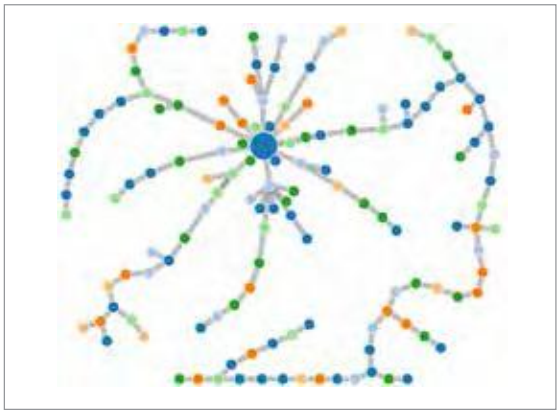
In 2013, The MacDiarmid Institute made several key steps towards stimulating nationwide discussion on the benefits of science and innovation in society. Examples included encouraging and upskilling Principal Investigators to increase their engagement with the media and hosting public science events.

MEDIA TRAINING FOR MACDIARMID INSTITUTE SCIENTISTS

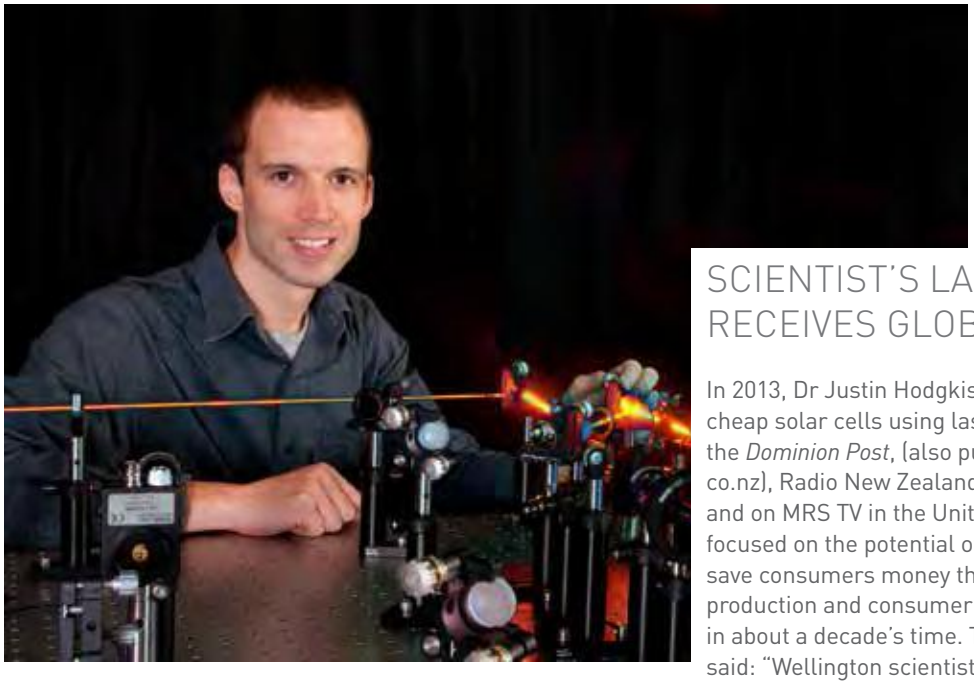
MacDiarmid Institute scientists were among a group of 12 people given media training by the Science Media Centre in 2013. The training aimed to make participants more aware of how to connect with different audiences. It also gave them the chance to make media contacts and gain first-hand insight into news media practices. Participants were able to practice pitching their stories to visiting journalists. Participants included researchers from AUT University, Plant & Food Research, the Liggins Institute, Unitec, The MacDiarmid Institute and the University of Auckland.

ONLINE GAME STIMULATES PUBLIC DEBATE ON SCIENCE

An online game stimulated public debate on scientific issues such as climate change in 2013. The game, called Pounamu, was developed by The MacDiarmid Institute's Professor Shaun Hendy and Stephanie Pride of consultancy business StratEDGY Strategic Foresight. It ran for 24 hours, with players involved in both posting ideas about and solving scientific problems in 140-word microposts (similar to tweets used on Twitter). Players gained points and moved up the game leader-board by posting ideas that created more discussion, contributed interesting ideas to the game and by winning awards. Data collected from the online game showed discussion occurred among children as young as seven, as well as university professors, bankers and librarians. It showed nearly 7,000 online posts were made and participants also used social media tools such as Twitter to get more people involved in debating science issues.



This image traces the debate and networking involved in a Pounamu discussion that sought to answer the question: 'What if all science was taught in te reo Māori?' courtesy of Dion O'Neale, Callaghan Innovation.



SCIENTIST'S LASER RESEARCH RECEIVES GLOBAL COVERAGE

In 2013, Dr Justin Hodgkiss' research into making cheap solar cells using lasers was reported in the *Dominion Post*, (also published online at stuff.co.nz), Radio New Zealand, *The Taranaki Daily News* and on MRS TV in the United States. The stories focused on the potential of Justin's research to save consumers money through the mass market production and consumer use of cheap solar cells in about a decade's time. The *Dominion Post* story said: "Wellington scientist Justin Hodgkiss is at the forefront of the global race to develop commercially viable printable energy-generating solar cells. The cells could transform life in the Third World and free the First World from the costly shackles of the electricity grid."

ANNUAL SCIENCE CLASS FOR MEDIA, PUBLISHERS AND CREATIVES

In 2013, The MacDiarmid Institute partnered with the Royal Society of New Zealand and, for the first time, the Science Media Centre, to run its monthly science class for invited journalists, radio producers and representatives from the publishing and creative industries. The Wellington-based event aims to stimulate discussion on the benefits of science and innovation. In 2013, topics included physics, astronomy, the science of land use, climate change, mathematical modelling and potential natural disasters. Set up in 2005, the classes have since led to the publication of science books, plays, paintings, poems and radio programmes.

COMMUNICATING SCIENCE TO THE PUBLIC **HIGHLIGHTS FROM 2013**

- First-ever annual report published for the public in 2013.
- Magazine, *Interface*, revamped for a broader audience.
- The MacDiarmid Institute's YouTube channel launched.
- Further development of The Hub, an online resource for science teachers and students featuring news, events and resources.
- MacDiarmid Institute scientists clock up more than two dozen media stories across a print, digital, broadcast and television media.

ROLE OF SCIENCE AND INNOVATION

In 2013, The MacDiarmid Institute found a range of new ways to engage directly with the New Zealand public, private sector and government, sharing the Institute's vision on the role of science and innovation in New Zealand's future. Examples included developing new industry, school and government networks and running a series of outreach activities aimed at schools and teachers.

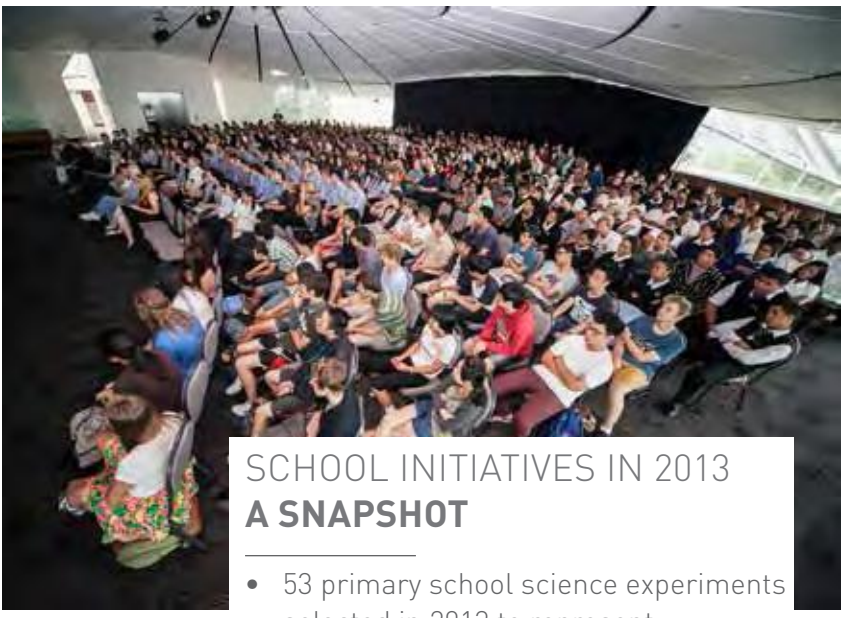
TELLING OUR STORIES / CONVEYING OUR VISION

The MacDiarmid Institute's scientists had several key opportunities to tell the organisation's story and convey its broader vision in 2013.

The Press (Christchurch) published a story on Principal Investigator Juliet Gerrard's research into using the proteins of fish eyes (a waste product from the fish processing industry) to develop cheap sensors for the early detection of diseases such as cancer.

