The MacDiarmid Institute Annual Report

2015

The MacDiarmid Institute for Advanced Materials and Nanotechnology

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Director's report

Great things start with a great vision. The MacDiarmid Institute for Advanced Materials and Nanotechnology is part of Sir Paul Callaghan's vision for a vibrant and prosperous New Zealand transformed through science and technology.

His recipe was simple: bring together New Zealand's best and brightest in science and give them the means and mission to undertake excellent research, train New Zealand's future leaders and translate the research outputs into economic benefit. When Sir Paul founded the MacDiarmid Institute in 2002, this idea was revolutionary; more than a decade later, it has proven its value and has been copied many times within the New Zealand research sphere. Sir Paul saw the value in bringing together not just the scientists but the scientists and the businesspeople, scientists and communities, New Zealand with the world. In setting up the MacDiarmid Institute and inspiring all that followed, he has made a huge impact on New Zealand's culture, society and economy.

2015 was a transition year for the MacDiarmid Institute. Director Professor Kate McGrath was appointed Vice-Provost (Research) at the Victoria University of Wellington after securing a further six years of funding for the Institute in 2014. Kate left a legacy of collaboration and excellent research outputs across a wide breadth of materials sciences. Around the same time, our new Centre Manager Jacqui FitzGerald, and a new chair of the board Dr Ray Thomson, commenced their roles. About mid-2015, two new Deputy Directors were appointed: Associate Professor Nicola Gaston (Stakeholder Engagement) and Dr Justin Hodgkiss (Commercialisation and Industry Engagement). I arrived mid-August and found the Institute in excellent shape. I would like to thank all of these wonderful people, who helped me in settling in and making this transition as smooth as possible. Throughout the transition, the Institute continued to achieve at the highest academic level.

I am very pleased to be able to report that the MacDiarmid Institute delivered in all key areas, and beyond: excellent research – "Out of the lab", commercialisation & industry engagement –"Into the marketplace", as well as outreach, education and leadership – "Into the community". Again, MacDiarmid Investigators have made it clear that team building and collaboration makes a real difference to New Zealand, well beyond what individuals could have achieved alone. MacDiarmid Investigators contributed at the highest level to the advancement of fundamental research, and showed that pure research and commercial success are natural companions; a number of young 'spin-out' companies formed from the MacDiarmid Institute research and our scientists made an impact at the Angel Investor forum "Pitch on a Peak" . Moreover, MacDiarmid researchers continued to empower teachers (early childhood, primary and secondary) to take science into the classroom, and inspire college and tertiary students to become New Zealand's future leaders. We saw Vision Mātauranga in action at the MacDiarmid Student and Postdoc Symposium and the Discovery Awards.

I invite you to read on and join us in celebrating our achievements in 2015, both in the laboratory and throughout society, where the MacDiarmid Institute continues to transform New Zealand culture, science and industry. Our stories speak for themselves.

Professor Thomas Nann
Director

Great things start with a great vision.

Chair's report

2015 has been a year of much change at the MacDiarmid Institute. I came in as a fresh board appointment to the Chair role on 1 January 2015 and Kate McGrath stepped down as Director on 30 June 2015.

As a result we have appointed a new and energetic leadership team. The new Director is Thomas Nann, who was chosen in a keen contest. Thomas brings international experience to the role and in addition to his strong academic background, has the necessary personal skills to help reshape the Institute over the next few years. In addition we have appointed two new Deputy Directors, Justin Hodgkiss (Commercialisation and Industry Engagement) and Nicola Gaston (Stakeholder Engagement).

In the commercialisation area I have been actively involved with several projects being worked on by our Investigators. At least five projects involved with MacDiarmid Investigators have entered or are in discussion to enter the recently established Tech Incubators.

Finally I extend my thanks to Kate McGrath, our immediate past Director, for her considerable contribution to the Institute over her four years as Director and I wish her well in her new role as Vice-Provost (Research) at Victoria University of Wellington.

Dr Ray Thomson
Chair

About us

The MacDiarmid Institute for Advanced Materials and Nanotechnology is a national network of top New Zealand scientists.

The Institute leverages strengths across the country and internationally, working collaboratively utilising a programme-based approach to undertake harder, higher level research that drives innovation and economic growth in and for relevant New Zealand industries.

MacDiarmid Institute
Annual Report
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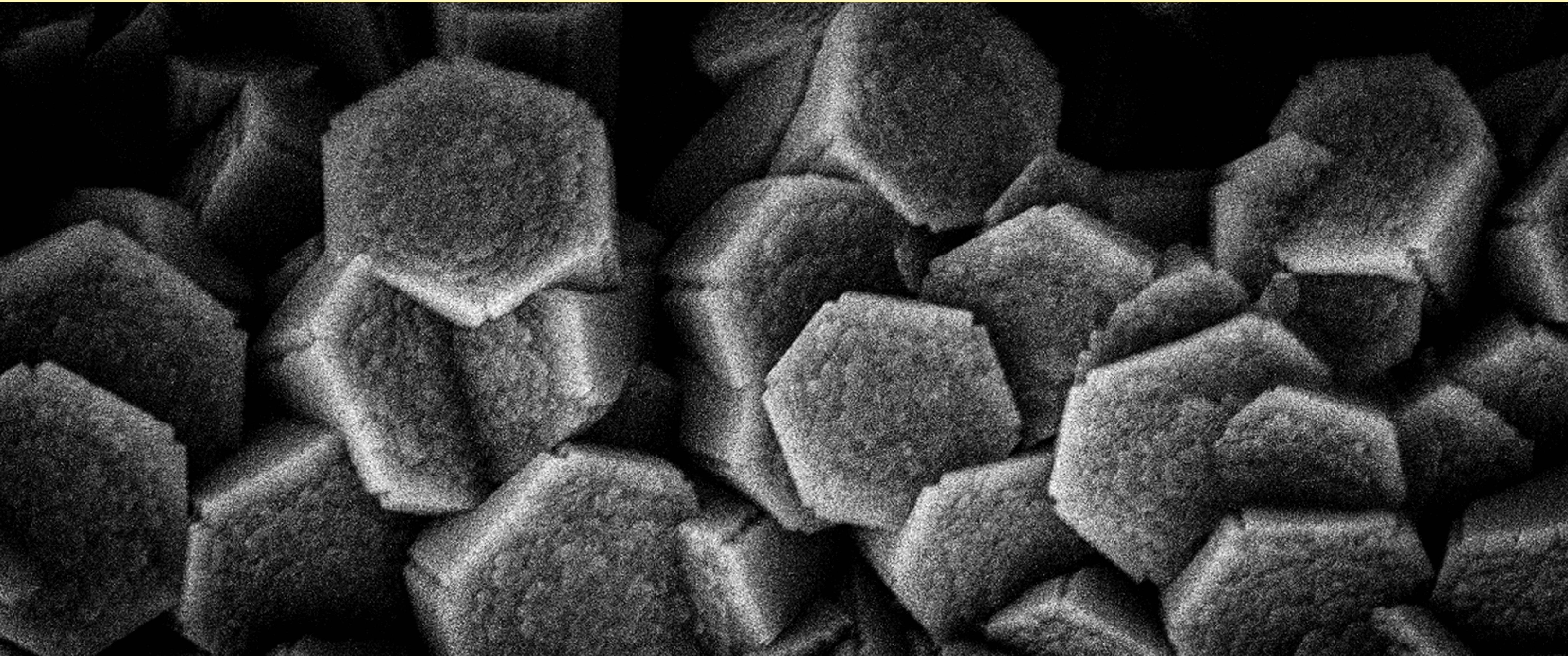
Out of the lab



It is this collaboration that allows researchers to get below the surface in materials science. This is the MacDiarmid difference.

Overview

Materials science areas

1
MacDiarmid researchers are teaming up to develop **smart materials inspired by the natural world**.

2
With MacDiarmid-led research, New Zealand has the potential to be a world-leader in the transition to a 100% renewable energy economy. MacDiarmid research on **clean energy materials** spans from new, highly efficient photovoltaic cells, and materials for greenhouse gas absorption and energy storage (for example batteries), to high temperature superconductors for wind turbines.

3
New materials enable new functions. MacDiarmid researchers develop **new advanced nanomaterials for devices** such as touchscreen displays and medical imaging technologies.

The MacDiarmid Institute is an interdisciplinary network of leading scientists in physics, chemistry and biology in New Zealand. Each MacDiarmid Investigator is based at a university or research institute, where they teach and research. Yet each Investigator connects tangibly with colleagues in their field and across disciplines through their engagement with the Institute.

The MacDiarmid takes us beyond our institutions," says Professor Thomas Nann, who has led the Institute since August 2015. "It gives the best researchers in nano and materials science in New Zealand the opportunity to share and learn and research together and make a real difference to New Zealand. Our science stories (pages 6–27) show 'the MacDiarmid difference'; stories of collaboration and discoveries that may never have happened without the MacDiarmid connections. These certainly would not have happened in the timeframes they have, and possibly not in New Zealand."

Over recent decades, science has become increasingly segregated. While necessary to some degree, the segregation creates artificial boundaries between the disciplines of physics, chemistry and biology. These boundaries do not represent the world around us; all science is part of a whole – learning from exploring the world around us – albeit – in our case – in the tiny dimensions of nanoparticles and materials science.

The MacDiarmid Institute dissolves these boundaries and enables researchers in one area of science to shine the light of their own research and singular approach onto the area of their MacDiarmid colleagues from other disciplines. It is this collaboration that allows researchers to get below the surface in materials science.

This is the 'MacDiarmid difference'.

Shining a light on milk

Most of us carefully keep milk away from light. But three teams of scientists at the MacDiarmid Institute are instead shifting milk into the light, so that it yields a wealth of useful information with the potential to add value to our dairy industry, and more.

Studying how matter interacts with electromagnetic waves – which include visible light – is called spectroscopy. Every atom, molecule, or more complex substance has its own 'absorption spectrum'. This can be graphed, and shows how a substance absorbs each frequency of electromagnetic wave. In theory, if you had the technology and knew what to look for, you could discover what was in almost anything by using spectroscopy. Of course, in practice, it's nowhere near that simple.

Absorbing projects

MacDiarmid Principal Investigator Associate Professor Cather Simpson, at the University of Auckland, has invented Milk-on-a-Disc. A transparent disc is spun inside a device like a robust CD-player.

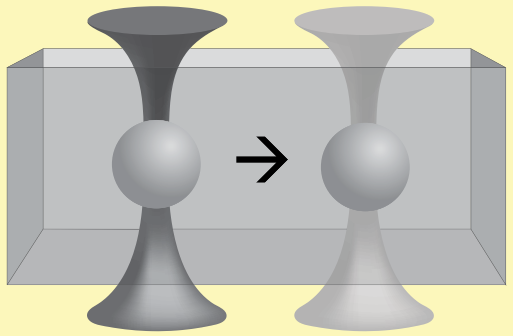
As milk flows down the disc's specially designed channels, light shines onto it, and an attached spectrometer charts which frequencies of light are absorbed, and which are scattered. The rapidly obtained results reveal detailed data about the milk's composition – providing a vital, no-fuss tool for dairy farmers.

Another team at the MacDiarmid Institute are also innovating in spectroscopy, with potentially exciting applications in dairying. Non-transparent, cloudy liquids often cause headaches for spectroscopists, but a possible solution recently emerged from fundamental research by a team comprising Professor Eric Le Ru, along with PhD student Brendan Darby and postdoctoral researcher Dr Baptiste Auguié.

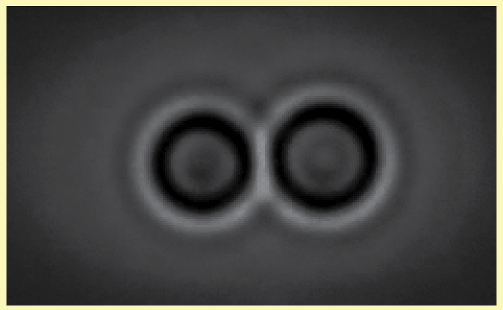
Their invention, dubbed 'CloudSpec' is little bigger than a microwave, and has a unique design that they hope will enable new information to be unlocked from cloudy liquids – milk and more.

Centrifugal microfluidic platform disc.

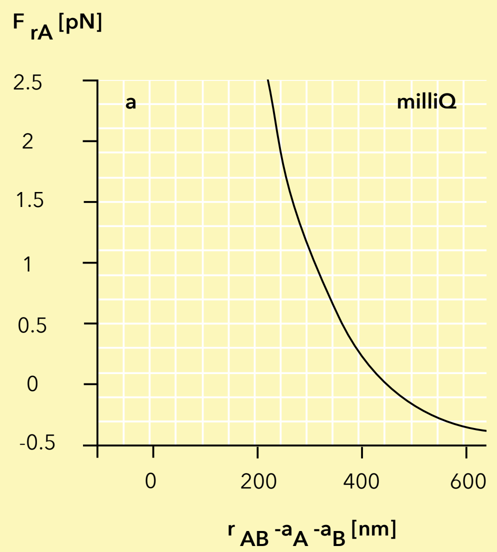
Schematic of two colloidal particles or emulsion drops trapped in optical potentials that are used to move them towards one another.



Two micron-sized emulsion drops brought close to one another using optical traps.



A typical force curve measured during the approach of one emulsion drop to another, showing how the electrostatic repulsion increases as they approach.



Laser sharp

Principal Investigator Professor Bill Williams, meanwhile, is experimenting with 'optical tweezers' – an instrument based on the discovery, around 30 years ago, that tightly focused beams of laser light can be used to grasp and then manipulate microscopic objects, in order to learn more about their physical properties.

Because this technique is so new, applications are waiting to be discovered, and Williams and his team are among the first in the world exploring the possibilities. As shown in a recent collaborative project with Professor Kate McGrath and Riddet Institute PhD student Marjorie Griffith, these include studying how milk fat globules can be manipulated.

Quick and convenient

Cather Simpson's work has attracted wide interest from dairy farmers, as Milk-on-a-Disc is designed to fit into their busy lives. Imagine a milking shed with one device set up at each milking station. The farmer loads the discs before milking, and chooses what needs to be tested for.

The rest of the process is automated. During milking, a small sample of each cow's milk is tested, and the data is collected and stored, allowing the farmer to analyse their milk production in multiple ways over time. The device is likely to also include a 'trigger' that identifies problems such as mastitis on the spot. Simpson and her team are planning for a commercial prototype in 2017.

Seizing the opportunity

CloudSpec is currently at the research stage. It began life as a customised lab instrument that the team developed for another project – studying the optical properties of molecules on metallic nanoparticles – which was recently published in Nature Photonics. Only recently did they begin to explore their invention's exciting range of commercial possibilities, thanks to Victoria University's tech-transfer office and additional support from a KiwiNet Emerging Innovator award received by MacDiarmid PhD student Brendan Darby.

The team has just begun an initial scoping project to establish what they'll need to do to produce a minimal working prototype that's inspired by market needs, and can be presented to potential investors. Ascertaining the composition of milk is just one possible use.

Paint could be analysed; so could blood, or water thick with algae. A big part of the team's work right now is figuring out exactly where to target efforts to maximise the potential for commercialisation.

Solving sticky issues

While Milk-on-a-Disc and CloudSpec have applications on the farm, research using optical tweezers could well benefit the factory.

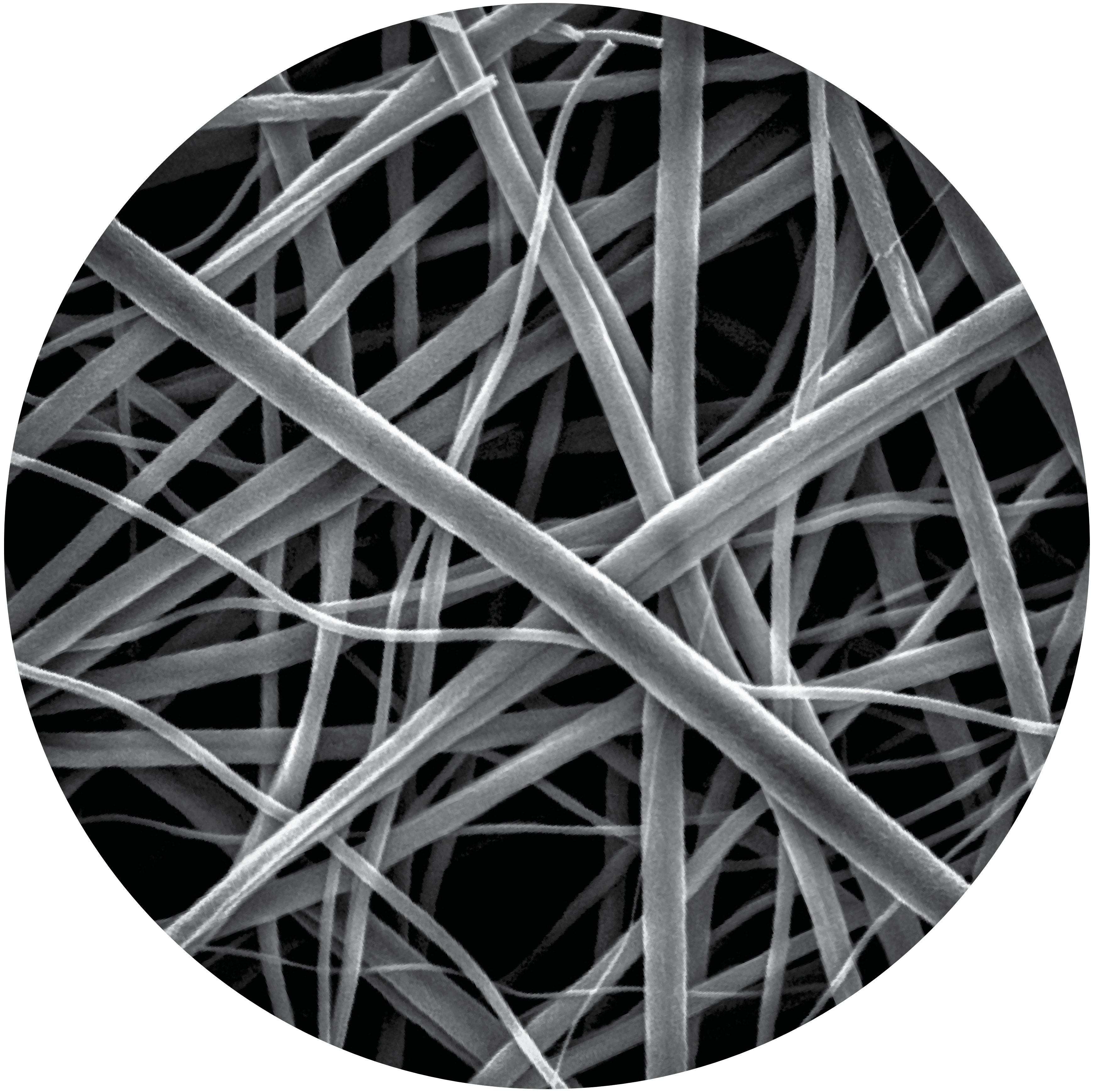
Optical tweezers can be used to study emulsions – microscopic droplets of one fluid immersed in another. Professor Williams and his team want to see how fat drops interact with other particles in various environmental conditions, including under different temperatures and pressures.

Making yoghurt and cheese relies on the destabilisation of these fat particles, so that they start sticking together. Using optical tweezers, postdoctoral researcher Dr Rob Ward and PhD student Sapna Ravindran, supported by a Primary Growth Partnership project and Fonterra, aim to measure how this stickiness develops. And understanding that in greater detail would allow makers of milk products to control these processes more tightly.

Different angles

When it comes to milk, the diversity of work undertaken by MacDiarmid scientists is one of our strengths. Our people are illuminating the way forward for New Zealand's world-class dairy industry.

Eric Le Ru, Bill Williams and Cather Simpson



Materials to answer the energy question

New Zealand's love of the great outdoors may be world-famous, but it is our use of renewable energy that really makes us stand out internationally. As of the end of 2015, 80% of our electricity was generated by renewable sources (largely geothermal and hydroelectric), leaving us second only to Iceland across all OECD countries. And we're not done yet – at the United Nations Conference of Parties (COP21) held in Paris in 2015, we committed to increasing that proportion to 90% by the year 2025.

Achieving this ambitious target will be a challenge, but the cutting-edge research from scientists at the MacDiarmid Institute will have a role to play, and could transform the way we harvest energy.

Maan Alkaisi and Jeff Tallon

Super-stuff

Passing electricity through a wire can produce a lot of heat. While this can be useful in some applications (e.g. electric ovens), in others, it causes considerable energy losses. There are a class of materials called superconductors that can conduct electricity without losing heat energy. They used to operate only at -269°C, but 28 years ago work from Professor Jeff Tallon and colleagues from Victoria University's Robinson Research Institute shifted their operating temperature to -163°C. While still undoubtedly cold, this big temperature jump helped to completely revolutionise the field of superconductivity and has major implications for the energy sector. Professor Tallon is still a leader in the field today. In a recent paper in Nature Communications, he and fellow researcher Dr Evgeny Talantsev uncovered a single underlying principle common to all superconductors, and proved that their fundamental behaviour could be described by a single measurement of electrical current density. This ground-breaking result will make it easier to identify materials with advantageous superconducting properties.

Full of energy

Cables made from superconductors are being used in the world's best particle accelerators, and in precision hospital MRI scanners, but it's their role in the energy sector that is causing a lot of excitement. Speaking about the efforts of his wider team, Professor Tallon said, "We have high-temperature superconductor programmes in energy generation, storage and conversion. All of which are hugely challenging projects. "In wind turbines, replacing the bulky copper cabling of the generator with resistance-free superconductors would greatly reduce the weight, and boost its efficiency. In large transformers, these materials remove the need to use oil as a coolant, hugely reducing the risk of accidental ignition. The key to their success is the vast amount of electrical current superconductors can carry, "Take a conductor with the same cross-section as my thumb, (1 cm^2)." said Professor Tallon. "One made from copper could carry about 500 Amps but for high-temperature superconductors, it's more like 30 million Amps!"

A shining example

Arguably, it's the sun that is our most vital source of energy. Not only does sunlight help plants and crops to flourish, but by using photovoltaic solar panels, it can also be converted into electricity. When sunlight hits these panels (which are mainly made from layers of silicon), it knocks electrons out of position, causing them to flow and contribute to conduction. Because only certain wavelengths of sunlight have this effect, while others are either reflected off the surface or transmitted out of the material, solar panels are far from 100% efficient.

But Professor Maan Alkaisi at the University of Canterbury is using nanotechnology to change that. By printing a pattern of inverted pyramids just 300nm tall (that's 20 times smaller than a red blood cell) on the surface of a solar panel, and coating them in silicon nanoparticles, he has been able to drastically improve the efficiency of the panel. "For all energy conversion devices, the challenge is always to increase the efficiency while keeping the cost down," Professor Alkaisi said. "What we're doing doesn't require expensive equipment, and it can be scaled up."

Glass ceiling

The coating has two features – the nanopyramids and the nanoparticles – each with a specific role. The nanopyramids trap sunlight, reducing reflections from the surface, and the nanoparticles tune the range of wavelengths that the panel can capture. Together they provide a thin, permanent structure that improves the efficiency of commercial solar panels at a very low cost. Professor Alkaisi has also shown that by making a master 'mould' of his pyramid structure, this coating can be applied to other materials, such as polymers and glass. "My vision is to use this to make transparent, building-integrated photovoltaics," he said. "Imagine a greenhouse that lets sunlight reach the plants, while absorbing some of it to produce electricity for use in irrigation, lighting and ventilation. For both the future of food production and energy generation, the possibilities are endless!"

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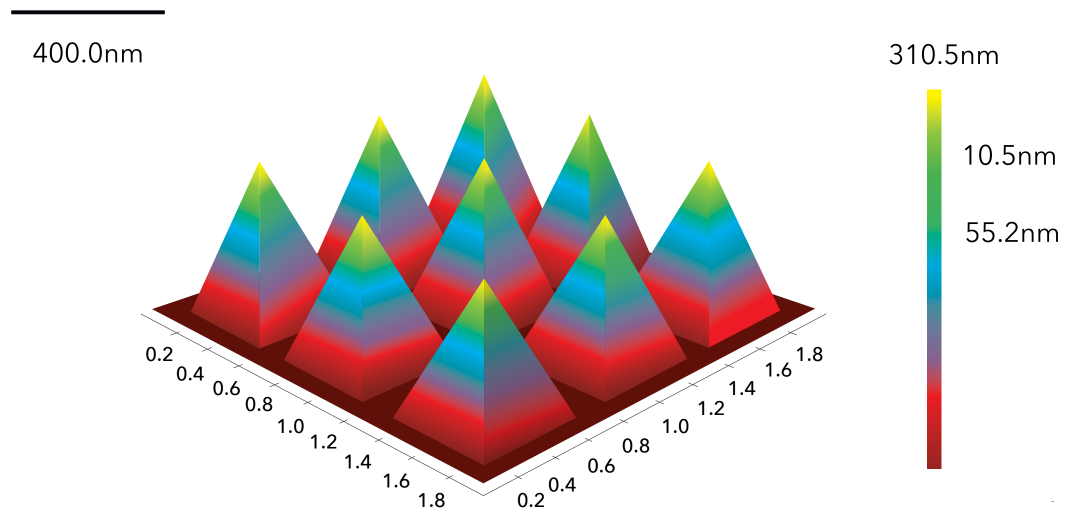


AFM image of the pyramid structures on glass substrate, measures 400nm base and 310nm height.

A clear way forward

Nowadays, we tap and swipe the touchscreens of our phones and tablets so routinely that we rarely stop to marvel at the amazing material technology that we're relying on. MacDiarmid Institute scientists, however, are thinking about it a great deal.

Natalie Plank, Alison Downard, Roger Reeves, Martin Allen and Uli Züelicke

The substances that coat our touchscreens and make them work need two key qualities: conductivity, so that they're sensitive to the position of our fingers; and transparency, so that we can see what's on the screen. They also need to be able to be mass produced economically and robust enough to facilitate long-term everyday use.

Race for replacement

Currently, most touchscreens in the world owe their functionality to a very thin layer of indium tin oxide. But there is global worry about the continued supply of this transparent conductive oxide. Supply of the mined ingredient that it's based on, indium, is finite, and prices for it are going up. The search is on to develop other transparent conductors that can be used in its place. This is where the MacDiarmid Institute scientists come in.

Something old, something new

Principal Investigators Associate Professor Martin Allen, Professor Alison Downard, and Professor Roger Reeves at the University of Canterbury, along with Principal Investigator Dr Natalie Plank, from Victoria University of Wellington's School of Chemical and Physical Sciences, are working with a tried and true material – zinc oxide. This is similar to indium tin oxide, but it's cheaper, and the ingredients needed to make it are much more readily available.

Meanwhile, Principal Investigator Professor Uli Züelicke, also at the Victoria University of Wellington School of Chemical and Physical Sciences, is working on understanding the new and exciting properties of graphene, a material made up of a microscopically thin sheet of carbon atoms arranged in a honeycomb lattice. Touchscreen manufacturers have already begun to use zinc oxide-based materials, but the field is wide open for further development. And the possibilities for zinc oxide – and other transparent conductors like graphene – don't stop there.

Wonder material

Graphene was isolated and studied electronically in 2004, and a Nobel Prize was awarded in 2010 in relation to its potential use in electronic devices. Scientists around the world have found increasingly effective ways to produce it, and have been experimenting with its exciting and unusual physical properties. Graphene is mechanically strong, and conducts electric current and heat better than almost anything else. This makes it an almost ideal candidate for use as a durable touchscreen material. Professor Züelicke is researching new ways to manipulate graphene's properties using mathematical models and simulations. In particular, he is investigating how graphene reacts to electric and magnetic fields as well as mechanical stress, which are crucial features for touchscreen development.

Safe, but not boring

While graphene is a young, unconventional material, zinc oxide has been used for years in sunscreens and other skin products, and as a nutritional food additive. It's inexpensive to produce, recyclable, and is known to be non-toxic and biocompatible. Plank, Allen, Downard and Reeves are excited by the numerous possibilities that such a safe and abundant substance offers. To make the best use of zinc oxide, and produce stable, viable devices, they and their teams are working on understanding and controlling its very unusual surface properties in detail. Other oxides are on their radar too: tin oxide, gallium oxide, and combinations of these.

A window to the future

Graphene, oxides, and other transparent conductors could form the basis for a new range of transparent devices for smart windows. Think invisible solar panels. Or thin-film transistors – where the finest of transparent coatings can be activated to become a video screen.

There are various ways of coating screens with transparent conductors, but nano-technology offers particularly exciting possibilities. Nanowires, so fine they can't be seen by the naked eye, can be made from an oxide, or a conductive metal, and placed across screens as a mesh.

Increasing flexibility

Dr Plank has developed a method to cheaply 'grow' nanowires. She says that while zinc oxide nanowires are usually around 150nm wide, she can now make wires that are only 10 to 20nm. "This gives them a vastly improved electronic response." Dr Plank says nanowires have the advantage of flexibility. "If you pull, press or bend them, they won't break. They can be used on flexible substrates like plastic, and could have all sorts of exciting and innovative uses on clothing and in medical diagnostic tools."

Making molecular magnets

These days, magnetic memory is everywhere. Hidden inside your smartphone, your laptop and even your credit card, billions of tiny magnetic stripes store information in the form of 1's and 0's; the language of our digital age. But recent research from Professor Sally Brooker's team at the University of Otago is looking at magnets in a new way. They have developed and immobilised magnets each made from a single molecule that could open up a world of high-density data storage, and futuristic computers.

Short on storage

Typically, magnets are made up of regions called domains, which, in reality, are clustered groups of atoms or molecules that are aligned with one another. Because these regions are separated by domain walls, each one can store a single 'bit' of information; so to store lots of data, we need lots of domains. But in this era of miniaturisation, size is everything, and the only way to squeeze more data in, is by making the domains themselves smaller. This is exactly where the Otago team's work comes in – instead of relying on groups of molecules, their single molecule magnets, or SMMs for short, could store information on just one.

So, what do they look like? "Our SMMs are macrocycles – large rings of organic fluff – that surround three transition metal ions and one lanthanide ion," said Professor Brooker, "and it's this structure that allows us to control their chemistry." 'Large' is very much a relative term here – the ring measures just 1.3nm across, equivalent to one-millionth of a millimetre. The big ring structure developed by Professor Brooker and her co-worker, Dr Humphrey Feltham, makes these SMMs very robust. Unlike many other molecular magnets in development, theirs retains its structure when dissolved – vital for processing into practical, scalable SMM devices.

Collaboration is key

Professor Brooker and Dr Feltham have worked on SMMs for a number of years, collaborating with Professor Annie Powell (Germany), Professor Rodolphe Clérac (France) and Professor Chibotaru (Belgium). Their first paper was featured on the cover of the Chemistry a European Journal, and has been highly cited (111 times since 2011). But it was during Dr Feltham's first post-doc, funded by the MacDiarmid Institute, that they had their latest breakthrough. Working with Professor Brooker's colleague Dr Carla Meledandri, they successfully attached their magnetic molecules to the surface of gold nanoparticles. The design of the connection between them ensured each nanoparticle was covered by a single layer of SMM. Then, using the Institute's SQUID magnetometer in Lower Hutt, they demonstrated that their molecule retained its unique magnetic behaviour once immobilised on the nanoparticle. A very exciting day at the lab!

Professor Brooker visited the world's leading SMM researcher, Professor Roberta Sessoli (Florence), and this result really caught the Italian team's attention. "This is the team that discovered the very first single molecule magnets in 1993," recalls Professor Brooker. "They can choose to work with any group they want, so we are very excited to be now collaborating with them in order to characterise our new material in more depth."

Sally Brooker and her research group

Cool customers

For most practical applications, magnetic storage materials need to retain their magnetisation for 10 years – right now, single molecule magnets are some way from that. Even at the incredibly low temperature of 1.5K (-271.65°C), the best lifetimes are only a couple of years, so they are not economically viable at present.

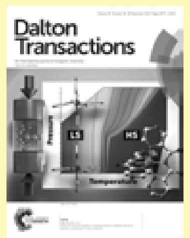
"It's important to remember that back in the day, it was thought computers could never be smaller than a room, or weigh less than several tonnes," Professor Brooker said. "Due to the low temperatures required, superconductors weren't considered practical at first either, and now they're vital to countless technologies… so don't write these magnets off!"

Data-mine

There is plenty of reason for her optimism – the payoff of the success of this technology could be huge. Because every molecule behaves like a separate magnetic domain, SMMs have the potential to store unimagined quantities of data in fantastically small volumes. In fact, one paper suggests that while every cm² of today's best memory devices can store 200GB (enough to store more than 80,000 books), single molecule magnets could manage more than 3TB per cm²… that's at least 150 times more information stored in the same space.

Looking even further ahead, SMMs could also have a role to play in the next generation of quantum computers. Because of their small size, these molecules can make use of a weird effect called 'quantum tunneling of magnetisation', whereby, instead of each domain storing either a 1 or a 0, it could store both at the same time. This seemingly small change could have massive implications – it would be as if, using the same 26 letters of the alphabet, we could suddenly spell billions of words instead of a few hundred thousand. To put it simply, this could change the world.

Today's best memory devices can store 200GB. Single molecule magnets could manage more than 3TB per cm², that's at least 150 times more information stored in the same space.