Wellington's *Dominion Post* covered the application of Principal Investigator Andreas Marwitz's research into strengthening metal using ion implantation technology. The story looked at Team New Zealand's use of strengthened metal knives to cut entangled ropes during America's Cup races.

In 2013, Radio New Zealand's Nine to Noon programme interviewed MacDiarmid Institute Director Kathryn McGrath about science funding.



SCHOOL INITIATIVES IN 2013 **A SNAPSHOT**

- 53 primary school science experiments selected in 2013 to represent the country's 100 best science experiments—the hunt for the final 47 continues in 2014. All experiments will be published on The Hub, the Institute's online resource for science teachers and students.

- 15 secondary school students selected to take part in The MacDiarmid Institute's fifth NanoCamp to learn about nanotechnology and carry out lab experiments.

- More than 400 senior school science students attend a nanotechnology show, called A Very Small Show, with talks by four of the greatest nanotechnologists in the world, at Auckland Museum in Auckland.

- New science training programme for early childhood education and primary school teachers piloted.

THE BEST 100 SCIENCE EXPERIMENTS

In 2013, primary schools across New Zealand were asked to enter a competition looking for the best 100 science experiments in the country—53 schools provided winning experiments. The competition, run by The MacDiarmid Institute and (what was then) the New Zealand Teachers Council in 2013, looked for simple, fun, fail-safe experiments that could be added to a national database and made available to all schools through The Hub—an online resource for science teachers and students. Winning schools got two iPads, one for their science teacher (for submitting the winning entry) and one for their school. The hunt for the final 47 continues in 2014.

SCIENCE TRAINING FOR EARLY CHILDHOOD AND PRIMARY TEACHERS

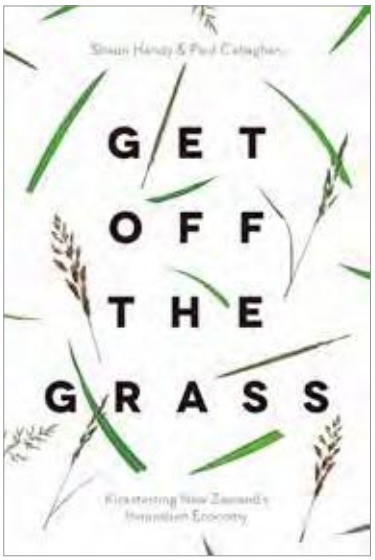
A partnership between The MacDiarmid Institute and the union for early childhood and primary school teachers, the New Zealand Educational Institute (NZEI), Te Riu Roa, was formalised in 2013, following a successful regional training pilot called 'Kōrero with Scientists'. The pilot was designed to reflect what teachers said they wanted from science training and saw them get together and learn from scientists in their region. It will be rolled out nationwide in 2014. The NZEI, Te Riu Roa and MacDiarmid Institute partnership aims to upskill the country's early childhood and primary teachers through practical training and by exposing teachers to scientific methods, how scientists think and the general nature of science.

SHOWCASE

In 2013, The MacDiarmid Institute continued to showcase its own and other science stories to New Zealanders of all ages. It achieved this strategic objective by publicising the potential of science to transform the New Zealand economy, hosting a public event presenting research as public artworks and developing outreach activities aimed at increasing the participation of Māori and Pasifika students in nanotechnology and science.

GET OFF THE GRASS
PUBLISHED

In 2013, the work of two MacDiarmid Institute scientists was published by Auckland University Press in a book called *Get Off The Grass*. In the book, Professor Shaun Hendy and the late Sir Paul Callaghan argue for New Zealand to diversify its economy beyond the primary sector if it is to grow more rapidly. They argue for nationwide communities of innovators, entrepreneurs and businesses, posing deep challenges to the country: Can New Zealand learn to innovate like a city of four million people? Can New Zealand become a place where talent wants to live? Can we learn to live off knowledge rather than nature? Are we willing to take science seriously?



SHOWCASING
Shaun Hendy

COMMUNICATOR AND AUTHOR

MacDiarmid Institute Principal Investigator and former deputy Director Shaun Hendy is a professor of physics at the University of Auckland and an industry and outreach fellow at Callaghan Innovation. He has a PhD in physics from the University of Alberta in Canada and research interests in nanotechnology, complex systems and innovation. He writes a blog, *A Measure of Science*, as part of Sciblogs.co.nz, a hub for New Zealand's science bloggers, and has a regular slot on Radio New Zealand Nights as physics correspondent. In 2010, he was awarded the New Zealand Association of Scientists Research Medal and a Massey University Distinguished Young Alumni Award. In 2012 he won the Callaghan Medal and the Prime Minister's Science Media Communication Prize.

REMEMBERING
Sir Paul Callaghan

COMMUNICATOR AND AUTHOR

Professor Sir Paul Callaghan (1947 – 2012) was one of New Zealand's most successful and internationally-renowned scientists. Sir Paul was the founding Director of The MacDiarmid Institute and the Alan MacDiarmid professor of physical science at Victoria University of Wellington.

He published over 240 articles in scientific journals, as well as the books *Principles of Nuclear Magnetic Resonance Microscopy* in 1994 and *Translational Dynamics and Magnetic Resonance* in 2011. He was founding Director and shareholder of Magritek, a Wellington-based technology company providing nuclear magnetic resonance instruments. He was a regular public speaker on science matters and, in 2007, one of his radio series appeared in book form, *As Far As We Know: Conversations about Science, Life and the Universe* (Penguin). His 2009 book, *Wool to Weta: Transforming New Zealand's Culture and Economy* (Auckland University Press), deals with the potential for science and technology entrepreneurialism to diversify New Zealand's economy.

In 2001, Sir Paul became the 36th New Zealander to be made a Fellow of the Royal Society of London. He was awarded the Ampere Prize in 2004 and the Rutherford Medal in 2005. He was appointed a Principal Companion of the New Zealand Order of Merit in 2006 and in 2007 was recognised by a KEA and New Zealand Trade and Enterprise World Class New Zealander Award and the Sir Peter Blake Medal. In 2010, he was awarded the Günther Laukien Prize for Magnetic Resonance and shared the Prime Minister's Science Prize. In 2011, he was named the Kiwibank New Zealander of the Year.

NANOTECHNOLOGY ARTWORK ON SHOW FOR THE PUBLIC

An art exhibition, called Art of the Invisible, was one of the ways The MacDiarmid Institute students generated public interest in nanotechnology in 2013. The exhibition, held in the Gus Fisher Gallery in Auckland, showcased more than 40 research images presented as artworks. The exhibition was held as part of AMN6: the Sixth International Conference on Advanced Materials and Nanotechnology and accompanied by a series of public lectures. The exhibition also captured media attention, appearing on TV3's *Nightline.*

MĀORI AND PASIFIKA

In 2013, The MacDiarmid Institute took its first steps towards direct engagement with Māori and Pasifika communities. Examples of engagement included appointing Dr Wayne Ngata to The MacDiarmid Institute board and running the annual Discovery Awards.

RECORD NUMBER OF DISCOVERY AWARDS IN 2013

Eleven Māori and Pasifika secondary school students won Discovery Awards in 2013 —the highest number of award-winners since the awards began. Discovery Awards are given to Māori and Pasifika students who demonstrate an interest in studying science at tertiary level and pursuing a science career. The awards include $1,000 and two weeks' work experience in a research lab within the University of Auckland, Massey University, Callaghan Innovation, Victoria University or the University of Canterbury. Wellington students also had the opportunity to tour the MRI unit at Wellington Hospital.

Wayne Ngata

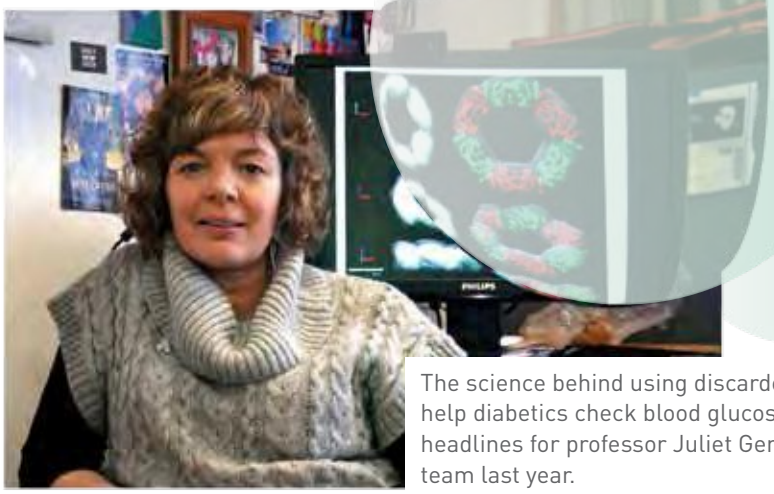
PROFILE OF A SCIENCE RANGITIRA

The MacDiarmid Institute welcomed indigenous researcher, linguist, educationalist and teacher Dr Wayne Ngata to the board in 2013. Wayne, who is based in Uawa (Tolaga Bay) on the East Coast, is of Te Aitanga a Hauiti, Ngāti Ira and Ngāti Porou descent.