S. Brooker, J. L. Tallon and co-workers

Dalton Transactions
Pressure induced separation of phase-transition-triggered-abrupt vs gradual components of spin crossover, Dalton Transactions, 2015

Borrowing from biology

What nature already knows

We seldom stop to think about how our bodies grow, develop and repair themselves. Or wonder how, from the time we are a tiny fertilised egg, our cells construct everything we need.

If humans were a mechanical device, made in a factory, each little part of us (protein, carbohydrate, hormone etc) would have to be laboriously assembled – like Lego. Unfortunately, this would not be quick enough or accurate enough to sustain life. We – and all life as we know it – would not be possible. But nature has a cunning mechanism – self-assembly. The biological lego assembles itself; proteins form naturally when a newly formed sequence of amino acids curves and twists itself into the finished structure.

Nature does this with ease and great accuracy. And it's this ability to self-assemble that MacDiarmid scientists are harnessing to collaborate on new and exciting nanomaterials.

Tiny and tricky to handle

You've found a new semi-conductor. It has great potential in the flexible and wearable electronics industry, potentially enabling computers to be printed on fabric or walls. But the material is tiny (as you'd expect) and making it is time-consuming and tedious. You need to find an efficient way to manufacture it. What do you do? You turn to nature, of course.

This is what happened when a team of MacDiarmid scientists at Victoria University led by Dr Justin Hodgkiss needed to find an efficient way to manufacture a new printable electronic material – an electronic ink called perylene diimide (PDI). PDI can be printed and offers new environmentally friendly and low cost ways of making existing electronic gadgets, plus the potential to enable computers, sensors, displays, or smart ID tags to be printed on walls, packaging, fabrics, or skin. But in order to conduct electricity, PDI needs to assemble in a very precise way. If left to assemble randomly, the material does not work as a semiconductor. Dr Hodgkiss and his team had been experimenting with peptides to get PDI to assemble properly but it just wasn't working. So they turned to their MacDiarmid colleague at Auckland University, Professor Juliet Gerrard.

Clicking two technologies together

Professor Gerrard's team had been experimenting with little pieces of protein – called peptides – to try to enhance protein assembly. They studied the peptides that influenced how a protein assembled different units into the correct size and shape and figured out how to modify the peptides but still retain the ability to self-assemble. By doing this they could control and enhance the way the peptide assembled.

This was just what Dr Hodgkiss' team needed to take their development forward. Working closely under the MacDiarmid umbrella, the two teams found they could improve the coupling between the peptides and the electronic material (PDI). By adding linker units between the peptide and the PDI they engineered a new material that could self-assemble. They managed to get hybrid (part chemical, part biological) materials to self-assemble from a water-based ink.

Professor Gerrard says her team had to design a peptide that would do the job the Wellington team needed. "Often in science we struggle to make something and then realise that biological systems have already worked out how to do it."

Knitting nature with nanoscience

Dr Hodgkiss' team then worked closely with a third MacDiarmid team led by Victoria University physicist Dr Plank. She had been looking at how hybrid materials could be used to form the active part of a transistor device – the building block of modern electronics. Her team used the new hybrid material to make a functioning device that worked as an electronic switch – a highlight result in the team's publication in Advanced Functional Materials.

Dr Plank says that compared to regular semi-conductors (made of silicon) these new materials are 'soft' and that it was initially hard to think of a way to make a device from something so different. "By mimicking biology we could get the material to grow from the 'bottom-up' rather than the usual and slow 'top-down' approach. It is exciting to take a biological assembly method and apply it to a material that can have a function electronically."

We talk about 'the MacDiarmid difference', and this project highlights that difference; the combination of chemistry, biology, and physics really allowed us to realise an ambitious idea and convey it to a broad audience.

Justin Hodgkiss

Our team was fiddling around with how to use our knowledge of proteins to assemble nanomaterials and the Victoria University team was trying to build field effect transistors. It was just a matter of clicking these two technologies together.

Juliet Gerrard

We can take a biological assembly method and apply it to a material that can have a function electronically.

Natalie Plank

A MOF could remove CO_2 from polluting smoke stacks.

Metal-organic frameworks that self-assemble from solution into rhombic dodecahedral crystals.

Molecular sponges

Another MacDiarmid team led by Massey University Professor Shane Telfer has developed self-assembling nanomaterials – in this case three dimensional metal-organic frameworks (or MOFs). MOFs are 'molecular sponges' with pores about the size of molecules. This means a MOF could deliver a drug to a specific site within the body, or store gases, such as hydrogen (for fuel) or carbon dioxide (to remove it from polluting smoke stacks). MOFs are mostly free space, like an open porous net, with a metal at the corners and an organic component as the rods or linkers.

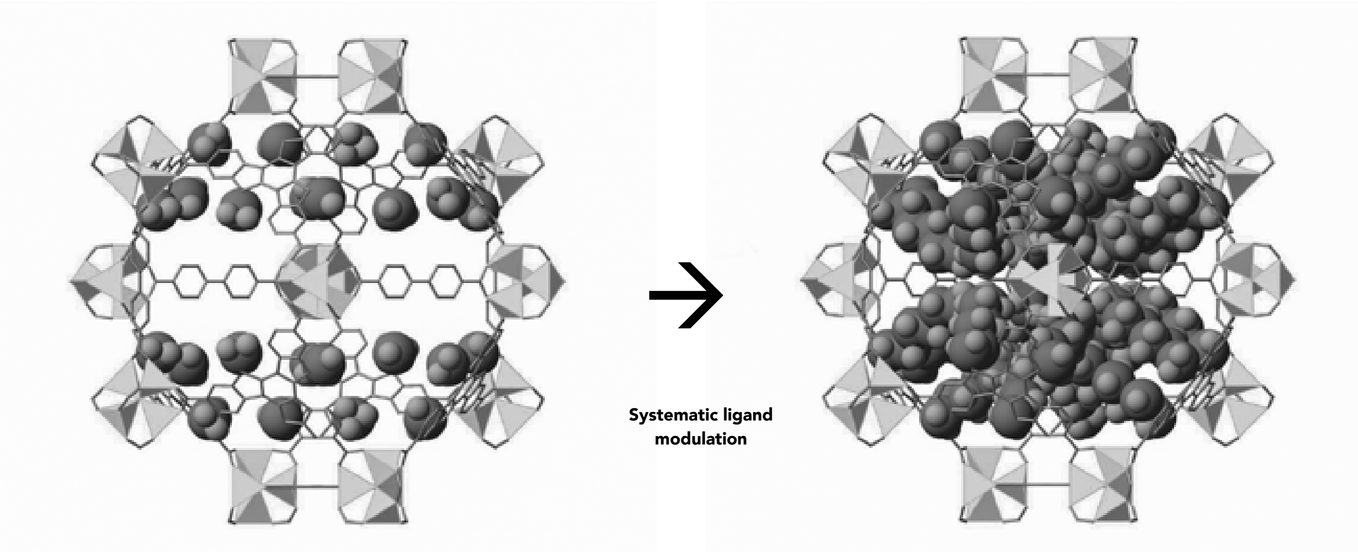
As with the two-dimensional electronic inks, the three-dimensional metal-organic framework materials that Professor Telfer's team are working on also self-assemble. His team has developed a way to get materials to self-assemble from the two-dimensional plane to the third dimension. They are added separately into a reaction mixture, which is then heated to crystallise (assemble) the framework. The metal and organic components come together and arrange themselves into an ordered lattice by self-assembly.

Professor Telfer says there are many applications for MOFs including drug delivery.

"We can make the molecular sponges small enough to be taken up by cells to deliver a payload, such as a drug or an imaging agent. Other applications include gas storage – for example for methane or hydrogen powered vehicles. Instead of an empty fuel tank which would have to be at very high pressure, we can pre-fill the tank with these materials and the gas can be held safely within them."

He says MOFs can also be used for separation/purifications – for example as breathing filters in gas masks for chemical weapon or pesticide detoxification. "We can use them in membranes on a larger scale for industry in the smokestacks of coal-fired power-plants where MOFs could filter CO_2 and other toxins before they get into the atmosphere."

Shane Telfer



Quanternary
Zn4O-carboxylate MOFs

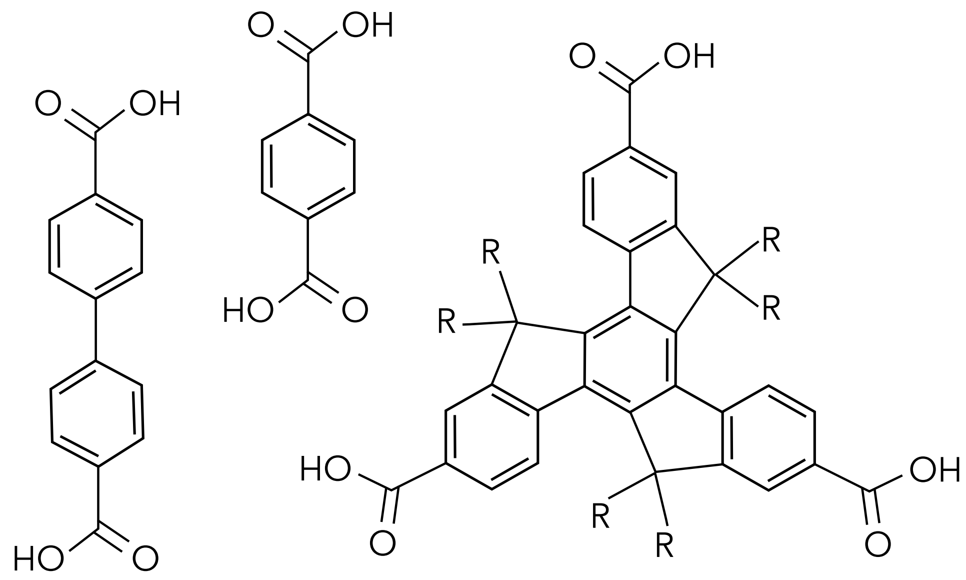
Stable to water vapour
& tunable gas adsorption

Abstract 1

Advanced Functional Materials, 2015, 25, 5640–5649

Functional Organic Semiconductors Assembled via Natural Aggregating Peptides

Natural proteins have evolved peptide sequences that adhere to each other with exceptional strength and specificity. In this work, we explore the concept of using such peptide sequences as tectons for encoding the self-assembly of synthetic functional materials. We first identified aggregating peptide sequences by inspection of protein-protein interfaces in the peroxiredoxin family. We then created hybrid bioelectronic materials by tethering these 8-mer peptide sequences to organic semiconducting molecules, along with an additional sequence to act as a trigger for aggregation. We show the hybrid materials self-assemble into nanofibres, whereby the semiconducting units are brought into electronic communication with each other in a way that strongly depends on the peptide interactions. A bioorganic field-effect transistor is fabricated from this class of materials, highlighting the possibilities of exploiting natural peptide tectons to encode self-assembly in other functional materials and devices.



Systematic ligand modulation
optimises water vapour stability
& gas adsorption capacity

Abstract 2

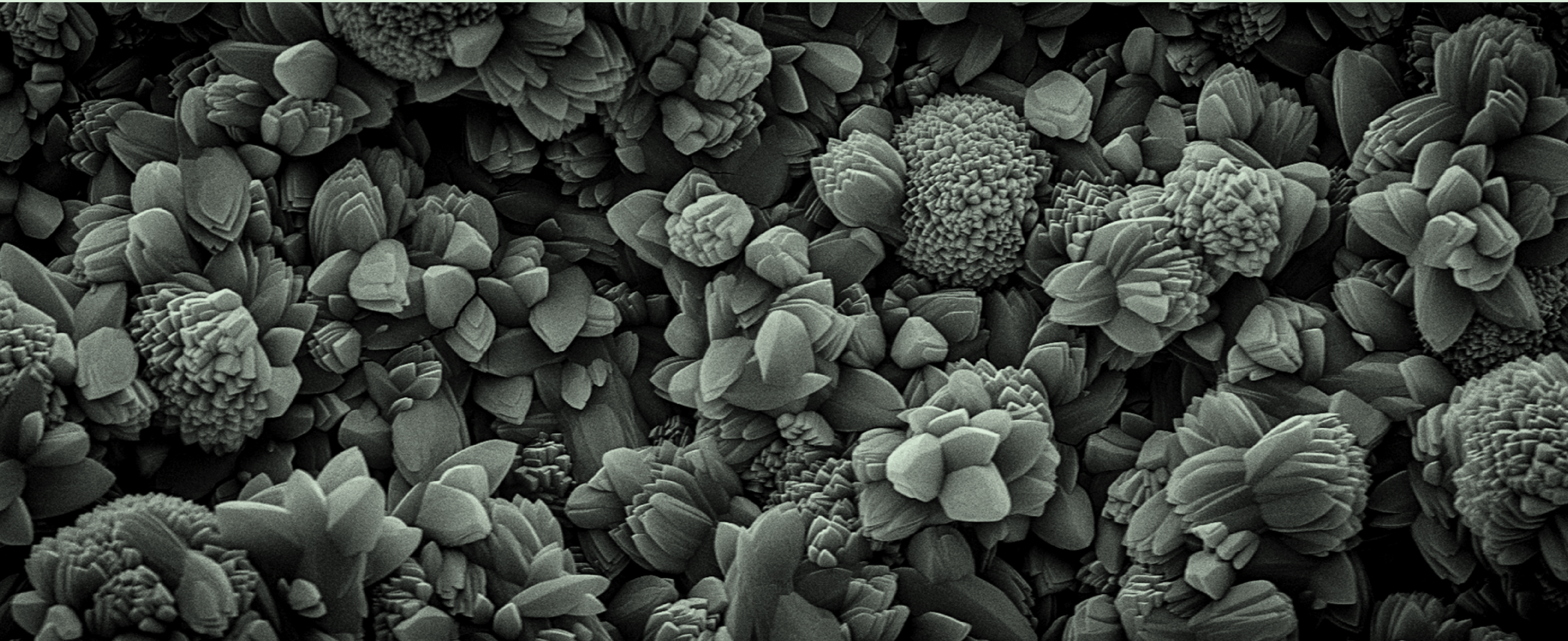
J. Am. Chem. Soc., 2015, 137 (11), pp 3901–3909

Systematic ligand modulation enhances the moisture stability and gas sorption characteristics of quaternary metal-organic frameworks.

Complex metal–organic frameworks (MOFs) that maintain high structural order promise sophisticated and tunable properties. Here, we build on our strategy of using combinations of structurally distinct ligands to generate a new isoreticular series of ordered quaternary Zn4O–carboxylate MOFs. Rational design of the framework components steers the system toward multicomponent MOFs and away from competing phases during synthesis. Systematic ligand modulation led to the identification of a set of frameworks with unusually high stability toward water vapour. These frameworks lose no porosity after 100 days' exposure to ambient air or 20 adsorption–desorption cycles up to 70% relative humidity. Across this series of frameworks, a counterintuitive relationship between the length of pendant alkyl groups and framework stability toward water vapour emerges. This phenomenon was probed via a series of gas and vapour adsorption experiments together with Grand Canonical Monte Carlo (GCMC) simulations, and could be rationalized on the basis of the propensity of the frameworks to adsorb water vapour and the proximity of the adsorbed water molecules to the water-sensitive metal clusters. Systematic variation of the pore volume and topography also tunes the CO_2 and CH4 gas adsorption behaviour. Certain of these materials display increases in their adsorption capacities of 237% (CO_2) and 172% (CH4) compared to the parent framework.

MacDiarmid Institute
Annual Report
2015

Into the marketplace



We create partnerships between research institutions, researchers and investors.

Spinning science into commerce

New materials science may spend years in the laboratory but must eventually emerge and make its way into the world. For this we need partnerships between research institutions, researchers and investors.

A central piece of the MacDiarmid Institute's original vision was that our science would lead to spin-out companies – even new industries – that would make a real and positive impact on our economy and make New Zealand a place where talent wants to live. This original vision is now being realised – with two new spin-out companies formed in 2015. Many other MacDiarmid researchers are in close discussions with investors and expected to form companies in 2015.

Hi-Aspect Ltd and AuramerBio Ltd, our spin-out companies from 2015, are profiled on the following pages. Both companies were formed with investment from PowerHouse Ventures Ltd in the Tech Incubator scheme. This relatively new investment vehicle seems well suited to advancing our early stage technologies out of the lab and we expect to see more projects moving down this path in the future.

A highlight of 2015 was the "Pitch on a Peak" event that was part of the Asian Business Angels forum in Queenstown. Tech investment conferences have not traditionally featured in our calendar, but this event highlighted the rewards at stake and showed how with MacDiarmid Institute coaching and support, our scientists can foot it with tech transfer specialists and wow international angel investors.