His background includes:

- 2012 Transit of Venus governance and steering group representative
- Principal Investigator for Ngā Pae o te Māramatanga (Centre of Research Excellence for indigenous research at Auckland University)
- member of Te Mata o Te Tau (academy for Māori research and scholarship at Massey University)
- Ministry of Education manager, specialising in te reo Māori in schools.

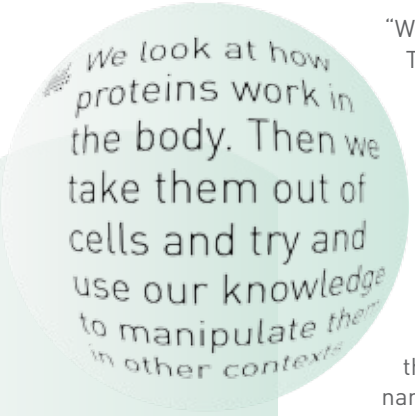
FISH EYES AND MILK POWDER



The science behind using discarded fish eyes to help diabetics check blood glucose levels grabbed headlines for professor Juliet Gerrard and her team last year.

The MacDiarmid Institute's Principal Investigator and Director of the Biomolecular Interaction Centre at the University of Canterbury.gained the most media coverage for the Institute in 2013.

Her focus is on understanding how proteins work, learning from biology and applying this knowledge to ground breaking areas.



"We look at how proteins work in the body. Then we take them out of cells and try and use our knowledge of what they do in biological systems to manipulate them in other contexts", she says.

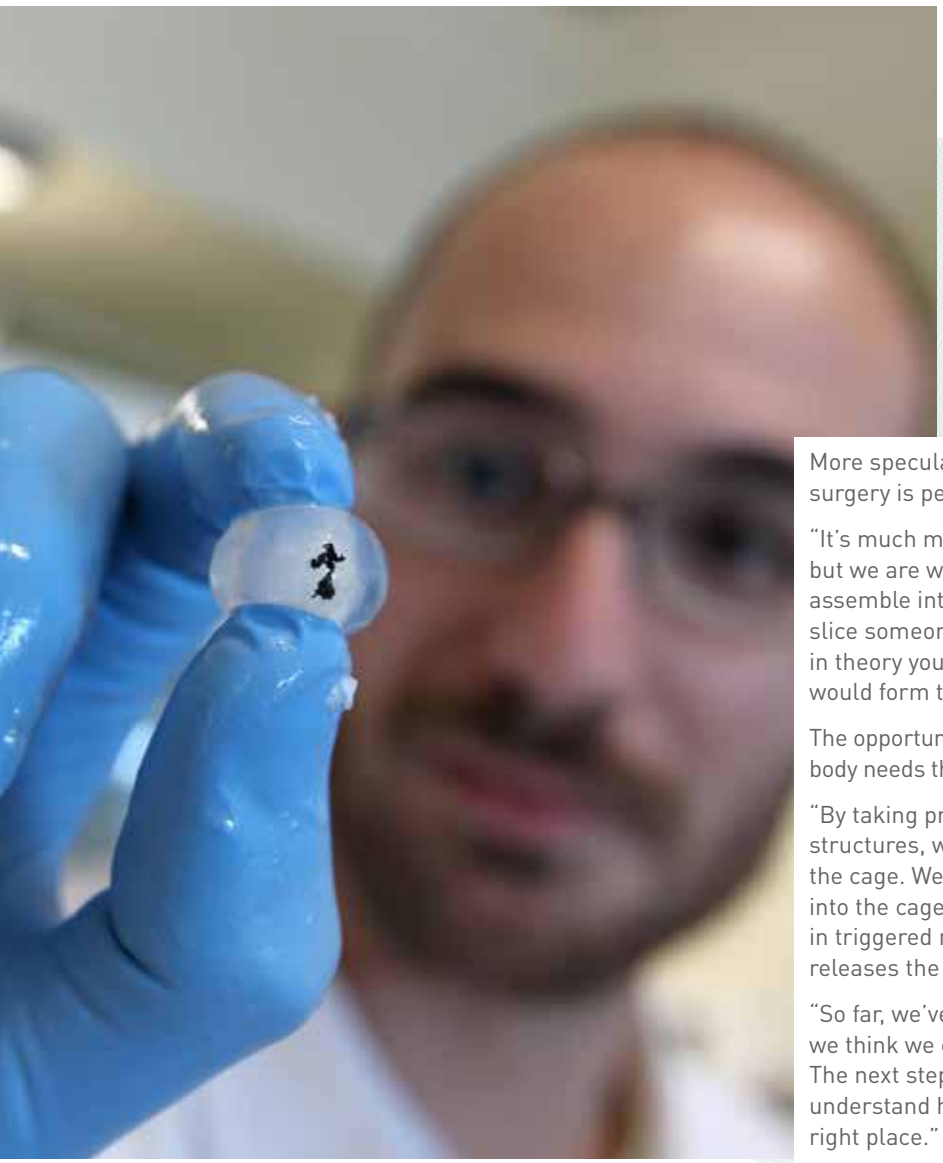
"One of the things we are interested in getting them to do, is assemble into precise structures we want, not necessarily the way biology intended."

The Biomolecular Interaction Centre is the only place in the world where protein nanofibres are manufactured on a large scale, in grams and soon kilograms, rather than milligrams.

Gerrard's work involves taking cheap proteins, turning them into high-value components, and then working with others to develop products. The potential for application is broad.

In the case of super-strong fibres not only fish lenses, but whey protein in the form of milk powder is being used.

"We make these protein nanofibres with properties like spider silk. This produces an exceptionally strong material, really light and quite elastic. You can potentially weave these fibres, which might be useful for things like body armour, since it is light-weight and comfortable but also incredibly strong."



Postdoctoral fellow Luigi Sasso works with Juliet Gerrard, developing these uses of hoki fish eyes

DEAN KOZANIC/Fairfax NZ

More speculative science could change the way surgery is performed.

"It's much more at the basic science stage, but we are working on persuading proteins to assemble into a gel. Then rather than having to slice someone open and put in a whole implant, in theory you could inject the gel solution and it would form the right shape in the body."

The opportunity to direct drugs to exactly where the body needs them is also at the theoretical stage.

"By taking proteins that naturally forms cage structures, we can learn to control formation of the cage. We might then be able to load a drug into the cage, inject it into the body and design in triggered release, when the cage opens and releases the drug at the right place in the body.

"So far, we've got a protein that forms cages, we think we can control when it forms the cage. The next step will be working with people who understand how to target the cages to go to the right place."

Gerrard is always on the look out for opportunities where proteins can 'create a real advantage'.

"Through The MacDiarmid Institute, we can much more easily connect with all sorts of sectors including schools, policy agencies, businesses and people who are there to constructively help with commercialisation. Having that central infrastructure really helps, it would be much harder to do many of these things from a single institution."

THE FISH LENS SMOOTHIE

"One of the problems we have working on proteins is you need to purify them", says professor Gerrard. "But a fish lens is pretty much made of pure protein, so it gives us a really nice raw material to work on.

"The fisherman we work with are keen to get rid of it too, so it's a nice coincidence of a starting material we really covet scientifically that we can get from people who are throwing it away.

"We think about how the eye lens works in the body, and also what stops it working. One of the things that happens with eyes is cataracts and clouding of eye lenses. What we've realised is that, using the raw material, that same process can take place outside the eye to make some really interesting nanostructures.

"Imagine making a fish lens smoothie. We take the eye lens and put it in a blender and we accelerate the process that would take place incredibly slowly in the natural system.

"We use it to make these little protein nanofibres. They are really tiny, about one thousandth of the width of a human hair. That gives you this massive surface area to stick things to.

"One of the limiting factors for making sensors that detect things like glucose is getting a big enough surface area to attach enough molecules to do the detecting. But because the components we make are really small on the nano scale, when we attach an enzyme (called glucoseoxidase) we get an enormous number of these detector molecules on every bit of surface which means we end up with a high sensitivity detector.

"Glucose sensing is a really nice system to learn on because a lot is understood about it, but it's already an established market. So once we've nailed the science for glucose we plan to look for more of a niche market to launch a biosensing product."

ADVANCEMENT OF NEW ZEALAND

TO ADVANCE A NEW FUTURE FOR NEW ZEALAND

This image, Liquid Crystal Kowhai Petals by William Greenbank, is nanotechnology presented as artwork. Art of the Invisible, 2013.