Scientists need to know more about financing and marketing before they can tell whether their idea is robust enough for somebody to make and sell it. If you don't go to events like this, you won't understand that.

David Williams

A premier investment showcase held in Queenstown with access to 150 global investors.

MacDiarmid science flies with angel investors

MacDiarmid Institute materials science is making its way from the laboratory into the wider economic sphere. It's always been the goal of MacDiarmid scientists to influence New Zealand's prosperity through research, and 2015 was an outstanding year.

This year for the first time MacDiarmid scientists took their ideas to the world – literally – meeting with 150 investors from around the world at a technology showcase in Queenstown. The showcase saw MacDiarmid scientists giving three minute 'pitches' to angel investors at the Asian Business Angel Forum hosted by New Zealand in October.

The Asian Business Angel Forum is Asia's largest premier angel investor gathering for emerging and growing businesses. "Pitch on a Peak" was one of the key components of the event, a showcase of New Zealand technology investment opportunities, ranging from early-stage technologies, to companies seeking first round angel funding, to internationalising companies.

The MacDiarmid Institute was strongly represented with five of the projects showcased on the day, including four of the five early-stage technologies. These were AuramerBio, Milk-on-a-Disc, BioActive Silver, Medical Dosimeters and Engender Technologies.

Readying the researchers

The MacDiarmid Institute science teams received extensive input from Dr Ray Thomson, Chair of the MacDiarmid Institute's board, Richard Pinfold, the Institute's commercialisation developer, and (NZTE) officials. These people helped the scientists review their business growth plans, become investment-ready and deliver compelling pitches. "It was an opportunity to put some of our scientists in front of international and local investors, to get them out of the lab and into the commercial arena," says Dr Thomson, who has had extensive involvement with angel investment, including time as Chair of the NZ Angel Association. "And hopefully a chance for them to develop some connections, get advice from the investors who were there, and maybe get them interested in investing in them." As Mr Pinfold notes, the event attracted around 150 angel investors, some of them with billion dollar exit packages from their own companies behind them. "Obviously fairly switched on types, who had made good business decisions in the past. There were far bigger hitters than we were anticipating, which really bought some gravitas to the entire event."

"Their responses were overwhelmingly positive," says Quentin Quin, NZTE's General Manager, Capital, who helped coach the scientists and also surveyed the attendees to get their feedback on the event. "Over 90% of attendees said that the investment opportunities presented met their expectations. 98% thought that all or most of the companies were well prepared and articulated their proposition clearly. Here's an example – 'Great coaching – it was hard to differentiate the researchers/academics from the tech-transfer specialists, something I have not seen before,' said one attendee."

Taking diagnostics to the farm

Milk-on-a-Disc was presented by Associate Professor Cather Simpson, who developed the novel technology with Professor David Williams; both researchers are from the School of Chemical Sciences at the University of Auckland and both are Principal Investigators with the MacDiarmid Institute. Milk-on-a-Disc could also be described as a laboratory on a disc, designed to measure the composition of the milk. This can be done on every cow, in the cow-shed and at milking time, before the cow leaves the bail.

150

150 angel investors—some of them with billion dollar exit packages.

Milk-on-a-Disc provides farmers with information such as the protein content and fat content, but also has the potential to help farmers assess the health of the animal, such as whether the cow is pregnant, has mastitis, or her nutritional status. The technology draws on the tools used in the human medical diagnostic sector; Associate Professor Simpson describes it as taking "point of care to point of cow". "It allows farmers to find out things that they don't know they want to know, but which will allow them to make better decisions and therefore enhance their productivity."

Learning to pitch

Associate Professor Simpson had only three minutes to present Milk-on-a-Disc at Pitch on a Peak, a considerably tighter timeframe than scientists are used to. It was challenge, she says, but one that focused the mind. "Pitch on a Peak allowed us to hone our story," she says. "Milk-on-a-Disc is a project that we may not have done at all if there wasn't a commercial outcome for it. The science is fascinating, but trying to analyse a complex fluid like milk is a really big ask, and there's no point in developing a technology like this if nobody is going to buy it. Pitch on a Peak gave us a better sense of what kind of investor pool there might be, to bring this through to completion."

Several investors who attended the conference have since visited Associate Professor Simpson and her team at the Photon Factory at the University or Auckland, or followed up to express interest not just about Milk-on-a-Disc but other projects the team is and could be working on. "The event helped build a buzz around our technology. That was happening before, but with a lower case b. Now we have a Buzz with a capital B and gold flashes around it." The spin-out company Orbis Diagnostics has since been established and registered to develop the technology. "So we now have a company, rather than an idea for a company," says Associate Professor Simpson. "I think the catalyst for that was Pitch on a Peak."

Both Associate Professor Simpson and Professor Williams say university scientists hoping to commercialise their research can only benefit from such events. "It was a high voltage high energy session," says Professor Williams. "Your ideas are challenged, you meet people who know more than you do about the domain that you're working in, you get new ideas, on how to get stuff out of the lab and into the marketplace, and you get a whole different perspective on research. It's very challenging and it's fun. "If you have any kind of expectation that what you're doing might lead to something that can be made and sold, you have to appreciate the other end of the business. Scientists need to know more about financing and marketing before they can tell whether their idea is robust enough for somebody to make and sell it. If you don't go to events like this, you won't understand that."

Aptamers – the new antibodies

Another MacDiarmid Institute project presented at Pitch on a Peak was from AuramerBio, a new medical diagnostics start-up combining aptamers with nanomaterials to create new diagnostic tools.

Aptamers are like a tiny antibody; they're made of DNA, and can be designed to bind to very specific targets. But it gets better. They can be made in a lab (rather than extracted from animals), and can be produced quickly and at a fraction of the cost.

AuramerBio have managed to develop an aptamer that can target much smaller molecules than antibodies normally can, and with a much greater level of sensitivity to the targeted molecule. "Hormones are a good example," says AuramerBio's CEO, Jeremy Jones. "Relative to a protein, these molecules can be thousands of times smaller. Targeting these small molecules is where we shine and blow competitors in aptamer science out of the water."

Milk-on-a-Disc is a project that we probably wouldn't be doing if there wasn't a commercial outcome for it.

Cather Simpson

Aptamers are poised to disrupt the 40 billion dollar market that antibodies currently have.

Jeremy Jones

buzz

The event helped build a buzz around our technology.

As Jones highlighted at Pitch on a Peak, there are many benefits that aptamers have over antibodies. "Antibodies can take 12 to 18 months to develop. For us to get to an equivalent point, it takes less than a month. This is going to revolutionise the way medical professionals diagnose and monitor the health of their patients," he adds. "Aptamers are poised to disrupt the 40 billion dollar market that antibodies currently have."

MacDiarmid collaboration

AuramerBio has emerged out of cross-discipline MacDiarmid collaboration between Professor Ken McNatty and Dr Shalen Kumar at Victoria University of Wellington's (VUW) School of Biological Sciences, Dr Justin Hodgkiss' team at VUW's School of Chemical Physical Sciences and Professor Jadranka Travas-Sejdic's team at the University of Auckland's School of Chemical Sciences. "So it was a combination of the biology, the development of synthetic antibodies, with engineering and surface chemistry, the development of the electrochemical device," says Jones. "It was in the two disciplines coming together that the magic happened." Until recently aptamers compared unfavourably to antibody technology, as the binding capacity was still weak. "But the work that Ken and Shalen have been doing in developing their aptamers, is allowing us to achieve a strength of binding that is far in excess of what people have seen before."

Already attracting investor interest

At the time of Pitch on a Peak, the company had already secured seed funding, with a 24-month runway to execute its business plan. "But for a start-up, capital raising is an ongoing cycle," says Jones "so it's important to get on the radar of new investors. And when it comes time for us to raise that next round of funding, they'll know who we are, those guys they saw at that Queenstown event, and be able to see how far we've come since then. It's about raising the profile among that community who could potentially invest in that next round. "There were a number of people who were in that room who were extremely experienced, international investors who had done what we're trying to do now with other products and companies. So I was hoping to tap into that experience." One of the highlights of the event was the chance to discuss the technology with Allan May, a life sciences investor who has worked with over 50 biotech and med-tech start-up companies. "His advice was invaluable helping to inform our strategies around our target markets." The contacts made and conversations that emerged at the event has also led to new opportunities. "One of the conversations was around drug testing, for illicit drugs. We've established our technology in relation to hormones, but it's a very small leap to go from that to illicit drugs, such as methamphetamine, or cocaine, or THC. They are in the same class of compounds that we've already been working with, and involves the same area of expertise. So that has led to us doing a bit of digging, sitting down with ESR [the Institute of Environmental Science and Research] to build a project, and we're now seeking funding to develop a product in that area."

Pitch on a Peak was held by New Zealand Trade and Enterprise (NZTE) in partnership with the Angel Association New Zealand and Callaghan Innovation.

Other MacDiarmid scientists who presented at the forum also sparked considerable interest among angel investors. Dr Carla Meledandri (BioActive Silver), and Dr Grant Williams (Medical Dosimeters) and their teams are in ongoing talks with investors about new MacDiarmid spin-out companies. Watch this space.

Healing skin with biomaterials

Moving research into the commercial world is not without its challenges, but it has been an exciting step for the University of Auckland's Professor Juliet Gerrard and her team. Her company, Hi-Aspect, was formed in order to commercialise a protein-based nanomaterial for use in skincare products and wound dressings.

The early days

It was a blue-sky research project, which led Professor Gerrard to her discovery of this material. While working at the University of Canterbury, and collaborating with Plant and Food Research, she began to explore how proteins assemble in the body – a fundamental biochemistry question. But the research team soon took their work further. "Rather than just understanding the structure that biology had given us, we wanted to change it, and see what we could do with it," Professor Gerrard said.

The structure they came up with is visually very similar to another superstar material – carbon nanotubes. But unlike carbon, these protein nanofibrils were found to form a soft, stable gel in water, which proved to be stronger than collagen. They're also stretchy, incredibly hard to break, and form a scaffold for other molecules, such as vitamins or healing ingredients, to stick to.

From a new generation of dressings that help wounds heal faster, to a moisturiser that actually delivers what it says on the label. All made using New Zealand science.

Spinning-out

Through the Institute, Professor Gerrard began to meet MacDiarmid researchers from other disciplines who were developing various nanotech devices – "Before that I was a biochemist working just on biological problems. Now I was looking at it from a new viewpoint." The big step, then, came with the realisation that their material could be produced not just from ultrapure lab ingredients, but with low-cost ingredients. They were ready to emerge from the lab.

Fundamental science may have driven the research, but Professor Gerrard was already aware of the potential impact that their results could have on the wider world. "New Zealand is very much a biological economy, and we felt confident that our work could add real value to that sector," she said. Others agreed, and with the support of Callaghan Innovation and Powerhouse Ventures Ltd, she set up Hi-Aspect in 2015.

Commercial future

The protein nanofibrils form the foundation of Hi-Aspect's work, and they are being made into gels, films and patches for use in wound dressings and skincare formulations. "The scale up has gone so well, we have kilograms of the stuff!" said Professor Gerrard, so it's perhaps unsurprising that they're now in discussion with organisations all over the world to develop the materials further.

Fundamentally, what Professor Gerrard and her team are doing is using otherwise wasted or low-value biological materials to produce high-value goods for export. But for the everyday consumer, Hi-Aspect's nanofibres could find their way into their daily lives – from a new generation of dressings that help wounds heal faster, to a moisturiser that actually delivers what it says on the label. All made using New Zealand science.

MacDiarmid Institute
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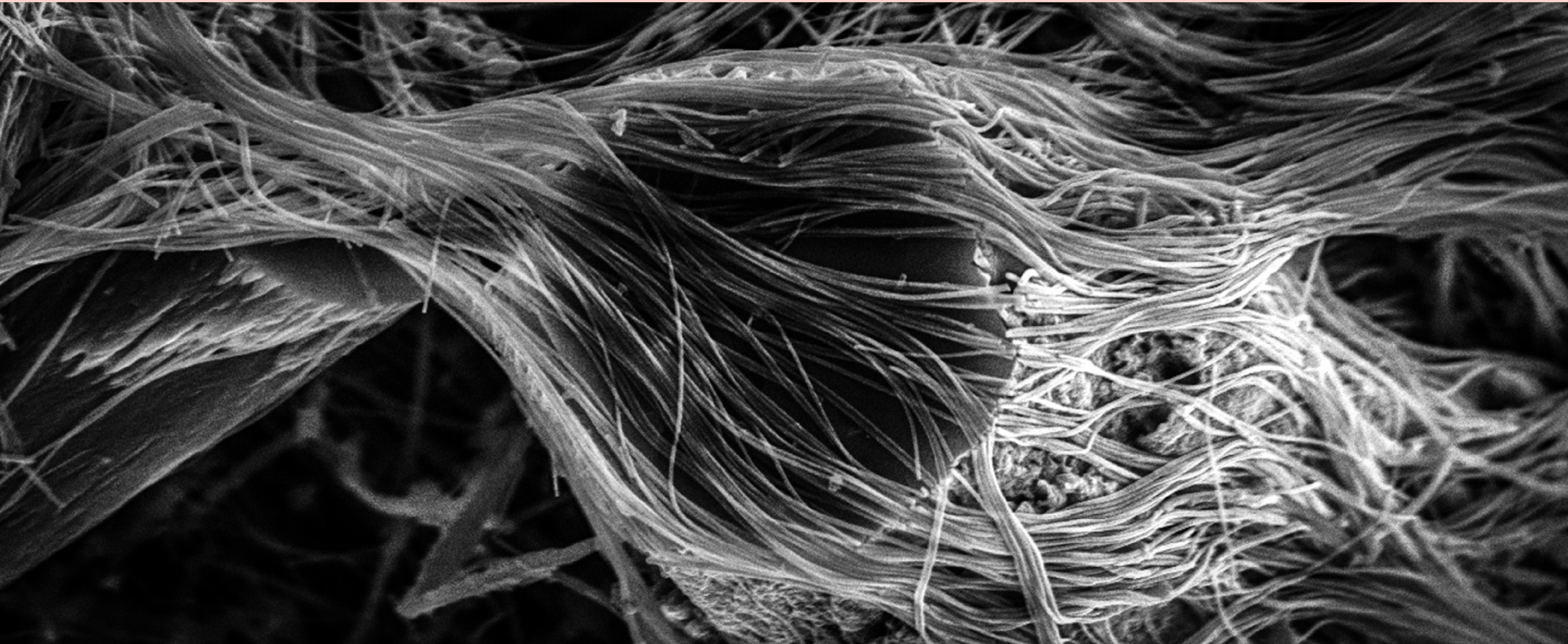
2015

Into the community



It's one thing to do great science. It's another to inspire New Zealand's next generation of leaders.

Overview

Sir Paul Callaghan, the founding director of the MacDiarmid Institute, used to talk about culture change in New Zealand science being the central mission of the institute. He led by example in taking science out of the labs and into the lives of all New Zealanders, and challenged us as scientists to take an entrepreneurial approach to our research and its broader possibilities.

We celebrate Sir Paul's vision of New Zealand as 'a place where talent wants to live' by continuing to take the MacDiarmid Institute's research out to teachers and students and communities under our 'inspire' strategic goal, which seeks to 'engender passion for science and innovation across society'.

We have continued to inspire educators to teach science with ease and enthusiasm with our highly popular Kōrero workshops for early childhood and primary school teachers (see page 44), and a new programme for high school physics teachers (page 46).

We ran our week-long NanoCamp to inspire secondary school pupils (page 48) and brought Māori and Pacific Island secondary school students into MacDiarmid labs for a week working with MacDiarmid scientists.

We took science to the regions with our new Lecture Series. In July and August MacDiarmid researchers gave lectures in Napier, Nelson, Tauranga and Whanganui, talking to packed halls about how we meet the world's future energy needs. The talks covered MacDiarmid research into CO_2 capture, and new printable photovoltaic cells which make solar power cheaper and more efficient. Justin Hodgkiss, Jeff Tallon (both Victoria University) Shane Telfer, Mark Waterland and Luke Liu (from Massey) and Keith Gordon (Otago) presented these popular talks.

The price of 'talent lives here' is the eternal sharing of our science with New Zealand communities. This is both a privilege and an enormous pleasure.

For us not knowing is an essential part of science – we wanted the teachers to pass this on to the kids.

Natalie Plank

The experiments could be run anywhere – schools do not need a lab to replicate the Kōrero science.

Gabriel

Engaging the educators

A group sits around a table playing with green slime. They giggle as the slime oozes through fingers and droops towards the table.

This isn't children's laughter. These are teachers, playing with science alongside MacDiarmid Institute scientists. They are pondering – what is slime? Is it a solid or a liquid? Or something else?