VISION

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MISSION

ALUMNI AS LEADING INNOVATORS

COMMERCIALISE RESEARCH

ENGENDERING ADVANCEMENT

COLLABORATIVE NETWORKS

Deliver and support responsible economic development.

COLLABORATIVE NETWORKS

In 2013, The MacDiarmid Institute partnered with applied research and development organisations to ensure economic outcomes for its science. This included developing a better understanding of the market demands important to New Zealand companies and delivering maximum benefit to the country, its people and its economy.

COMMERCIAL PRODUCTION OF NGA PURE TAKES FIRST STEP

In 2013, the commercialisation of a new wool product got a step closer, with a United Kingdom firm expressing interest in piloting its commercial production. The product, called Nga Pure, is wool combined with silver to produce an antimicrobial fibre. It is the brainchild of MacDiarmid Institute Principal Investigator Jim Johnson and Dr Kerstin Lucas of Victoria University. In 2012, the pair set up Noble Bond Ltd—a firm focused on commercialising new yarn technology. Jim, a professor at Victoria University, specialises in industrial chemistry, material science and nanotechnology. In 2006, he and Kerstin began developing environmentally-friendly gold and silver wool products, which they are looking to commercialise with the help of Wools of New Zealand. The pair have developed two main wool products—wool combined with a tiny amount of pure gold, which chemically produces colours of purple, grey and blue, and Nga Pure, a wool combined with silver to produce an antimicrobial wool that is effective against 600 microbes.

ALUMNI AS LEADING INNOVATORS

The MacDiarmid Institute continued to produce scientists who make leading contributions to New Zealand's prosperity in 2013—examples included Dr Ojas Mahapatra's leadership role at Photonic Innovations and commercialisation fellow Keoni Mahelona's innovative water management pilot.

The Institute achieved this goal through engaging PhD students and postdoctoral fellows in commercialisation opportunities, strengthening the capability of The MacDiarmid Emerging Scientist Association (MESA) to deliver commercialisation opportunities and maintaining connections with MacDiarmid Institute alumni achieving commercialisation success within New Zealand industries.

MACDIARMID ALUMNI: A LEAD INNOVATOR IN GAS DETECTION TECHNOLOGY

MacDiarmid Institute alumni Dr Ojas Mahapatra was appointed chief executive Photonic Innovations in 2013, the same year he completed his PhD with the Institute. Ojas' new role is a prime example of leadership in the area of research commercialisation. Dunedin-based Photonic Innovations aims to commercialise a novel gas detection technology developed jointly at The Dodd Walls Centre for Quantum Science and Technology and Canterbury University's physics department, where Ojas was based from 2010 funded by a MacDiarmid Institute scholarship.

COMMERCIALISE RESEARCH

Commercialising The MacDiarmid Institute's research remained a focus in 2013, with the aim of bringing the greatest possible benefit to New Zealand, its people and the economy. It achieved this strategic objective in a range of ways—through employing innovation agents focused on supporting scientists to commercialise their research, an annual commercialisation event, attracting seed funding and working with industry to scope and address their research needs.

COMMERCIALISATION FELLOWSHIP LEADS TO SOCIAL ENTERPRISE PILOT

In 2013, MacDiarmid Institute alumni Keoni Mahelona piloted a water management system that allows households using rainwater tanks to better manage their water use. Keoni, who has joined the Wellington-based business incubator Lightning Lab to fully commercialise the system, received early funding for the research underpinning the pilot through The MacDiarmid Institute Research Commercialisation Fellowship. The fellowship funds research students and postdoctoral fellows to carry out scoping or in depth evaluation reports. Keoni also received Bright Ideas Funding from the Institute to field trial his new technology. Keoni's water management system, called WaterGenie, uses a cloud-based smart meter to work out how much water is in a rainwater tank. The WaterGenie also predicts future water use and forecasts future rainfall. It draws on Keoni's research on new surfaces for collecting dew.

MACDIARMID INSTITUTE SIGNS MOU WITH ALUMNI STARTUP, PUBLONS

In 2013, The MacDiarmid Institute signed a Memoranda of Understanding (MoU) with Publons to formalise each partner's commitment to collaborating and achieving mutually beneficial goals. Publons is a Wellington start-up launched in 2013 by MacDiarmid Institute alumni Andrew Preston and business partner Daniel Johnston. It aims to speed up the academic peer review process by turning peer review into a measurable research output. Currently, it has more than 3,000 reviews authored by more than 1,600 reviewers.

INNOVATION AGENT: MacDiarmid Institute innovation agent Desi Ramoo was a research scientist with the Building Research Association of New Zealand (BRANZ). He has a PhD in theoretical physics and is an experienced entrepreneur.

INNOVATION AGENTS FOCUS ON COMMERCIALISATION

In 2013, MacDiarmid Institute employed two innovation agents—Desi Ramoo in the North Island and Bill Swallow in the South Island—to help The MacDiarmid Institute's scientists turn their research into commercial ideas. The role of the agent is to identify research with commercial potential, identify markets for the commercial application of the research, analyse competition and generally develop a pipeline for new commercialisation opportunities within the Institute.

COMMERCIALISING RESEARCH **A YEAR IN NUMBERS**

- 9 commercialisation scoping projects complete.
- 1 major commercialisation workshop hosted (in partnership with KiwiNet), the Science Commercialisation Symposium in Wellington.
- 1 new commercial spin-off using MacDiarmid Institute technology set up (Air Quality Limited).
- 1 Pre-seed Accelerator Fund Investment in MacDiarmid Institute innovation.
- Research support provided to 10 New Zealand companies (Veritide Ltd, Raztec Sensors, Gallagher, Tait Communications, Stafford Engineering, Kline Pharmaceuticals, BENEX Ltd, Izon Science, Fonterra, Canterbury Scientific Limited).
- 2 patents filed.

BREAKTHROUGH RESEARCH SCORES KIWINET PRE-SEED ACCELERATOR FUNDING

MacDiarmid Institute Principal Investigator Martin Allen successfully gained Pre-Seed Accelerator Funding (PSAF) from the Kiwi Innovation Network (KiwiNet) in 2013. The funding will enable him to trial a new (recently patented) way of manufacturing smart phones and TV displays, using zinc oxide-based materials. Martin will spend two years trialling his patented approach in collaboration with Korean research engineer Saurabh Saxena from global firm LG. KiwiNet is a consortia of universities and Crown Research Institutes and entities focused on supporting research commercialisation through a range of investment and collaboration initiatives.

CALLAGHAN COMMERCIAL-ISATION FELLOWSHIP FOR INNOVATION IN THE DAIRY INDUSTRY

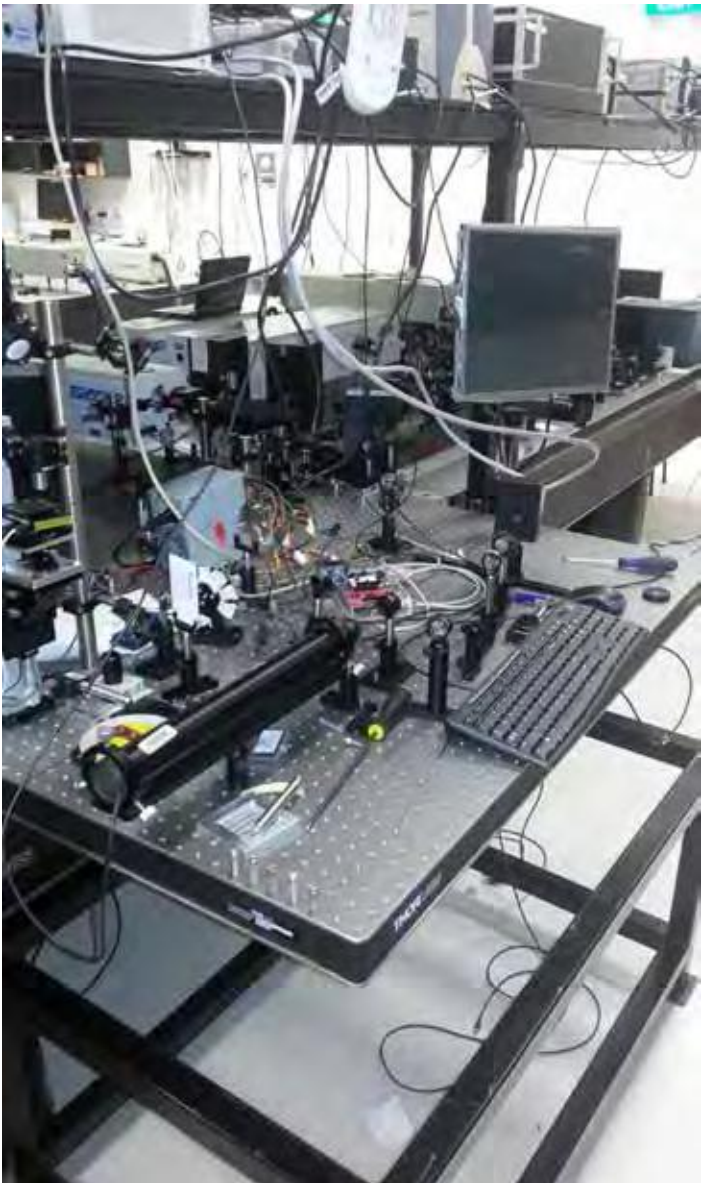
In 2013, MacDiarmid Institute Principal Investigator Cather Simpson received a commercialisation fellowship to explore the commercialisation potential of a new technique, removing water from milk during the processing of milk powder. The fellowship gave Cather access to a business investment mentor, dairy plant visits and industry feedback on the technique.