The primary and early childhood teachers are at a MacDiarmid Kōrero with Scientists workshop. In two-hour interactive workshops, they explore basic concepts like magnets, light, and acids and bases. In its third year, the Kōrero programme is already hugely popular, oversubscribed and with waiting lists of primary and early childhood teachers wishing to attend.

For MacDiarmid Institute Principal Investigator Dr Duncan McGillivray, who ran the Auckland workshops, the best thing was seeing the teachers become passionate about science. "When teachers are excited about science, their excitement flows through to the kids." Gabrielle from Chisnallwood Intermediate School in Christchurch was fresh out of teachers' college when she attended her first Kōrero workshop run by MacDiarmid Institute Principal Investigator Professor Paul Kruger in 2014 and then again in 2015. "I learnt how to relate science to kids." She says the experiments they were taught could be run anywhere – schools do not need a lab to replicate the Kōrero science.

"I popped into a couple of shops to buy what we needed then headed straight back to the school and had the kids making pH indicators out of red cabbage and extracting DNA from strawberries. I set up science stations and the kids came around and explored. The kids loved everything we showed them, especially the bubbles." The kids from her classroom then tried the experiments out with their families at home. "We could see from the photos they uploaded into Google Classroom that they'd done the red cabbage experiment at home. And made bubbles and talked with their families about surface tension."

The Kōrero programme was revamped in 2015, with returning teachers asked to give a presentation on how they had taken the Kōrero science into the classroom.

Dr Natalie Plank, Principal Investigator with the MacDiarmid Institute, ran the Wellington workshop. She said the teacher's videos showed the children's keen interest in science. "We could see how children are inherently little scientists, asking how and why."

Just three weeks after attending Kōrero 2015 in Auckland, early childhood teacher James set up a Facebook page 'Science ECE – experiments for young children'. The page now has over 2700 members.

James says people seem to be hearing of the Facebook page by word of mouth. "After going on the Kōrero course, I thought I'd start the page and just pin up experiments. Lots of the members are kiwi parents but there's also a group of 50 or so science teachers from Mumbai who have joined."

Dr McGillivray says the key was getting away from the idea that science was about knowing stuff, and helping teachers realise that science is about finding stuff out. "Science is about noticing and asking questions – I observe, I wonder, I think."

Dr Plank says that scientists do not know everything but are comfortable with not knowing. "For us the not-knowing is an essential part of science." Gabrielle said she felt she could pass this on to the kids. "I didn't feel stupid asking any question at all. Paul Kruger and his team put things into 'teacher speak' so even teachers with no science training, people who had themselves disliked science at school, were able to come up with scientific language and made to feel more comfortable with the 'scientific method'."

The Kōrero programme will run again in 2015 with the development of more online forums for teachers wishing to keep in touch with each other and with the MacDiarmid scientists they met. "One of the things we hear is that the teachers want to keep in touch with us so we plan to make it very easy for them to do that throughout the year," says Dr McGillivray.

And is slime a solid or a liquid? It turns out it is neither. It's a gel.

Taking physics out of the classroom

Most days you will find Dr Kerry Parker, physics and science teacher at Wellington High School, in front of a class of NCEA students. But 9 October 2015 found her up a ladder having a good look at Victoria University's NMR machine.

Dr Parker was one of 12 physics teachers from around the country getting a crash course in current physics thinking at the MacDiarmid Institute physics teachers workshop.

Dr Parker says the whole day was great. "It was unlike any professional development I'd ever done. I felt as though I'd had a deep massage of my brain in places that hadn't been used for a long time."

The teachers spent the morning up-skilling on classical and quantum mechanics with MacDiarmid Institute Principal Investigators, Associate Professors Michele Governale and Ben Ruck. In the afternoon they checked out the NMR machine, took a physics quiz and heard about the quirks of Einstein's relativity theory from MacDiarmid Principal Investigator Professor Uli Züelicke.

Associate Professor Michele Governale, who organized the workshop with Associate Professor Ben Ruck, said the idea of the MacDiarmid workshop was to give high school teachers the chance to practice physics at a level higher than the NCEA curriculum. "We maintain that a teacher will be more effective if their understanding of the subject goes beyond what they are required to teach."

David Housden, Chairperson of the New Zealand Institute of Physics Education Section (NZIPES) and science teacher at St Bernard's College in Lower Hutt, says the workshop was outstanding.

Gisborne Boys' High Deputy Principal and science teacher Peter Ray agrees. "I could take the workshop learning straight back into the classroom. The modern physics and relativity topics we did were right in line with the (NCEA) curriculum but extended it for us. When I returned I showed the students a web-link of what you would see if you were traveling at the speed of light. The students are fascinated by that stuff and it takes them a little bit further, gives them a glimpse of what's coming up for them if they take physics at university. They love astrophysics – black holes, bending of light – and I can use these to teach physics concepts."

Wellington High School's Dr Parker says it helped remind her that physics doesn't stop with NCEA. "I've been able to draw on Professor Züelicke's discussion about relativity in my Year 13 physics classes and also make students aware of the maths and physics they will experience at university. And if a student wants to pursue particular questions, I can point them up the hill to Victoria University to speak with one of the MacDiarmid scientists we met at the workshop.

Many of the teachers found the physics and maths hard going. David Housden adds – "It was a pretty tough day."

Peter Ray says it was nice to have professional development that was subject focused rather than teaching focused. "As teachers we get a lot of professional development that is about assessing NCEA etc. This was purely about developing and inspiring the subject itself." David Housden echoes this. "Much of our professional development is generic and not subject specific. But this was professional development we could actually use. It was meaty and tough and academically challenging. It got us thinking about how we prepare students to actually succeed at university." Associate Professors Governale and Ruck say that although the MacDiarmid Institute is already involved in a huge amount of outreach activities, they have identified an urgent need for robust professional development opportunities for secondary school physics teachers.

> ***It was unlike any professional development I'd ever done – I felt as though I'd had a deep massage of my brain in places that hadn't been used for a long time.***

"This was not being met within the wider New Zealand science community."

Associate Professors Governale and Ruck say developing sufficient graduates skilled in physics is a key aspect of ensuring a workforce capable of driving wealth creation via high value manufacturing.

"There is presently a shortage of highly skilled secondary school physics teachers capable of raising the overall level of performance of physics students. The ability to deliver subject-focused professional development to physics teachers resides almost exclusively in the physics departments of the universities. But up till now there has been little of this kind of engagement between the two. So we developed the hands-on workshop where physics teachers could learn new physics as well as deepening their knowledge of the NCEA curriculum." This is something Peter Ray applauds. "Being in Gisborne I can feel professionally isolated, so it was a real opportunity for me to attend the workshop. It gave me inspiration I could pass onto the students – really extend their minds."

Summer of Discovery

Students go behind the scenes to explore science at the MacDiarmid NanoCamp and Discovery programmes.

NanoCamp

Fifteen of New Zealand's brightest high school science pupils traveled from all over the country to Wellington to get an introduction to nanoscience and advanced materials during NanoCamp 2015 (held in January 2016). The annual MacDiarmid camp, held for the sixth year, introduces Year 12 and 13 pupils to materials science with a hands-on programme. The aim is to encourage pupils to pursue science when they leave school by providing them with an overview of the excellent science being done in New Zealand. The 2015 camp included courses in spintronics, microscopy, nanoelectronics, chemistry, superconductors, and optics at Victoria University of Wellington, Callaghan Innovation and GNS Science.

Discovery Awards

Two groups of talented Māori and Pasifika pupils from around the country descended on Auckland and Victoria universities in January to get a taste of tertiary-level science. In Wellington the students joined the NanoCamp programme and in Auckland students spent time in the photon factory, played with ultra-fast cameras and nanofluidics and saw a high tech materials science company in action.

Overall this week was very fascinating and broadened my views on the jobs scientists can actually obtain

Alex

There is so much to science that I never knew about – whole branches of fascinating things that are waiting to be discovered.

The experience was really indescribable and has reawoken to me why I love science so much.

Shania

Higher Learning

Optical bootcamp

The MacDiarmid Emerging Scientists Association (MESA) ran its 4th annual three-day 'bootcamp' – an 'adventurous academic experience in a remote location' – during the International Year of Light.

Themed 'Shining Light,' the 2015 camp explored new frontiers in optical research at the Kaikoura Field Station. MacDiarmid Principal Investigators Associate Professor Cather Simpson and Professor Bill Williams, along with Dr Baptiste Auguié, joined the students and post-docs in a long weekend of intensive research.

Integrating science with Māori culture

The 2015 Student and Postdoc Symposium was held in Te Ūpoko o te Ika a Māui in November on the theme of 'Mātauranga Māori, Nanotechnology and Advanced Materials'.

Postdoc Bart Ludbrook said the aim was to stimulate discussion around the role of the MacDiarmid Institute with respect to the development of Mātauranga Māori and that a highlight was a crash course in Te Reo Māori. MESA past president and PhD student Harry Warring said he really enjoyed the fresh approach to the Symposium. "It was great to explore how we can better integrate science with Māori culture."

Gender imbalance within science

The evidence shows that science is sexist because we are sexist about science.

Nicola Gaston

MacDiarmid Institute Deputy Director and Principal Investigator Associate Professor Nicola Gaston published a book (Why Science is Sexist, BWB Texts, 2015) that looks at the gender imbalance within science, and asks why this is.

Associate Professor Gaston notes that of the 209 Nobel Prizes awarded in physics, only two have ever gone to women. "I wanted to figure out what is actually happening – why are women so poorly represented in science, especially physical science, at senior levels in particular? There is an unconscious bias that women don't belong in science, because of historical differences in the contribution that women and men have been able to make. It's important we take on board that these biases are in all of us. And by getting this conversation started, we hopefully reframe things so that it is clear that academic success is about hard work and not about some mysterious talent."

Associate Professor Gaston has had positive feedback, with the President of the Royal Society of New Zealand Richard Bedford calling the book useful and noting that the Society would be recommending the book to all RSNZ Fellowship Evaluation Panel conveners this year.

"Even more important to me has been the many personal emails I've received from other women – many of whom I don't know well – expressing a general sense of relief that it's possible to talk about the topic. To be able to start a conversation.

"One thing we learned in the MacDiarmid Institute from Paul Callaghan, was that we can all contribute to the public space, beyond just doing our science."

Bringing international nanoscience to Nelson

In 2015 the MacDiarmid Institute's biennial Advanced Materials and Nanoscience conference (AMN7) featured a stunning line up of local and international presenters, whose specialty areas covered the whole spectrum of research in advanced materials and nanotechnology. The whole programme was of exceptional quality.

The conference is designed to provide delegates with a platform to exchange ideas, broaden their knowledge, kick-start collaborations, reacquaint with colleagues, and meet new friends. AMN7 was no exception with plenty of opportunities to connect over morning and afternoon tea breaks and poster sessions and a conference dinner designed to allow delegates to mingle as much as possible.

Delegates also had a chance to view nanoscience in a new light at the exhibition 'Small Matters, Nanoart' held alongside the conference. An astonishing range of novel images from the world of nanotechnology at the Nelson Provincial Museum were shown in an exhibition mounted by the Institute in association with the AMN7 conference. In a city famous for its artists, and as the home of the great Lord Rutherford, this combination of art and science seemed particularly apt.

Members of the International Science Advisory Board met at AMN-7 in Nelson in February 2015.

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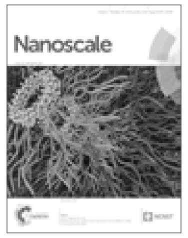
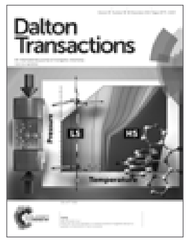
Accolades



David Williams, Juliet Gerrard, Jadranka Travas-Sejdic and coworkers

Nanoscale

Protein nanorings organised by poly (styrene-block-ethylene oxide) self-assembled thin films, 2015



Sally Brooker, Jeff Tallon and coworkers

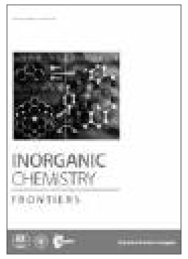
Dalton Transactions

Pressure induced separation of phase-transition-triggered-abrupt vs gradual components of spin crossover, Dalton Transactions, 2015

Sally Brooker and coworkers

Chem Soc Rev

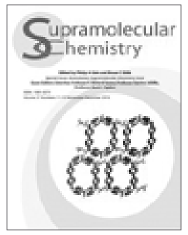
A family of fourteen stable soluble macrocyclic $[Ni^{II}_3Ln^{III}]$ complexes, Inorganic Chemistry Frontiers, 2015



Sally Brooker

Inorganic Chemistry Frontiers

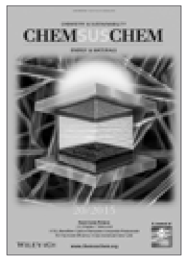
Spin crossover with thermal hysteresis: practicalities and lessons learnt, invited review, 2015



Paul Kruger and coworkers

Super Molecular Chemistry

Metallosupramolecular architectures based upon new 2-(1-pyrazolyl)-benzimidazole chelating ligands, 2015



Thomas Nann and coworkers

ChemSusChem

A TiO_2 nanofiber-carbon nanotube-composite photoanode for improved efficiency in dye-sensitized solar cells, 2015

Awards

Ian Brown

Shortland Medal 2015

2015 Hector Medal

Richard Blaikie

2015 Thomson Medal — Science leadership for nanotechnology and research collaboration

Elected to Fellowship of Optical Society of America

Sally Brooker

Awarded the University of Otago Distinguished Research Medal

Invited to present the inaugural triennial Curtis Lecture, Victoria University of Wellington

Justin Hodgkiss

Easterfield Medal from the New Zealand Institute of Chemistry

Keith Gordon

University of Otago Division of Sciences Senior Researcher of the Year 2015

Shane Telfer

NZIC prize for Excellence in Chemical Research (2015)

David Williams

Awarded the 2015 Castner Medal

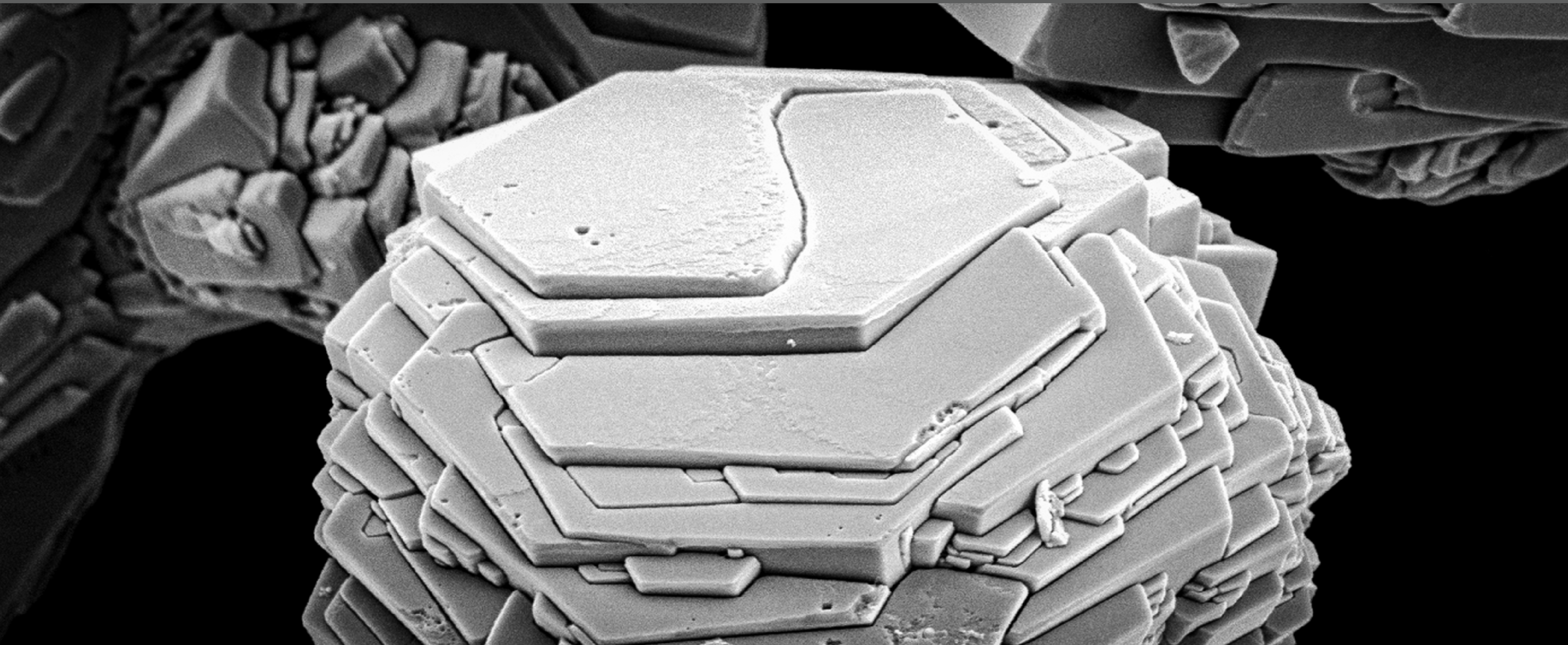
Michelle Dickinson, also known as Nanogirl