RESEARCH HIGHLIGHTS COMMERCIAL APPLICATION OF CONJUGATED POLYMERS

The MacDiarmid Institute's research into the commercial application of conjugated polymers for industry took a leap forward in 2013. The research looked at how to make conjugated polymers more soluble and responsive to water. Conjugated polymers can be used in chemical and biological sensors and throughout the bioengineering and printing electronics industries. However, their full commercial application is currently limited by their poor solubility. In 2013, a team led by MacDiarmid Institute Principal Investigator Jadranka Travas-Sejdic, successfully trailed a range of new ways to make the polymers more soluble and responsive to factors such as temperature, pH and electrical stimuli. They also began exploring the use of conjugated polymers in biological tissue engineering.

IMPROVED FEMTOSECOND LASER MACHINE MAY BENEFIT INDUSTRY

The MacDiarmid Institute started exploring how its femtosecond laser machine might benefit the country's fabrication industry in 2013. MacDiarmid Institute scientists successfully set up and began testing a relocated and improved femtosecond laser machine. The machine is now based in at the University of Auckland and has a new spatial light modulator. This year, a research team led by Principal Investigator Cather Simpson explored the machine's beam-shaping optics and redesigned the optical train for easier, more flexible on-demand use of the machinery. They also approached Wellington firm Mesynthes Ltd to see if the machine could improve the company's biomembrane processing. In time, the machine may help improve the cutting methods used within the country's fabrication industry.



GRANT FOR FABRICATION IMPROVEMENTS: With the help of a Ministry of Business Innovation and Employment (MBIE) Targeted Research grant, The MacDiarmid Institute is looking to bring improvements to New Zealand's fabrication industry through innovative use of a state-of-the-art femtosecond laser machine. The machine (pictured) is based at the University of Auckland.

ENGENDERING ADVANCEMENT

In 2013, MacDiarmid continued to share its vision for adaptable and sustainable economic growth based on a high-technology export sector. It achieved this strategic objective by demonstrating its achievements and sharing the Institute's vision for science innovation in New Zealand in government reports, media stories and through sponsorships and events.

MACDIARMID: A LEADER IN HIGH-VALUE MANUFACTURING INNOVATION

In 2013, the Ministry of Education published an evaluative analysis on the performance of the country's Centres of Research Excellence (CoRE) since 2002. The MacDiarmid Institute was one of the seven CoREs reviewed by the Ministry.

The Ministry's study, called *CoREs and Effect*, highlighted the following examples of the MacDiarmid Institute's high-value manufacturing innovation.

Magritek Limited (NMR Instruments), a spin-off company established by MacDiarmid Institute founder professor Sir Paul Callaghan, which makes portable magnetic resonance imaging devices. Magritek won the 2011 New Zealand Innovators Awards in the Health and Sciences category.

Anzode Inc, an award-winning spin-off company founded to commercialise Simon Hall's nick-zinc battery technology, won a Bayers Innovators Award in 2010.

Research on the use of gold and silver nanoparticles as colourants for wool and other fibres for high-value fashion fabrics, carpet and functional textiles.

HTS-100, a spin-off company partly founded on the innovative science of MacDiarmid Institute scientists. HTS-110 is a high temperature superconductor company, responsible for world-leading approaches to the manufacture of high temperature superconductor wire used in high-quality magnets.

ADVANCEMENT IN MAGNETIC RESONANCE IMAGING

In 2013, MacDiarmid Institute Associate Investigator Petrik Galvosas and his team demonstrated for the first time that it was possible to photograph the small cells of the human body using standard commercial MRI hardware. Until recently, it was thought cells such lung alveoli, cancerous cells and nerve bundles were too small to be picked up by a conventional MRI. MacDiarmid Institute scientists developed their experiments, drawing on an existing theory developed by the German Cancer Research Centre in 2011. Petrik and his team have called their new technique the Magnetic Resonance Pore Imaging (MRPI) technique.

INDUSTRY INITIATIVES IN 2013 **A SNAPSHOT**

- Memoranda of Understanding (MoUs) signed with industry partners (Callaghan Innovation, Publons, KiwiNet and the New Zealand Educational Institute).

- Industry advisory group set up, with representatives from Rakon, Fisher and Paykel Healthcare, TIN100, Scott Technology, Everedge IP and consultant Simon Arnold. The role of the group is to bridge the gap between industry and researchers.

- Inaugural Callaghan commercialisation fellowship awarded to MacDiarmid Institute Principal Investigator Cather Simpson to give her the skills and time to explore commercialisation ideas and work with and learn more about the needs of industry.

- Four PhD student industry internships set up for students keen to intern in a relevant industry.

SYMPOSIUM RECOGNISES SIR PAUL'S VISION FOR ADVANCEMENT THROUGH SCIENCE

The MacDiarmid Institute held a national symposium recognising the innovative leadership of MacDiarmid founder Sir Paul Callaghan in 2013. The two-day symposium, called 'The Inspiration of Paul Callaghan' was held at Victoria University of Wellington and attracted more than 140 participants from all over the world. The symposium reflected on Sir Paul's vision for advancement through science, covering the past work of Paul and his work that would continue into the future.

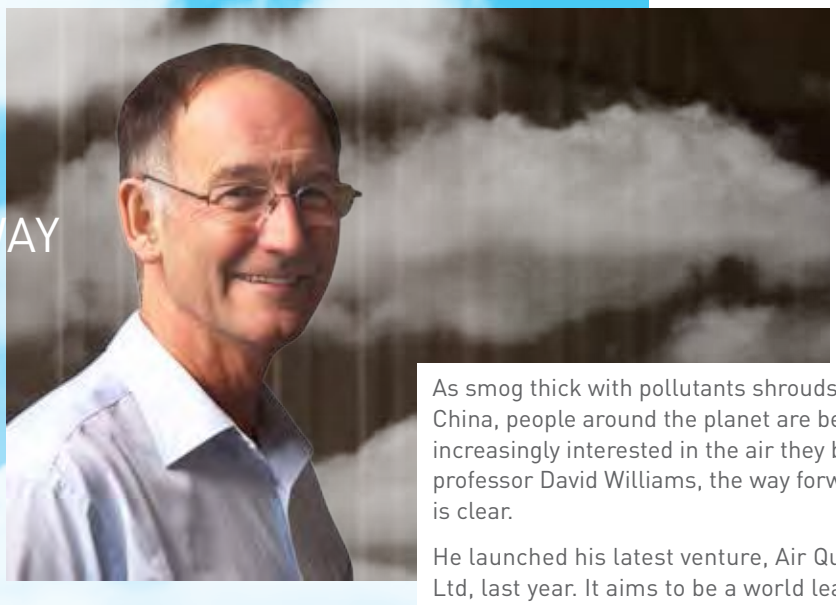
MACDIARMID INSTITUTE **SPONSORSHIPS IN 2013**

- Wellington Glean Report 2013, a twice-weekly email service providing information and links on upcoming science, environment and humanities events in the Wellington region.
- Sir Paul Callaghan and Eureka! Symposium (silver sponsor), a symposium run by the Rotary Club of Wellington to help maintain the legacy of Sir Paul Callaghan.
- New Zealand Chemistry Olympiad, training and participation in an international event open to four secondary school students from New Zealand.
- International Conference on the Frontiers of Polymers and Advanced Materials.
- Annual Chemistry Research Showcase, Auckland University event for PhD and postgraduate students
- New Zealand Research Honours, annual awards for the country's top researchers.
- Te Rōpū Āwhina outreach programmes, programmes for Māori and Pasifika students attending Victoria University.
- NZAMT Maths Quest, annual mathematics competition run by the New Zealand Association of Mathematics Teachers.
- NZIC Annual Conference, annual conference of the New Zealand Institute of Chemistry.
- NZIP Annual Conference, annual conference of the New Zealand Institute of Physics.
- ANZCOP conference, Australia and New Zealand Conference on Optics and Photonics.
- Chiasma Wellington conference for Wellington students and representatives from the high-tech industry.