New Zealand Order of Merit (MNZM)

The Blake Leadership Award

The Callaghan Medal

Governance & financials



Financials 2015

CATEGORY	TOTAL
Core Funding	2,920,054.18
Other Funding (Mainly Interest Income)	227,002.66
Total Revenue	**3,147,056.84**
Director and Principal Investigators	659,156.83
Associate Investigators	0.00
Post Doctoral fellows	125,151.28
Research/Technical assistants	116,819.08
Others	221,231.00
Total Salaries & Salary-related costs	**1,122,358.19**
Overheads	981,563.42
Project Costs	377,957.82
Travel	256,841.29
Postgraduate students	408,336.12
Equipment depreciation/rental	0.00
Subcontractor(s) specified	0.00
Total Other Costs	**2,024,698.65**
Total Expenditure	**3,147,056.84**
Net Surplus / (Deficit)	**0.00**

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At a Glance 2015

BROAD CATEGORY	DETAILED CATEGORY	YEAR 1
FTEs by category	Principal Investigators	2.6
	Associate Investigators	4.2
	Postdoctoral fellows	4
	Research technicians	1.5
	Administrative/support	4.17
	Research students	19
	Total	**35.47**
Headcounts by category	Principal Investigators	31
	Associate Investigators	42
	Postdoctoral fellows	4
	Research technicians	2
	Administrative/support	5
	Research students	176
	Total	**260**
Peer reviewed research outputs by type	Journal articles	203
	Conference papers	12
	Total	**215**
Commercial activities	Patent applications	9
	Patents granted	3
	Number of new spinouts	1
	Total	**13**
Students studying at CoRE by level	Doctoral degree	25
	Total	**25**
Number of students completing qualifications by level	Doctoral degree	13
	Total	**13**
Immediate post-study graduate destinations	Employed overseas	6
	Other	7
	Total	**13**

Governance Representative Board

Dr Raymond Thomson
Chair of the Board

Professor Mike Wilson
Pro Vice-Chancellor Science, Engineering, Architecture & Design
Victoria University of Wellington

Dr Wayne Ngata
Ministry of Education

Dr Richard Templer
General Manager, Research and Technical Services, Callaghan Innovation

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

Professor Wendy Lawson
Pro Vice-Chancellor Science
University of Canterbury

Dr Ian Graham
Director, Research GNS Science, Lower Hutt

Dr Tracey Swift
Director of Research Management
Corporate Services Team
University of Auckland

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

Geoff Todd
Managing Director, VicLink Limited
Victoria University of Wellington

Professor Roger Reeves
Science Executive Representative
University of Canterbury

Ex-officio

Professor Kathryn McGrath
Director of the MacDiarmid Institute
Victoria University of Wellington

Professor Thomas Nann*
Director of the MacDiarmid Institute
Victoria University of Wellington

Professor Alison Downard
Deputy Director Stakeholder Engagement
University of Canterbury

Associate Professor Nicola Gaston*
Deputy Director Stakeholder Engagement
Victoria University of Wellington

Professor David Williams
Deputy Director, Commercialisation and Industry Engagement, University of Auckland

Dr Justin Hodgkiss*
Deputy Director, Commercialisation and Industry Engagement Victoria University of Wellington

**From August 2015*

Industry Advisory Group

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
CEO, EverEdge IP

Simon Arnold
CEO, Arnold Consulting

International Science Advisory Board

Dr Jeff Tallon
Chair
Principal Investigator, MacDiarmid Institute
Principal Scientist at Robinson Research Institute
Victoria University of Wellington,
New Zealand

Professor Haroon Ahmed
Microelectronics Research Centre, Cavendish Laboratory, University of Cambridge,
UK Advisor on Higher Education to the Pakistan Government
Nanoengineered devices

Professor Neil Ashcroft
Horace White Professor of Physics
Laboratory of Atomic and Solid State Physics
Cornell University, Ithaca, USA
Materials Science

Dr Don Eigler
Nanoscience

Professor Sir Richard Friend
Cavendish Professor of Physics University of Cambridge, Great Britain
Organic Optoelectronics

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

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

Professor Sir Harry Kroto,
Nobel Laureate
Department of Chemistry and Biochemistry
Florida State University, USA
Spectroscopy, radioastronomy, nanoscience

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

Professor Daniel Nocera
The Henry Dreyfus Professor of Energy and Professor of Chemistry MIT, USA
Catalysis, energy

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

Professor Henry Smith
Keithley Professor of Electrical Engineering and Head of NanoStructures Laboratory, MIT, USA
Nanofabrication

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

Dr David Williams
Chief Research Scientist and Laboratory Manager, Hitachi Cambridge Laboratory, Cambridge, UK
Nanoengineered electronic devices

Science Executive

Professor Kathryn McGrath
Director
Victoria University of Wellington

Professor Thomas Nann*
Director
Victoria University of Wellington

Professor Alison Downard
Deputy Director, Stakeholder Engagement
University of Canterbury

Associate Professor Nicola Gaston*
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Professor David Williams
Deputy Director, Commercialisation and Industry Engagement, University of Auckland

Dr Justin Hodgkiss*
Deputy Director, Commercialisation and Industry Engagement, Victoria University of Wellington

Professor Keith Gordon
Science Leader: Materials for Energy Capture & Utilisation University of Otago

Professor Roger Reeves
Science Leader: Materials for High Value Technologies
University of Canterbury

Professor Juliet Gerrard
Science Leader: Functional Nanostructures
University of Auckland

Dr Geoff Willmott
Principal Investigator Representative
University of Auckland

Professor Shane Telfer
Principal Investigator Representative
Massey University

Dr Simon Granville
Associate Investigator Representative
Robinson Research

Harry Warring
MESA Chairperson
Victoria University of Wellington

MacDiarmid Emerging Scientist Association (MESA) 2015

Harry Warring
Chair
PhD Student
Victoria University of Wellington

Brendan Darby
PhD Student
Victoria University of Wellington

Pablo Hernandez
PhD Student
Massey University

Lakshika Perera
PhD Student
University of Auckland

Cherie Tollemache
PhD Student
University of Auckland

Jan Dormanns
PhD Student
University of Canterbury

Nihan Aydemir
PhD Student
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PhD Student
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Lucy Gloag
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Victoria University Wellington

Gregory Huff
PhD Student
University of Otago

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Professor Brooker, Sally, University of Otago
Professor Brown, Simon, University of Canterbury
Professor Downard, Alison, University of Canterbury
Associate Professor Gaston, Nicola, Victoria University of Wellington
Professor Gerrard, Juliet, University of Canterbury
Professor Gordon, Keith, University of Otago
Associate Professor Governale, Michele, Victoria University of Wellington
Dr Hodgkiss, Justin, Victoria University of Wellington
Dr Kennedy, John, GNS Science
Associate Professor Kruger, Paul, University of Canterbury
Professor Le Ru, Eric, Victoria University of Wellington
Dr Markwitz, Andreas, GNS Science
Dr McGillivray, Duncan, The University of Auckland
Professor Nann, Thomas, Victoria University of Wellington
Dr Plank, Natalie, Victoria University of Wellington
Professor Reeves, Roger, University of Canterbury
Professor Rehm, Bernd, Massey University
Dr Ruck, Ben, Victoria University of Wellington
Associate Professor Simpson, Cather, The University of Auckland
Professor Smith, Kevin, The University of Auckland
Professor Tallon, Jeff, Victoria University of Wellington
Professor Telfer, Shane, Massey University
Professor Travas-Sejdic, Jadranka, The University of Auckland
Professor Trodahl, Joe, Victoria University of Wellington
Professor Williams, Bill, Massey University
Professor Williams, David , The University of Auckland
Dr Williams, Grant, Victoria University of Wellington
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Professor Züelicke, Ulrich, Victoria University of Wellington

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Professor Brothers, Penny, The University of Auckland
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Dr Buckley, Bob, Callaghan Innovation
Dr Bumby, Chris, Callaghan Innovation
Dr Carder, Damian, Callaghan Innovation
Dr Chong, Shen, Robinson Research Institute
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Dr Downes, James, Macquarie University
Professor Evans, John, Christchurch School of Medicine & Health Sciences, University of Otago
Dr Galvosas, Petrik, Victoria University of Wellington
Dr Golovko, Vladimir, University of Canterbury
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Dr Meledandri, Carla, University of Otago
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Dr Nock, Volker, University of Canterbury
Dr Prabakar, Sujay, LASRA
Dr Reid, Mike, University of Canterbury
Professor Spencer, John, Victoria University of Wellington
Dr Staiger, Mark, University of Canterbury
Dr Wang, Wenhui, Tsinghua University
Associate Professor Waterland, Mark, Massey University
Dr Waterhouse, Geoff, The University of Auckland
Dr Whitby, Catherine, Massey University
Dr Wimbush, Stuart, Callaghan Innovation
Dr Woodfield, Tim, University of Otago
Dr Zujovic, Zoran, The University of Auckland

Emeritus Investigators

Professor Hall, Simon, Massey University
Professor Hendy, Shaun, The University of Auckland
Professor Johnston, Jim, Victoria University of Wellington
Professor Kaiser, Alan, Victoria University of Wellington
Professor MacKenzie, Ken, Victoria University of Wellington
Professor McGrath, Kate, Victoria University of Wellington
Professor Metson, Jim, The University of Auckland
Professor Tallon, Jeff, Victoria University of Wellington

Postdoctoral Fellows

Postdoctoral Fellow, Hammerschmidt, Lukas, Victoria University of Wellington
Postdoctoral Fellow, Dubuis, Guy, Victoria University of Wellington
Postdoctoral Fellow, Bradley, Siobhan, Victoria University of Wellington
Postdoctoral Fellow, Medini, Karima, University of Auckland
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Postdoctoral Fellow, Chen, Kai, Victoria University of Wellington
Postdoctoral Fellow, Bose, Saurabh, University of Canterbury
Postdoctoral Fellow, Kueh, Brian, University of Auckland
Postdoctoral Fellow, Alavi-Shooshtari, Maryam, University of Auckland
Postdoctoral Fellow, Domigan, Laura, University of Auckland
Postdoctoral Fellow, Hilder, Tamsyn, Victoria University of Wellington
Postdoctoral Fellow, Auguié, Baptiste, Victoria University of Wellington

Administration Team

Centre Manager, FitzGerald, Jacqui, Victoria University of Wellington
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Administrator, Hunt, Rebekah, Canterbury University
Communications and Marketing Officer, Docherty, Kylie, Victoria University of Wellington
Research Technician, Flynn, David, Victoria University of Wellington
Technical Assistant, Turner, Gary, Canterbury University

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Jayawardena, Gimshan, MSc, University of Auckland
Alkas, Adil, PhD, Massey University
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Owen, Jessie, PhD, Massey University
Ravindran, Sapna, PhD, Massey University
Alsager, Omar, PhD, Victoria University of Wellington
Eakins, Galen, PhD, Victoria University of Wellington

DOI	EID	AUTHORS	JOURNAL NAME	
10.1116/1.4931591		Hashemi, A., Mutreja, I., **Alkaisi, M.M.**, Nock, V., Azam Ali, M.	Journal of Vacuum Science & Technology	Fabrication of free-standing casein devices with micro-and nanostructured regular and bioimprinted surface features
		Siti Noorjannah Ibrahim and **Maan M Alkaisi**	Advanced Materials Research	Microelectrode Design for Particle Trapping on Bioanalysis Platform
10.1088/1758-5090/7/2/025002		Mutreja, I., Woodfield, T.B.F., Sperling, S., Nock, V., Evans, J.J., **Alkaisi, M.M.**	Biofabrication	Positive and negative bioimprinted polymeric substrates: new platforms for cell culture
102147/IJNS86336		Tan LH Sykes PH **Alkaisi MM** Evans JJ	International Journal of Nanomedicine	The characteristics of Ishikawa endometrial cancer cells are modified by substrate topography with cell-like features and the polymer surface
10.1088/0268-1242/30/2/024008	2-s2.0-84921533498	S Elzwawi A Hyland M Lynam J Partridge D McCulloch and **MW Allen**	Semiconductor Science and Technology	Effect of Schottky gate type and channel defects on the stability of transparent ZnO MESFETs
10.1111/phpp.12179	2-s2.0-84940787037	B Køster J Søndergaard JB Nielsen **M Allen** M Bjerregaard A Olsen and JBentzen	Photodermatology, Photoimmunology and Photomedicine	Feasibility of smartphone diaries and personal dosimeters to quantitatively study exposure to ultraviolet radiation in a small national sample
10.1109/LED.2015.2412124	2-s2.0-84928734536	GT Dang T Kawaharamura M Furuta and **MW Allen**	IEEE Electron Device Letters	Metal-Semiconductor Field-Effect Transistors With In-Ga-Zn-O Channel Grown by Nonvacuum Processed Mist Chemical Vapor Deposition
10.1109/TED.2015.2477438	2-s2.0-84946490022	GT Dang T Kawaharamura M Furuta and **MW Allen**	IEEE Transactions on Electron Devices	Mist-CVD Grown Sn-Doped alpha-Ga2O3 MESFETs
10.1063/1.4906868	2-s2.0-84923899886	R Heinhold RJ Reeves GT Williams DA Evans and **MW Allen**	Applied Physics Letters	Mobility of indium on the ZnO(0001) surface
10.1016/j.ypmed.2015.09.027	2-s2.0-84955491253	K A Miller J Huh JB Unger JL Richardson **MW Allen** DH Peng and MG	Preventive Medicine	Patterns of sun protective behaviors among Hispanic children in a skin
10.1111/php.12461	2-s2.0-84934276434	V Nurse CY Wright M **Allen M** and RL McKenzie	Photochemistry and Photobiology	Solar Ultraviolet Radiation Exposure of South African Marathon Runners During Competition Marathon Runs and Training Sessions: A Feasibility Study
10.1063/1.4931960	2-s2.0-84943311502	GT Dang T Kawaharamura M Furuta S Saxena and **MW Allen**	Applied Physics Letters	Stability of In-Ga-Zn-O metal-semiconductor field-effect-transistors under bias illumination and temperature stress
		RKR Scragg AW Stewart RL McKenzie AI Reeder JB Liley and **MW Allen**	Journal of Exposure Analysis and Environmental Epidemiology	Sun exposure and 25-hydroxyvitamin D3 levels in a community sample: quantifying the association with electronic dosimeters"
10.1002/pssb.201552155	2-s2.0-84943200933	Chen XX Chen YH Qiu M **Blaikie RJ** and Ding BY	Phys Stat Solidi B	Control of fluorescence enhancement and directionality upon excitations in a thin-film system
10.1007/s11468-015-0148-3	2-s2.0-84949525208	Chen, X., Qiu, M., **Blaikie, R.J.**, Ding, B.	Plasmonics	Illumination Dependent Optical Properties of Plasmonic Nanorods Coupled to Thin-Film Cavities
10.1021/acs.jpcc.5b06006	2-s2.0-84939129531	Chen XX Yang YQ Chen YH Qiu M **Blaikie RJ** and Ding BY	J Phys Chem C	Probing plasmonic gap resonances between gold nanorods and a metallic surface
10.1117/12.2201167	2-s2.0-84959898149	Kumari, M., Ding, B., **Blaikie, R.**	Proceedings of SPIE – The International Society for Optical Engineering	Relative humidity sensing using dye-doped polymer thin-films on metal substrates
10.1117/1.JMM.14.4.043510	2-s2.0-84952684251	Lowrey S and **Blaikie RJ**	J Micro-nanolith MEMS and MOEMS	Solid immersion optical lithography: index matching and resonant reflectors for large exposure field high-aspect ratio imaging in the ultrahigh-numerical aperture regime

DOI	EID	AUTHORS	JOURNAL NAME	
10.1117/12.2175627	2-s2.0-84931337671	Lowrey, S., **Blaikie, R.J.**	Proceedings of SPIE – The International Society for Optical Engineering	Solid immersion optical lithography: Tuning the prism/sample interface for improved ultra high-NA, high aspect ratio resist patterns over large exposure fields
10.1039/c5qi00130g	2-s2.0-84946205920	Feltham, H.L.C., Dhers, S., Rouzières, M., Clérac, R., Powell, A.K., **Brooker, S.**	Inorg Chem Frontiers (invited contribution to a special issue on magnetism refereed as usual)	A family of fourteen stable soluble macrocyclic [NiII3LnIII] complexes
10.1016/j.ccr.2015.03.012	2-s2.0-84928150330	S Dhers H L C Feltham and **S Brooker**	Coord Chem Rev	A toolbox of building blocks linkers and crystallisation methods used to generate Single-Chain Magnets
10.1021/acs.inorgchem.5b02038	2-s2.0-84951335532	Romain, C., Bennington, M.S., White, A.J.P., Williams, C.K., **Brooker, S.**	Inorg Chem	Macrocyclic Di-Zinc(II) Alkyl and Alkoxide Complexes: Reversible CO_2 Uptake and Polymerization Catalysis Testing
	2-s2.0-84948418875	Cowan, M.G., Miller, R.G., **Brooker, S.**	Supramolecular Chemistry	Smaller is smarter in a new cobalt(II) imide: Intermolecular interactions involving pyrazine versus the larger aromatic quinoxaline
10.1021/acs.inorgchem.5b00428	2-s2.0-84930616015	RG Miller and **S Brooker**	Inorg Chem	Spin crossover reversible redox and supramolecular interactions in 3d complexes of 4-(4-pyridyl)-25-di-pyrazyl-pyridine
10.1039/c4cs00376d	2-s2.0-84929336705	**S Brooker**	Chem Soc Rev	Spin crossover with thermal hysteresis: practicalities and lessons learnt invited review
10.1103/PhysRevE.92.052134	2-s2.0-84949495898	Fostner, S., **Brown, S.A.**	Physical Review E – Statistical, Nonlinear, and Soft Matter Physics	Neuromorphic Behavior in Percolating Nanoparticle Films
10.1103/PhysRevE.92.052134	2-s2.0-84949495898	P.J. Kowalczyk, O. Mahapatra, D. Belic, **S. A. Brown**, G. Bian and T.-C. Chiang,	Physical Review B – Condensed Matter and Materials Physics	Origin of the Moire pattern in thin Bi films deposited on HOPG
10.1021/acs.langmuir.5b00730	2-s2.0-84929206908	Lee, L., Leroux, Y.R., Hapiot, P., **Downard, A.J.**	Langmuir	Amine-terminated monolayers on carbon: preparation characterization and coupling reactions
10.1002/elan.201500288	2-s2.0-84954452144	Harvey, H.M., Gross, A.J., Brooksby, P., **Downard, A.J.**, Green, S.J., Winlove, C.P., Benjamin, N., Winyard, P.G., Whiteman, M., Hammond, J.L., Estrela, P., Marken, F.	Electroanalysis	Boron-Doped Diamond Dual-Plate Deep-Microtrench Device for Generator-Collector Sulfide Sensing
10.1039/c5ra00295h	2-s2.0-84943786294	Ke, N.J., **Downard, A.J.**, Golovko, V.B.	RSC Adv	Carbon nanotube diameter control via catalytic Co nanoparticles electrodeposited in porous alumina membranes
10.1039/c5cp01401h	2-s2.0-84929192578	Menanteau, T., Levillain, E., **Downard, A.J.**, Breton, T.	Phys Chem Chem Phys	Evidence of monolayer formation from diazonium grafting with radical scavenger: electrochemical AFM and XPS monitoring
10.1021/acsami.5b06493	2-s2.0-84946058318	Rawson, F.J., Hicks, J., Dodd, N., Abate, W., Garrett, D.J., Yip, N., Fejer, G., **Downard, A.J.**, Baronian, K.H.R., Jackson, S.K., Mendes, P.M.	ACS Appl Mater Interfaces	Fast ultrasensitive detection of reactive oxygen species using an electrocatalytic intracellular nanosensor
10.1021/acs.jpcc.5b08622	2-s2.0-84947720650	Brooksby, P.A., Farquhar, A.K., Dykstra, H.M., Waterland, M.R., **Downard, A.J.**	J Phys Chem C	Quantum capacitance of aryldiazonium modified large area few-layer graphene electrodes
10.1039/c4cp05143b	2-s2.0-84921653060	Ojha, U., Steenbergen, K.G., **Gaston, N.**	Physical Chemistry Chemical Physics	Al20 + does melt, albeit above the bulk melting temperature of aluminium
10.1021/acs.jpcc.5b04930	2-s2.0-84945547531	Ojha, U., **Gaston, N.**	Journal of Physical Chemistry C	Characterizing the Greater-Than-Bulk Melting Behavior of Ga–Al Nanoalloys

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10.1103/PhysRevB.91.235148	2-s2.0-84935124620	Marsoner Steinkasserer, L.E., Paulus, B., **Gaston, N.**	Physical Review B – Condensed Matter and Materials Physics	Hybrid density functional calculations of the surface electronic structure of GdN
10.1002/chem.201405718	2-s2.0-84920179366	Steenbergen, K.G., **Gaston, N.**	Chemistry – A European Journal	Quantum Size Effects in the Size-temperature Phase Diagram of Gallium: Structural Characterization of Shapeshifting Clusters
10.1063/1.4917170	2-s2.0-84928324392	Steinkasserer, L.E.M., **Gaston, N.**, Paulus, B.	Journal of Chemical Physics	Weak interactions in Graphane/BN systems under static electric fields – a periodic ab-initio study
10.1016/j.str.2015.03.019	2-s2.0-84930189772	Radjainia, M., Venugopal, H., Desfosses, A., Phillips, A.J., Yewdall, N.A., Hampton, M.B., **Gerrard, J.A.**, Mitra, A.K.	Structure	Cryo-electron microscopy structure of human peroxiredoxin-3 filament reveals the assembly of a putative chaperone
10.1002/cplu.201500133	2-s2.0-84927602666	Kaur, M., Roberts, S., Healy, J., Domigan, L., Vasudevamurthy, M., **Gerrard, J.A.**, Sasso, L.	ChemPlusChem	Crystallin nanofibrils: A functionalizable nanoscaffold with broad applications manufactured from a waste
	2-s2.0-84938695045	**Gerrard, J.A.**	Journal of the Royal Society of New Zealand	Investigator-led science: Predict the unpredictable and be ready to capture transformational change
10.1016/j.ultramic.2014.12.004	2-s2.0-84919884221	Roache, F.J.M., Radjainia, M., **Williams, M.E.**, **Gerrard, J.A.**, **Travas-Sejdic, J.**, Malmström, J.	Ultramicroscopy	Novel lift-off technique for transmission electron microscopy imaging of block copolymer films
10.1039/c5nr05476a	2-s2.0-84948655388	Malmström, J., Wason, A., Roache, F., Yewdall, N.A., Radjainia, M., Wei, S., Higgins, M.J., **Williams, D.E.**, **Gerrard, J.A.**, **Travas-Sejdic, J.**	Nanoscale	Protein nanorings organized by poly(styrene-block-ethylene oxide) self-assembled thin films
10.1002/bip.22592	2-s2.0-84925258000	Ashmead, H.M., Negron, L., Webster, K., Arcus, V., **Gerrard, J.A.**	Biopolymers	Proteins as supramolecular building blocks: Nterm-Lsr2 as a new protein tecton
10.1016/j.jfca.2014.08.007	2-s2.0-84925841288	Lassé, M., Deb-Choudhury, S., Haines, S., Larsen, N., **Gerrard, J.A.**, Dyer, J.M.	Journal of Food Composition and Analysis	The impact of pH, salt concentration and heat on digestibility and amino acid modification in egg white protein
10.1016/j.foodchem.2014.10.147	2-s2.0-84910647039	Newton, A.E., Fairbanks, A.J., Golding, M., Andrewes, P., **Gerrard, J.A.**	Food Chemistry	The influence of emulsion structure on the Maillard reaction of ghee
10.1021/ic503040f	2-s2.0-84924956362	Feltham, H.L.C., Johnson, C., Elliott, A.B.S., **Gordon, K.C**., Albrecht, M., **Brooker, S.**	Inorganic Chemistry	"Tail" tuning of iron(II) spin crossover temperature by 100 K
10.1021/acs.inorgchem.5b01032	2-s2.0-84937675951	Lo, W.K.C., Huff, G.S., Preston, D., McMorran, D.A., Giles, G.I., **Gordon, K.C**., Crowley, J.D.	Inorganic Chemistry	A Dinuclear Platinum(II) N4Py Complex: An Unexpected Coordination Mode for N4Py
10.1039/c5cc01973g	2-s2.0-84928962831	Scottwell, S.O., Elliott, A.B.S., Shaffer, K.J., Nafady, A., McAdam, C.J., **Gordon, K.C**., Crowley, J.D.	Chemical Communications	Chemically and electrochemically induced expansion and contraction of a ferrocene rotor
10.1021/ic502557w	2-s2.0-84923207242	Lo, W.K.C., Huff, G.S., Cubanski, J.R., Kennedy, A.D.W., McAdam, C.J., McMorran, D.A., **Gordon, K.C**., Crowley, J.D.	Inorganic Chemistry	Comparison of inverse and regular 2-Pyridyl-1,2,3-triazole "click" Complexes: Structures, Stability, Electrochemical, and Photophysical Properties
10.1021/acs.jpcc.5b00147	2-s2.0-84924588060	Zhao, L., Wagner, P., Van Der Salm, H., Clarke, T.M., **Gordon, K.C**., Mori, S., Mozer, A.J.	Journal of Physical Chemistry C	Dichromophoric zinc porphyrins: Filling the absorption gap between the soret and Q bands
10.1016/j.ica.2015.01.006	2-s2.0-84921820440	Van Der Salm, H., Larsen, C.B., McLay, J.R.W., Huff, G.S., **Gordon, K.C**.	Inorganica Chimica Acta	Effects of protonation on the optical and photophysical properties of ReCl(CO)3(dppz-TAA) and [Ru(bpy)2(dppz-TAA)]2+

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10.1002/chem.201501938	2-s2.0-84945449686	Van Der Salm, H., Wagner, P., Wagner, K., Officer, D.L., Wallace, G.G., **Gordon, K.C**.	Chemistry – A European Journal	Flexible Tuning of Unsaturated β-Substituents on Zn Porphyrins: A Synthetic, Spectroscopic and Computational Study
10.1071/CH14700	2-s2.0-84953876803	Cubanski, J.R., Reish, M.E., Blackman, A.G., Steel, P.J., **Gordon, K.C**., McMorran, D.A., Crowley, J.D.	Australian Journal of Chemistry	Hybrid Pyrazolyl-1,2,3-Triazolyl Tripodal Tetraamine Ligands: Click Synthesis and Cobalt(III) Complexes
10.1039/c4dt03228d	2-s2.0-84928811360	Werrett, M.V., Huff, G.S., Muzzioli, S., Fiorini, V., Zacchini, S., Skelton, B.W., Maggiore, A., Malicka, J.M., Cocchi, M., **Gordon, K.C**., Stagni, S., Massi, M.	Dalton Transactions	Methylated Re(i) tetrazolato complexes: Photophysical properties and Light Emitting Devices
10.1021/acs.inorgchem.5b01690	2-s2.0-84951733335	Horvath, R., Fraser, M.G., Clark, C.A., Sun, X.-Z., George, M.W., **Gordon, K.C**.	Inorganic Chemistry	Nature of Excited States of Ruthenium-Based Solar Cell Dyes in Solution: A Comprehensive Spectroscopic Study
10.1021/acs.jpcc.5b07129	2-s2.0-84942767059	Van Der Salm, H., Lind, S.J., Griffith, M.J., Wagner, P., Wallace, G.G., Officer, D.L., **Gordon, K.C**.	Journal of Physical Chemistry C	Probing Donor-Acceptor Interactions in meso-Substituted Zn(II) Porphyrins Using Resonance Raman Spectroscopy and Computational Chemistry
10.1021/cm504655f	2-s2.0-84928662096	Reish, M.E., Huff, G.S., Lee, W., Uddin, M.A., Barker, A.J., Gallaher, J.K., **Hodgkiss, J.M.**, Woo, H.Y., **Gordon, K.C**.	Chemistry of Materials	Thermochromism, Franck-Condon analysis and interfacial dynamics of a donor-acceptor copolymer with a low band gap
10.1103/PhysRevB.92.115414	2-s2.0-84942465840	F S Gray T Kernreiter **M Governale U Zülicke**	Physical Review B	Coulomb-exchange effects in nanowires with spin splitting due to a radial electric field
10.1103/PhysRevB.91.125401	2-s2.0-84924366236	S Droste J Splettstoesser **M Governale**	Physical Review B	Finite-frequency noise in a quantum dot with normal and superconducting leads
10.1039/c4nr07412b	2-s2.0-84922832024	Lee, T., **Hendy, S.C.**, Neto, C.	Nanoscale	Control of nanoparticle formation using the constrained dewetting of polymer brushes
10.1017/S144618111500019X	2-s2.0-84944049151	Cox, B.J., **Hendy, S.C.**	ANZIAM Journal	Editorial: Modelling approach to nanoscale science and technology
10.1039/c5cp04448k	2-s2.0-84946926154	Rajabi, L., **Hendy, S.C.**	Physical Chemistry Chemical Physics	Effective rate constant for nanostructured heterogeneous catalysts
10.1017/S1446181115000127	2-s2.0-84944179732	Zhang, X.P., Lund, N.J., **Hendy, S.C.**	ANZIAM Journal	Effective slip length: Some analytical and numerical results
	2-s2.0-84948433157	Eakins, G.L., Wojciechowski, J.P., Martin, A.D., Webb, J.E.A., Thordarson, P., **Hodgkiss, J.M.**	Supramolecular Chemistry	Chiral effects in peptide-substituted perylene imide nanofibres
10.1038/ncomms9420	2-s2.0-84942587144	Price, M.B., Butkus, J., Jellicoe, T.C., Sadhanala, A., Briane, A., Halpert, J.E., Broch, K., **Hodgkiss, J.M.**, Friend, R.H., Deschler, F.	Nature Communications	Hot-carrier cooling and photoinduced refractive index changes in organic-inorganic lead halide perovskites
		B Zhu O A Alsager S Kumar J M Hodgkiss **J Travas-Sejdic**	Biosens Bioelectron	Label-free electrochemical aptasensor for femtomolar detection of 17β-estradiol
10.1002/asia.201500313	2-s2.0-84942364871	Zhu, B., Booth, M.A., Woo, H.Y., **Hodgkiss, J.M.**, **Travas-Sejdic, J.**	Chemistry – An Asian Journal	Label-Free, Electrochemical Quantitation of Potassium Ions from Femtomolar Levels

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10.1103/PhysRevApplied.4.024017	2-s2.0-84951311161	Barker, A.J., **Hodgkiss, J.M.**	Physical Review Applied	Quantitative Decoupling of Excited-State Absorption Cross Section and Population via Pump-Probe Spectroscopy with a Strong Probe
10.1021/acs.jpclett.5b00589	2-s2.0-84928999734	McVey, B.F.P., Butkus, J., Halpert, J.E., **Hodgkiss, J.M., Tilley, R.D.**	Journal of Physical Chemistry Letters	Solution synthesis and optical properties of transition-metal-doped silicon nanocrystals
10.1039/c5ee01713k	2-s2.0-84940534894	Gallaher, J.K., Prasad, S.K.K., Uddin, M.A., Kim, T., Kim, J.Y., Woo, H.Y., **Hodgkiss, J.M.**	Energy and Environmental Science	Spectroscopically tracking charge separation in polymer : fullerene blends with a three-phase morphology
10.1021/jz502528c	2-s2.0-84939144517	Chen, K., Barker, A.J., Morgan, F.L.C., Halpert, J.E., **Hodgkiss, J.M.**	Journal of Physical Chemistry Letters	Effect of carrier thermalization dynamics on light emission and amplification in organometal halide perovskites
10.1002/adfm.201501537	2-s2.0-84941023701	Lukman, S., Musser, A.J., Chen, K., Athanasopoulos, S., Yong, C.K., Zeng, Z., Ye, Q., Chi, C., **Hodgkiss, J.M.**, Wu, J., Friend, R.H., Greenham, N.C.	Advanced Functional Materials	Tuneable Singlet Exciton Fission and Triplet-Triplet Annihilation in an Orthogonal Pentacene Dimer
10.1021/acs.analchem.5b00335	2-s2.0-84928485011	Alsager, O.A., Kumar, S., Zhu, B., **Travas-Sejdic, J.**, McNatty, K.P., **Hodgkiss, J.M.**	Analytical Chemistry	Ultrasensitive colorimetric detection of 17-estradiol: The effect of shortening dna aptamer sequences
10.1039/c4dt03086a	2-s2.0-84922786783	Webster, A.A., Prasad, S.K.K., **Hodgkiss, J.M.**, Hoberg, J.O.	Dalton Transactions	An N-heterocyclic carbene phenanthroline ligand: Synthesis, multi-metal coordination and spectroscopic studies
10.1039/c5ra16700k	2-s2.0-84950159618	Kolb, A.N.D., Harvey, J.E., **Johnston, J.H.**	RSC Advances	Functional, water-dispersible gold nanoparticles produced with N,N-bis(acryloyl)-(l)-cystine
	2-s2.0-84951968673	Mesic, B.B., Järnström, L., **Johnston, J.**	Nordic Pulp and Paper Research Journal	Latex-based barrier dispersion coating on linerboard: Flexographic multilayering versus single step conventional coating technology
10.1039/c5ra15132e	2-s2.0-84942913338	Kaviyasaru K; Manikandan E; **Kennedy JV**; Maaza M	RSC Advances	A comparative study on the morphological features of highly ordered MgO:AgO nanocube arrays prepared via a hydrothermal method
10.1142/S0217979215400135	2-s2.0-84928547064	Fang, F., **Kennedy, J.**, Dhillon, M., Flint, S.	International Journal of Modern Physics B	Antibacterial effect of silver nanofilm modified stainless steel surface
10.1016/j.eurpolymj.2015.05.016	2-s2.0-84929624901	Chaudhary, O.J., Calius, E.P., **Kennedy, J.V.**, Dickinson, M., Loho, T., **Travas-Sejdic, J.**	European Polymer Journal	Bioinspired dry adhesive: Poly(dimethylsiloxane) grafted with poly(2-ethylhexyl acrylate) brushes
10.1109/TASC.2014.2366079	2-s2.0-84921453347	Strickland, N.M., Wimbush, S.C., **Kennedy, J.V.**, Ridgway, M.C., Talantsev, E.F., Long, N.J.	IEEE Transactions on Applied Superconductivity	Effective low-temperature flux pinning by Au ion irradiation in HTS coated conductors
10.1016/j.jallcom.2015.08.094	2-s2.0-84940516682	Sathyaseelan, B., Manikandan, E., Sivakumar, K., **Kennedy, J.**, Maaza, M.	Journal of Alloys and Compounds	Enhanced visible photoluminescent and structural properties of ZnO/KIT-6 nanoporous materials for white light emitting diode (w-LED) application
10.1016/j.jallcom.2015.06.102	2-s2.0-84933565123	Manikandan, E., **Kennedy, J.**, Kavitha, G., Kaviyarasu, K., Maaza, M., Panigrahi, B.K., Mudali, U.K.	Journal of Alloys and Compounds	Hybrid nanostructured thin-films by PLD for enhanced field emission performance for radiation micro-nano dosimetry applications