LETTING THE SCIENCE

I'm interested in doing really good science and I wouldn't have been able to sustain my career if it hadn't been for good science

LEAD THE WAY



As smog thick with pollutants shrouds cities in China, people around the planet are becoming increasingly interested in the air they breathe. For professor David Williams, the way forward is clear.

He launched his latest venture, Air Quality Ltd, last year. It aims to be a world leader in environmental measuring and monitoring, delivering excellent results at a competitive price.

The MacDiarmid Institute's Deputy Director (commercialisation and industry engagement) and Principal Investigator has an eye for turning top-notch science into successful business opportunities.

It's the third spin-off company for the scientist, who works in the field of electro-chemistry and chemical sensors, measuring air quality. He is inventor of around 40 patents. Throughout his career, he has maintained a focus on good science while always considering how people are using that science.

"I'm interested in doing really good science and I wouldn't have been able to sustain my career if it hadn't been for good science," he says.

"I've worked on this stuff for about 30 years. My work started off seeking materials for sensors that would detect and measure trace gases in air.

It then moved on to making more sophisticated devices that would generate error signals. Later it moved on to developing instruments using these sensors and now it's moved on to networks of instruments.

"The question is what do people want next? I found the science leads you on. There are new and interesting questions at each stage," says Williams.

New Zealand-based company Aeroqual was formed in 2001 to make instruments measuring air quality. It now has an annual turnover of about $4 million.

"We saw an opportunity to move from hand-held ozone detectors to more sophisticated instrument packages measuring ozone, nitrogen dioxide and smoke, all sorts of things.

"We developed a small box of instruments with a wireless modem and an air sampling pump that measures air quality. It sells for about $20,000 to $50,000. There are many opportunities where that is exactly what's needed. The alternative would be the size of a shipping container and would cost between $200,000 and $500,000."

The latest business developed after Aeroqual found itself involved in installing and managing networks. It was cash-flow positive in its first year of operation.

"We set up Air Quality Ltd to sell validated data. We install and manage a network, say around a roading project like the Victoria Park tunnel or a geothermal area, and we charge a fee for doing that.

"Dust is a big thing. People want to know they are controlling it and we provide data you can rely on.

"We are looking at how to build networks to monitor air quality at high spatial density, using low cost instruments that deliver reliable data direct to consumers."

Williams says every environment raises different issues.

"Now in China, you don't really need a device to identify the air quality is bad.

"But that generates other problems. You have people buying air purifiers and wanting to identify what the air quality is like inside."

And there's always another question waiting to be answered.

"The current questions are if you have devices that are small, cheap and light how do you ensure you get good quality data? And how do we provide people with reliable data at high spatial resolution that is still affordable?

"That's a significant opportunity and it's also scientifically significant so it keep me interested."

FINDING A MARKET

Professor David Williams was working at the Atomic Energy Research Establishment in the United Kingdom in the 1980s, investigating the measurement of oxygen in vehicle exhaust pipes, when he discovered a group of materials that could be used for sensors, semiconducting oxides that change electrical resistance when exposed to different gases in the air—ozone, nitrogen dioxide and other common pollutants.

Building on this work, he co-founded Capteur Sensors in 1991.

"It was venture-capital funded and we sold sensors to people who make instruments.

"At that time, the big interest was in domestic carbon monoxide measurement. If you've got a gas boiler that's not working efficiently it puts carbon monoxide into the atmosphere and it's going to kill you, so you want to make sure you can monitor it.

"Then our market development guy was at a Trade Show in the United States and he met someone who said he wanted to measure ozone. We tried out one of our sensor materials and it worked.

"Supplying ozone generators is a big market in the United States where the temperatures drop to minus 20 degrees in winter time. The houses are shut up, so the smell of smoke or booze or mould gets trapped. You want to kill that smell and everywhere else you would open a window, but it's minus 20 degrees, so you have an ozone generator.

"You can even turn a smoking room in a hotel into a non-smoking room by filing it full of ozone for a bit. This guy wanted to use ozone generators to kill the smells but not the people.

"That got us thinking and we came up with an ozone detector and we sold about a million."

GOVERNANCE AND FINANCE

MANAGEMENT TEAM

This image, Flower-like Vanadium Oxide Crystals by Surayya Mukhtar, is nanotechnology presented as artwork. Art of the Invisible, 2013.

The MacDiarmid Institute is led by Director professor Kathryn McGrath based at Victoria University of Wellington and Deputy Directors professor Alison Downard at the University of Canterbury (Stakeholder Engagement) and professor David Williams at the University of Auckland (Commercialisation and Industrial Engagement).

Centre Manager, Emily Sullivan, and senior administrator Sarah Dadley are also based at Victoria University of Wellington, while administrator Rebekah Hunt is located at the University of Canterbury.

In 2013, professor Simon Brown held the position of Deputy Director Commercialisation and Industrial Engagement until June 2013 and was manager of the Commercialisation Programme between July and December 2013.

REPRESENTATIVE GOVERNANCE BOARD

In 2013, The MacDiarmid Institute board were:

Dr Steve Thompson, chair, Science and Innovation Promoter, British High Commission.

Professor David Bibby, pro vice-chancellor and dean of science, architecture and design (until 30 June 2013), Victoria University of Wellington.

Dr Wayne Ngata, Ngā Pae o te Māramatanga Principal Investigator, University of Auckland, Te Mata o Te Tau member, Massey University, and Te Reo Māori Schooling group manager at the Ministry of Education.

Dr Bob Buckley, manager, Materials Technologies Group, Industrial Research Ltd.

Professor Don Cleland, Head of School and Professor of Process Engineering, Massey University.

Professor Charles Daugherty, associate vice chancellor research, Victoria University of Wellington.

Professor Jan Evans-Freeman, pro vice chancellor of engineering, University of Canterbury.

Dr Ian Graham, research director, GNS Science.

Professor Jane Harding, deputy vice chancellor (research), University of Auckland.

Roger Ridley, general manager, Strategy and Evaluation Science, Engineering and Technology Delivery, Industrial Research Ltd.

Professor Vernon Squire, deputy vice chancellor, Academic and International, University of Otago.

Mr Geoff Todd, managing director, VicLink Limited

Mr Fred Samandari, Director, Wireless Research Centre, University of Canterbury

EX-OFFICIO

Professor Kathryn McGrath, MacDiarmid Institute Director, Victoria University of Wellington.

Professor David Williams, MacDiarmid Institute Deputy Director, University of Aucland.

Professor Alison Downard, MacDiarmid Institute Deputy Director, University of Canterbury

Professor Simon Brown, MacDiarmid Institute Deputy Director, University of Canterbury.

SCIENCE EXECUTIVE

Members of The MacDiarmid Institute 2013 science executive were:

Professor Kathryn McGrath, MacDiarmid Institute Director, Victoria University of Wellington.

Professor Alison Downard, MacDiarmid Institute Deputy Director (from July 2013) and theme leader of the molecular materials theme (until June 2013), University of Canterbury.

Professor David Williams, MacDiarmid Institute Deputy Director (cross-theme representative), University of Auckland.

Professor Simon Brown, MacDiarmid Institute Deputy Director for commercialisation and industry engagement (until June 2013), University of Canterbury.

Dr Steve Thompson, MacDiarmid Institute board chair, British High Commission promoter of science and innovation.

Professor Shaun Hendy, MacDiarmid Institute theme leader for nanofabrication and devices, Victoria University of Wellington and Industrial Research Ltd.

Shane Telfer, MacDiarmid Institute theme leader for molecular materials (from July 2013), Massey University.

Dr Geoff Willmott, MacDiarmid Institute theme leader for the intersection of nanoscience and biology, Industrial Research Ltd.

Professor Juliet Gerrard, MacDiarmid Institute cross-theme representative, University of Canterbury.

Alex Barker, MacDiarmid Institute MESA chair, Victoria University of Wellington.

Emily Sullivan, MacDiarmid Institute centre manager, Victoria University of Wellington.

INDUSTRY ADVISORY GROUP

The MacDiarmid Institute's Industry Advisory Group comprised:

Michael McIlroy, managing director, Rakon.

Lewis Gradon, senior vice president products and technology, Fisher & Paykel Healthcare.

Greg Shanahan, managing director, TIN100.

Barbara Webster, general manager business development and innovation, Scott Technology.

Paul Adams, chief executive officer, EverEdge IP.

Simon Arnold, chief executive officer, Arnold Consulting.

INTERNATIONAL SCIENCE ADVISORY BOARD

In 2013 The MacDiarmid Institute International Science Advisory Board were:

Dr Jeff Tallon (chair), MacDiarmid Institute Principal Investigator, Robinson Research Institute principal scientist, Victoria University of Wellington. (New Zealand, high-T superconductors.)

Professor Haroon Ahmed, Microelectronics Research Centre emeritus professor, Cavendish Laboratory, University of Cambridge. (United Kingdom, nanoengineered devices.)

Professor Neil Ashcroft, Horace White Professor of Physics, Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca. (United States of America, nanoscience.)

Dr Don Eigler, The Wetnose Institute for Advanced Pelagic Studies director, Auckland and California (New Zealand, United States of America, nanoscience.)

Professor Sir Richard Friend, Cavendish Professor of Physics, University of Cambridge. (United Kingdom, electronic properties of novel materials.)

Professor Lynn Gladden OBE, FRS, Shell professor of chemical engineering and pro vice chancellor for research, Department of Chemical Engineering, University of Cambridge. (United Kingdom, chemical engineering and porous media.)

Professor Michael Kelly, FRS, Prince Philip Professor of Technology, University of Cambridge. (United Kingdom, electro-optic materials and devices.)

Professor Sir Harry Kroto, Nobel Laureate, Francis Eppes, professor of chemistry, Department of Chemistry and Biochemistry, Florida State University. (United States of America, spectroscopy, radioastronomy, nanoscience.)

Professor Hiroshi Mizuta, School of Electronics and Computer Science, University of Southampton. (United Kingdom, nanoengineered electronic devices.)

Professor Daniel Nocera, The Henry Dreyfus Professor of Energy and Professor of Chemistry, Massachusetts Institute of Technology. (United States of America, catalysis, energy.)

Professor Michelle Simmons, Director, Australian Research Council Centre of Excellence for Quantum Computation and Communication Technology. Federation fellow and physics professor, University of New South Wales (Australia, fabrication of atomic-scale devices.)

Professor Mark Warner, Theory of Condensed Matter Group, Cavendish Laboratory Cambridge University. (United Kingdom, soft materials.)

Dr David Williams, chief research scientist and laboratory manager, Hitachi Cambridge Laboratory, Cambridge. (United Kingdom, nanoengineered electroic devices.)

PRINCIPAL INVESTIGATORS

Associate Professor Maan Alkaisi, University of Canterbury.

Dr Martin Allen, University of Canterbury.

Professor Richard Blaikie, University of Otago.

Professor Sally Brooker, University of Otago.

Professor Simon Brown, University of Canterbury.

Professor Alison Downard, University of Canterbury.

Professor Pablo Etchegoin, Victoria University of Wellington.

Dr Nicola Gaston, Victoria University of Wellington.

Professor Juliet Gerrard, University of Canterbury.

Professor Keith Gordon, University of Otago.

Associate Professor Michele Governale, Victoria University of Wellington.

Professor Simon Hall, Massey University.

Professor Shaun Hendy, Victoria University of Wellington.

Dr Justin Hodgkiss, Victoria University of Wellington.

Professor Jim Johnston, Victoria University of Wellington.

Dr John Kennedy,* GNS Science.

Associate Professor Paul E. Kruger,* University of Canterbury.

Associate Professor Eric Le Ru, Victoria University of Wellington.

Dr Duncan McGillivray,* University of Auckland.

Professor Kathryn McGrath, Victoria University of Wellington.

Dr Andreas Markwitz, GNS Science.

Professor Jim Metson, University of Auckland

Dr Natalie Plank,* Victoria University of Wellington.

MACDIARMID EMERGING SCIENTIST ASSOCIATION (MESA)

2013 MESA committee members:

Alex Barker (chair), PhD student, University of Auckland.

Leah Graham (treasurer), PhD student, Victoria University of Wellington.

Brad Mansel, PhD student, Massey University.

Dr Luigi Sasso, postdoctoral fellow, University of Canterbury.

Andrea Kolb, PhD student, Victoria University of Wellington.

Chris Larsen, PhD student, University of Otago.

Rosa Hughes-Currie, PhD student, University of Canterbury.

Brendan Derby, PhD student, Victoria University of Wellington.

Akshita Watson, PhD student, University of Canterbury.

Moritz Banholzer, PhD student, Victoria University of Wellington.

Pauline Calloch, PhD student, Victoria University of Wellington.

Yiewn Pei, PhD student, University of Auckland.

Professor Roger Reeves, University of Canterbury.

Professor Bernd Rehm,* Massey University.

Dr Ben Ruck, Victoria University of Wellington.

Dr Cather Simpson,* University of Auckland.

Professor Jeff Tallon, Industrial Research Ltd.

Associate Professor Shane Telfer, Massey University.

Associate Professor Richard Tilley, Victoria University of Wellington.

Associate Professor Jadranka Travas-Sejdic, University of Auckland.

Professor Joe Trodahl, Victoria University of Wellington.

Associate Professor Bill Williams, Massey University.

Professor David Williams, University of Auckland.

Dr Grant Williams, Victoria University of Wellington.

Dr Geoff Willmott, Industrial Research Ltd.

Professor Ulrich Zuelicke, Victoria University of Wellington.

EMERITUS INVESTIGATORS

Professor Alan Kaiser,* Victoria University of Wellington.

Professor Ken MacKenzie,* Victoria University of Wellington.

**New to role in 2013.*

ASSOCIATE INVESTIGATORS

Dr Mike Arnold, Callaghan Institute.

Professor Margaret Brimble,* University of Auckland.

Professor Penny Brothers,* University of Auckland.

Dr Bob Buckley, Callaghan Institute.

Dr Damian Carder, Callaghan Institute.

Dr Mark Bowden,** United States Department of Energy.

Dr Ian Brown, Callaghan Institute.

Dr Chris Bumby, Callaghan Institute.

Dr Shen Chong,* Callaghan Institute.

Professor Sally Davenport, Victoria University of Wellington.

Dr James Downes, Macquarie University.

Dr Petrik Galvosas, Victoria University of Wellington.

Dr Simon Granville, Callaghan Institute.

Associate Professor Yacine Hemar,** University of Auckland.

Dr Guy Jameson, University of Otago.

Dr Michelle Dickinson,* University of Auckland.

Professor John Evans, University of Canterbury.

Dr Vladimir Golovko, University of Canterbury.

Professor Lyall Hanton,* University of Otago.

Dr Bridget Ingham, Industrial Research Ltd.

Professor Geoff Jameson, Massey University.

Dr Jianyong Jin,* University of Auckland.

Dr Ruth Knibbe, Callaghan Institute.

Dr Aaron Marshall, University of Canterbury.

Associate Professor Stephen Moratti,* University of Otago.

Dr Franck Natali, Victoria University of Wellington.

Dr Tim Kemmitt, Callaghan Institute.

Dr Nigel Lucas, University of Otago.

Dr Carla Meledandri, University of Otago.

Dr Suresh Narayanaswamy,* Industrial Research Ltd.

Dr Volker Nock, University of Canterbury.

Dr Mike Reid, University of Canterbury.

Professor John Spencer, Victoria University of Wellington.

Dr Wenhui Wang, Tsinghua University.

Dr Geoff Waterhouse, University of Auckland.

Dr Stuart Wimbush, Callaghan Institute.

Dr Zoran Zujovic,*

Professor Kevin Smith,* University of Auckland.

Dr Mark Staiger, University of Canterbury.

Dr Mark Waterland, Massey University.

Dr John Watt,** Victoria University of Wellington.

Dr Tim Woodfield,* University of Otago.

Dr Zoran Zujovic,* University of Auckland.

**New in 2013 ** Left in 2013.*

HONORARY INVESTIGATORS

Professor David Officer, University of Wollongong (Australia).

Associate Professor Steve Durbin, State University of New York at Buffalo (United States of America).

POSTDOCTORAL FELLOWS

Dr Baptiste Auguie, Victoria University of Wellington (supervisor, Associate Professor Eric Le Ru).

Dr Paula Brooksby, University of Canterbury (supervisor, Professor Alison Downard).

Dr Ciaran Dolan, University of Auckland (supervisor, Professor David Williams).

Dr Fleur Drouet, University of Auckland (supervisor, Professor David Williams).

Dr Mike Fraser, University of Otago (supervisor, Professor Keith Gordon).

Dr Humphrey Feltham, University of Otago (supervisor, Professor Sally Brooker).

Dr Dang Thai Giang, University of Canterbury (supervisor, Dr Martin Allen).

Dr Thomas Kernreiter, Victoria University of Wellington (supervisor, Professor Uli Zuelicke).

Dr Haifeng Ma, University of Canterbury (supervisor, Professor Simon Brown).

Dr Doreen Mollenhaue, Industrial Research Ltd (supervisor, Dr Nicola Gaston).

Dr Suresh Narayanaswamy, Victoria University of Wellington (supervisor, Professor Jeff Tallon).

Dr Yiwen Pei, University of Auckland (supervisor, Professor David Williams).

Dr Luigi Sasso, University of Canterbury (supervisor, Professor Juliet Gerrard).

Dr James Storey, Victoria University of Wellington (supervisor, Dr Grant Williams).

Dr Sandy Suei, Massey University (supervisor, Professor Bill Williams).

ESTABLISHMENT POSITIONS

Dr Martin Allen, University of Canterbury.

Associate Professor Richard Tilley, Victoria University of Wellington.

RESEARCH FELLOWS/ TECHNICAL ASSISTANTS

David Flynn, Victoria University of Wellington.

Dr Natasha Munro, Victoria University of Wellington.

Olly Pantoja, Victoria University of Wellington.

Gary Turner, University of Canterbury.

Pablo Lepe, University of Canterbury.

David Lun, Massey University.

FINANCE

The MacDiarmid Institute ended the 2013 calendar year in a sound financial position.
The following tables outline the Institute's financial performance in 2013.

THE MACDIARMID INSTITUTE
SPECIAL PURPOSE – STATEMENT OF FINANCIAL PERFORMANCE
FOR THE PERIOD ENDED 31 DECEMBER 2013

ALL QUOTED EXCL OF GST	Note	Victoria University Wellington	University of Canterbury	Massey University	University of Otago	University of Auckland	IRL	GNS	Consolidated
		$ 000	**$ 000**	**$ 000**	**$ 000**	**$ 000**	**$ 000**	**$ 000**	**$ 000**
REVENUE									
Operational Receipts		3,714	1,550	494	435	605	271	152	7,221
Interest Income	1	155							155
Other Income	2	-	87	8	31		10		136
Total Revenue		3,869	1,637	502	466	605	281	152	7,512
EXPENDITURE									
People Costs		833	597	176	190	260	141	86	2,283
Overheads		511	378	81	120	142	74	36	1,342
Direct Project Costs		1,156	73	43	19	21	25	-	1,337
Travel		275	100	21	17	36	41	30	520
Postgraduate Students		774	282	131	117	146			1,450
Depreciation on CoRE Eqpt	3	320	207	50	3				580
Subcontractors		-							-
Extraordinary Items		-							-
Total Expenditure		3,869	1,637	502	466	605	281	152	7,512
Surplus for the year		-	-	-	-	-	-	-	-

STATEMENT OF MOVEMENTS IN EQUITY
FOR THE PERIOD ENDED 31 DECEMBER 2013

	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 DEC 2013

	Victoria University Wellington	University of Canterbury	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	5,681	2,140	818	219	134	-88	-	8,904
Accounts Receivable & Prepayments	-		-	-				-
Total Current Assets	5,681	2,140	818	219	134	(88)	-	8,904
NON-CURRENT ASSETS								
Plant & Equipment	7,914	5,281	996	496	-	-	-	14,687
Construction in Progress	-		-	-				-
Total Non-Current Assets	7,914	5,281	996	496	-	-	-	14,687
TOTAL ASSETS	**13,595**	**7,421**	**1,814**	**715**	**134**	**(88)**	**-**	**23,591**
CURRENT LIABILITIES								
Accounts Payable and Accruals	-	-	-	-	-	-	-	-
Research Grants Unexpended	3,275	334	162	151	134	-88	-	3,968
Total Current Liabilities	3,275	334	162	151	134	(88)	-	3,968
TOTAL NET ASSETS	**10,320**	**7,087**	**1,652**	**564**	**-**	**-**	**-**	**19,623**
Represented By:								
COMMUNITY EQUITY	**10,320**	**7,087**	**1,652**	**564**	**-**	**-**	**-**	**19,623**

THE MACDIARMID INSTITUTE
SPECIAL PURPOSE - STATEMENT OF CASH FLOWS
FOR THE PERIOD ENDED 31 DECEMBER 2013

	Victoria University Wellington	University of Canterbury	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	3,020	1,590	442	435	549	200	104	6,340
Interest income on funds held	155							155
Other sources	-	87	8	31		8		134
	3,175	1,677	450	466	549	208	104	6,629
Cash was applied to:								
Employees and Suppliers	(3,549)	(1,430)	(452)	(463)	(605)	(281)	(152)	(6,932)
	(3,549)	(1,430)	(452)	(463)	(605)	(281)	(152)	(6,932)
NET CASH FLOWS FROM OPERATING	**(374)**	**247**	**(2)**	**3**	**(56)**	**(73)**	**(48)**	**(303)**
INVESTING ACTIVITIES								
Cash was provided from:								
	-	-	-	-	-	-	-	-
Cash was applied to:								
Property, Plant & Equipment	-		(372)	101	-	-	-	(271)
NET CASH FLOWS FROM INVESTING	**-**	**-**	**(372)**	**101**	**-**	**-**	**-**	**(271)**
FINANCING ACTIVITIES								
Cash was provided from:								
Funds from TEC	-	-	-	-	-	-	-	-
NET CASH FLOWS FROM FINANCING	-	-	-	-	-	-	-	-
Net Cash Flows for the year	(374)	247	(374)	104	(56)	(73)	(48)	(574)
Add Cash at start of year	6,055	1,893	1,192	115	190	-15	48	9,478
CASH AT END OF THE YEAR	**5,681**	**2,140**	**818**	**219**	**134**	**(88)**	**-**	**8,904**
Cash at end of the year comprises:								
Cash at Bank/Short Term Investments	5,681	2,140	818	219	134	(88)	-	8,904
CASH AT END OF THE YEAR	**5,681**	**2,140**	**818**	**219**	**134**	**(88)**	**-**	**8,904**

NOTES TO THE SPECIAL PURPOSE FINANCIAL STATEMENTS

NOTE 1:

Interest Income: Revenue generated from investment of Centre of Research Excellence (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.

NOTE 4:

Payments from the Tertiary Education Commission: During 2013, The MacDiarmid Institute received CoRE funding from the TEC. The funding received from the TEC was $6,385,553 (2012: $6,632,145)

STATEMENT OF ACCOUNTING POLICIES

The reporting entity

The MacDiarmid Institute is a collaboration between Victoria University Wellington, University of Canterbury, The University of Auckland, Massey University, University of Otago, GNS Science and Callaghan Innovation to undertake research on a project funded by the Ministry of Education (MoE) via the Tertiary Education Commission (TEC). The terms of this collaboration are set out in the Memorandum of Understanding agreed by the partners in July 2008 and was initially established in 2002.

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 and 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.

Cash flow policy

The following are the definitions of the terms used in the Special Purpose Statement of Cash Flows: (a) Operating activities include all transactions and other events that are not investing or financing activities, (b) Investing activities are those activities relating to the acquisition, holding and disposal of property, plant and equipment and of investments. Investments can include securities not falling within the definition of cash, (c) Financing activities are those activities that result in changes in the size and composition of the capital structure. This includes both equity and debt not falling within the definition of cash. Dividends paid in relation to the capital structure are included in financing activities and (d) Cash is considered to be cash on hand and current accounts in banks, net of bank overdrafts.

Changes in accounting policy

There have been no changes to the accounting policies outlined above.

DIRECTORY

THE MACDIARMID INSTITUTE FOR ADVANCED MATERIALS AND NANOTECHNOLOGY
Victoria University of Wellington
PO Box 600
Wellington 6140
New Zealand

Courier address:
Room 410 Laby Building
Gate 7 Kelburn Parade Victoria University of Wellington macdiarmid-institute@vuw.ac.nz

phone: +64 (0)4 463 5950
fax: +64 (0)4 463 9975
www.macdiarmid.ac.nz

PARTNER INSTITUTIONS:

UNIVERSITY OF AUCKLAND
The University of Auckland
Private Bag 92019
Auckland 1142
New Zealand
www.auckland.ac.nz

VICTORIA UNIVERSITY OF WELLINGTON
PO Box 600
Wellington 6140
New Zealand
www.vuw.ac.nz

THE UNIVERSITY OF CANTERBURY
Private Bag 4800
Christchurch 8140
New Zealand
www.canterbury.ac.nz

MASSEY UNIVERSITY
Private Bag 11 222
Palmerston North 4442
New Zealand
www.massey.ac.nz

THE UNIVERSITY OF OTAGO
Private Bag 56
Dunedin 9054
New Zealand
www.otago.ac.nz

CALLAGHAN INNOVATON
PO Box 31 310
Lower Hutt 5040
New Zealand
www.callaghaninnovation.govt.nz

GNS SCIENCE
PO Box 30 368
Lower Hutt 5040
New Zealand
www.gns.cri.nz

For current contact information for all our investigators and support staff, please refer to www.macdiarmid.ac.nz