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	2-s2.0-84922534310	**Kennedy, J.**, Leveneur, J., Murmu, P.P., Aamiriqbal	International Journal of ChemTech Research	Ion implantation study of rare-earth doped strontium titanate
10.1007/s13391-015-5124-8	2-s2.0-84947252972	Murmu, P.P., **Kennedy, J.**, **Ruck, B.J.**, Rubanov, S.	Electronic Materials Letters	Microstructural, electrical and magnetic properties of erbium doped zinc oxide single crystals
10.1016/j.msea.2015.04.073	2-s2.0-84929353128	Carpeno DF; Ohmura T; Zhang L; Leveneur J; Dickinson M; Seal C; **KennedyJV**; Hyland M	Materials Science & Engineering A Structural Materials: Properties Microstructure and Processing	Nanomechanical and in-situ TEM characterization of boron carbide thin films on helium implanted substrates: delamination real-time cracking and substrate buckling
10.1063/1.4905175	2-s2.0-84923558935	David, C., Varghese Anto, C., Dholakia, M., Chandra, S., Nair, K.G.M., Panigrahi, B.K., Santhana Raman, P., Amirthapandian, S., Amarendra, G., **Kennedy, J.**	Journal of Applied Physics	Nonlinear effects in defect production by atomic and molecular ion implantation
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10.1021/acs.inorgchem.5b00626	2-s2.0-84939422990	Kotova, O., Daly, R., Dos Santos, C.M.G., **Kruger, P.E.**, Boland, J.J., Gunnlaugsson, T.	Inorganic Chemistry	Cross-linking the fibers of supramolecular gels formed from a tripodal terpyridine derived ligand with d-Block metal ions
10.1080/10610278.2015.1067315	2-s2.0-84948400672	Hawes, C.S., **Kruger, P.E.**	Supramolecular Chemistry	Metallosupramolecular architectures based upon new 2-(1-pyrazolyl)-benzimidazole chelating ligands
10.1021/acs.inorgchem.5b01352	2-s2.0-84942853690	Yang, H., **Kruger, P.E.**, **Telfer, S.G.**	Inorganic Chemistry	Metal-organic framework nanocrystals as sacrificial templates for hollow and exceptionally porous titania and composite materials
10.1039/c5dt00011d	2-s2.0-84929095547	Bryant, M.R., Burrows, A.D., Fitchett, C.M., Hawes, C.S., Hunter, S.O., Keenan, L.L., Kelly, D.J., **Kruger, P.E.**, Mahon, M.F., Richardson, C.	Dalton Trans	The synthesis and characterisation of coordination and hydrogen-bonded networks based on 4-(35-dimethyl-1H-pyrazol-4-yl) benzoic acid
10.10022014	2-s2.0-84926294092	Pandurangan, K., Kitchen, J.A., Blasco, S., Boyle, E.M., Fitzpatrick, B., Feeney, M., **Kruger, P.E.**, Gunnlaugsson, T.	Angewandte Chemie – International Edition	Unexpected self-sorting self-assembly formation of a [4:4] sulfate:ligand cage from a preorganized tripodal urea ligand
10.1364/JOSAB.32.000485	2-s2.0-84924302069	Raziman, T.V., Somerville, W.R.C., Martin, O.J.F., **Le Ru, E.C.**	Journal of the Optical Society of America B: Optical Physics	Accuracy of surface integral equation matrix elements in plasmonic calculations
10.1016/j.jqsrt.2015.03.020	2-s2.0-84926145291	Somerville, W.R.C., Auguié, B., **Le Ru, E.C.**	Journal of Quantitative Spectroscopy and Radiative Transfer	Accurate and convergent T-matrix calculations of light scattering by spheroids
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10.1007/s00445-015-0925-z	2-s2.0-84927135221	Schipper, C.I., Castro, J.M., Tuffen, H., Wadsworth, F.B., Chappell, D., Pantoja, A.E., Simpson, M.P., **Le Ru, E.C.**	Bulletin of Volcanology	Cristobalite in the 2011-2012 Cordón Caulle eruption (Chile)
10.1038/nphoton.2015.205	2-s2.0-84946134691	Darby, B.L., Auguié, B., Meyer, M., Pantoja, A.E., **Le Ru, E.C.**	Nature Photonics	Modified optical absorption of molecules on metallic nanoparticles at sub-monolayer coverage
		Suschke K; Hübner R; Murmu P P; Gupta P; Futter J; **Markwitz A**	Coatings 2015	Deposition process of diamond-like carbon coatings produced by a 360 degree circular anode layer ion source
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10.1016/j.apsusc.2015.06.199	2-s2.0-84941966077	Akers, P.W., Nelson, A.R.J., **Williams, D.E.**, **McGillivray, D.J.**	Applied Surface Science	Formation of hydrated layers in PMMA thin films in aqueous solution
10.1039/c5tb00702j	2-s2.0-84937510579	Shahlori, R., Waterhouse, G.I.N., Nelson, A.R.J., **McGillivray, D.J.**	Journal of Materials Chemistry B	Morphological, chemical and kinetic characterisation of zein protein-induced biomimetic calcium phosphate films
10.1021/acs.langmuir.5b02458	2-s2.0-84947997021	Knobloch, J.J., Nelson, A.R.J., Köper, I., James, M., **McGillivray, D.J.**	Langmuir	Oxidative Damage to Biomimetic Membrane Systems: In Situ Fe(II)/Ascorbate Initiated Oxidation and Incorporation of Synthetic Oxidized Phospholipids
10.1039/c5sm01378j	2-s2.0-84939802034	Xu, A.Y., Melton, L.D., Jameson, G.B., **Williams, M.A.K.**, **McGillivray, D.J.**	Soft Matter	Structural mechanism of complex assemblies: Characterisation of beta-lactoglobulin and pectin interactions
10.1039/C5RA22744E		Yang, Z.; Chaieb, S.; Hemar, Y.; de Campo, L.; Rehm, C.; **McGillivray, D. J.**;	RSC Advances	Investigating Linear and Nonlinear Viscoelastic behaviour and microstructures of Gelatine-Multiwalled carbon nanotubes composites
10.1002/cssc.201500945	2-s2.0-84945470650	MacDonald, T.J., Tune, D.D., Dewi, M.R., Gibson, C.T., Shapter, J.G., **Nann, T.**	ChemSusChem	A TiO_2 Nanofiber-Carbon Nanotube-Composite Photoanode for Improved Efficiency in Dye-Sensitized Solar Cells
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10.1039/c5py01245g	2-s2.0-84945249089	Kroon, R., Melianas, A., Zhuang, W., Bergqvist, J., Diaz De Zerio Mendaza, A., Steckler, T.T., Yu, L., Bradley, S.J., Musumeci, C., Gedefaw, D., **Nann, T.**, Amassian, A., Müller, C., Inganäs, O., Andersson, M.R.	Polymer Chemistry	Comparison of selenophene and thienothiophene incorporation into pentacyclic lactam-based conjugated polymers for organic solar cells
10.1039/c5ta01821h	2-s2.0-84934927511	Macdonald, T.J., Mange, Y.J., Dewi, M.R., Islam, H.U., Parkin, I.P., Skinner, W.M., **Nann, T.**	Journal of Materials Chemistry A	$CuInS_2/ZnS$ nanocrystals as sensitisers for NiO photocathodes
10.1002/adom.201400570	2-s2.0-84929265251	Bear, J.C., Hollingsworth, N., Roffey, A., Mcnaughter, P.D., Mayes, A.G., Macdonald, T.J., **Nann, T.**, Ng, W.H., Kenyon, A.J., Hogarth, G., Parkin, I.P.	Advanced Optical Materials	Doping Group IIB Metal Ions into Quantum Dot Shells via the One-Pot Decomposition of Metal-Dithiocarbamates
10.1016/j.nano.2015.02.016	2-s2.0-84931090855	Simovic, S., Song, Y., **Nann, T.**, Desai, T.A.	Nanomedicine: Nanotechnology, Biology, and Medicine	Intestinal absorption of fluorescently labeled nanoparticles
10.1021/nn5058408	2-s2.0-84923433498	Dewi, M.R., Gschneidtner, T.A., Elmas, S., Ranford, M., Moth-Poulsen, K., **Nann, T.**	ACS Nano	Monofunctionalization and dimerization of nanoparticles using coordination chemistry
10.1016/j.nanoen.2015.08.022	2-s2.0-84942509038	Chandrasekaran, S., **Nann, T.**, Voelcker, N.H.	Nano Energy	Nanostructured silicon photoelectrodes for solar water electrolysis
10.1039/c5ra08029k	2-s2.0-84934919687	Lindén, J.B., Larsson, M., Kaur, S., Skinner, W.M., Miklavcic, S.J., **Nann, T.**, Kempson, I.M., Nydén, M.	RSC Advances	Polyethyleneimine for copper absorption II: kinetics, selectivity and efficiency from seawater
10.1039/c5ra12559f	2-s2.0-84944750191	Chandrasekaran, S., McInnes, S.J.P., MacDonald, T.J., **Nann, T.**, Voelcker, N.H.	RSC Advances	Porous silicon nanoparticles as a nanophotocathode for photoelectrochemical water splitting
10.1039/c5ce01325a	2-s2.0-84944089128	Mange, Y.J., Dewi, M.R., Macdonald, T.J., Skinner, W.M., **Nann, T.**	CrystEngComm	Rapid microwave assisted synthesis of nearly monodisperse aqueous $CuInS_2/ZnS$ nanocrystals
10.1007/s00604-015-1571-z	2-s2.0-84941936025	Dewi, M.R., Laufersky, G., **Nann, T.**	Microchimica Acta	Selective assembly of Au-Fe<inf>3</inf>O<inf>4</inf> nanoparticle hetero-dimers
10.1063/1.4916222	2-s2.0-84926433576	Wickberg, A., Mueller, J.B., Mange, Y.J., Fischer, J., **Nann, T.**, Wegener, M.	Applied Physics Letters	Three-dimensional micro-printing of temperature sensors based on up-conversion luminescence
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10.1002/adfm.201502255	2-s2.0-84941743241	Eakins, G.L., Pandey, R., Wojciechowski, J.P., Zheng, H.Y., Webb, J.E.A., Valéry, C., Thordarson, P., **Plank, N.O.V.**, **Gerrard, J.A.**, **Hodgkiss, J.M.**	Advanced Functional Materials	Functional Organic Semiconductors Assembled via Natural Aggregating Peptides
10.1016/j.jlumin.2014.09.050	2-s2.0-84908439690	Hughes-Currie RB Salkeld AJ Ivanovskikh KV Reid MF Wells JPR **Reeves RJ**	Journal of Luminescence	Excitons and Inter-configurational transitions in $CaF_2:Yb^{2+}$ crystals
10.1117/12.2179709	2-s2.0-84931843486	Hyndman, A.R., **Allen, M.W.**, **Reeves, R.J.**	Proceedings of SPIE – The International Society for Optical Engineering	Growth of epitaxial ZnO films on sapphire substrates by plasma assisted molecular beam epitaxy
		Hughes-Currie RB Salkeld AJ Ivanovskikh KV Reid MF Wells JPR **Reeves RJ**	Journal of Luminescence	Vacuum ultraviolet synchrotron measurements of excitons in $NaMgF_3:Yb^{2+}$
10.1063/1.4916375		Senanayake, Pubudu S; Wells, JPR; Reid, MF; Hughes-Currie, RB; Berden, G; **Reeves, RJ**; Meijerink, A	Journal of Applied Physics	Frequency non-degenerate sequential excitation of the impurity trapped exciton in strontium fluoride crystals doped with ytterbium
10.1128/mBio.00453-15	2-s2.0-84936944363	Moradali MF Donati I Sims IM Ghods S **Rehm BHA**	mBio 6	Alginate polymerization and modification are linked in Pseudomonas aeruginosa
10.3389/fmicb.2015.00496	2-s2.0-84931270989	Schmid, J., Sieber, V., **Rehm, B.**	Frontiers in Microbiology	Bacterial exopolysaccharides: Biosynthesis pathways and engineering strategies
		Ghods S Sims IM Moradali MF **Rehm BHA**	Appl Environ Microbiol	Bactericidal compounds controlling growth of the plant pathogen Pseudomonas syringae pv actinidiae which forms biofilms composed of a novel exopolysaccharide

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10.1007/s10529-014-1735-7	2-s2.0-84925518227	Jahns, A.C., **Rehm, B.H.A.**	Biotechnology Letters	Immobilization of active lipase B from Candida antarctica on the surface of polyhydroxyalkanoate inclusions
		Hay ID Du J Rubio Reyes P **Rehm BHA**	Microbial Cell Factories	In vivo polyester immobilized sortase for tagless protein purification
10.1007/s00253-015-6719-6	2-s2.0-84941176828	Hooks, D.O., **Rehm, B.H.A.**	Applied Microbiology and Biotechnology	Insights into the surface topology of polyhydroxyalkanoate synthase: self-assembly of functionalized inclusions
10.1007/s00253-015-6591-4	2-s2.0-84939257362	Wang, Y., Hay, I.D., Rehman, Z.U., **Rehm, B.H.A.**	Applied Microbiology and Biotechnology	Membrane-anchored MucR mediates nitrate-dependent regulation of alginate production in Pseudomonas aeruginosa
10.1111/1751-7915.12241	2-s2.0-84922601615	**Rehm, B.H.A.**	Microbial Biotechnology	Synthetic biology toward the synthesis of custom-made polysaccharides
10.1063/1.4905598	2-s2.0-84923814731	Lee, C.-M., Warring, H., Vézian, S., Damilano, B., Granville, S., Al Khalfioui, M., Cordier, Y., **Trodahl, H.J.**, **Ruck, B.J.**, **Natali, F.**	Applied Physics Letters	Highly resistive epitaxial Mg-doped GdN thin films
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10.3168/jds.2015-10342	2-s2.0-84957928561	Nieuwoudt, M.K., Holroyd, S.E., McGoverin, C.M., **Simpson, M.C.**, **Williams, D.E.**	Journal of Dairy Science	Raman spectroscopy as an effective screening method for detecting adulteration of milk with small nitrogen-rich molecules and sucrose
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10.1088/0953-8984/27/10/105503	2-s2.0-84923634342	Chen, B., Laverock, J., Newby, D., McNulty, J.F., **Smith, K.E**., Glans, P.-A., Guo, J.-H., Qiao, R.-M., Yang, W.-L., Lees, M.R., Tung, L.D., Singh, R.P., Balakrishnan, G.	Journal of Physics Condensed Matter	Effects of rare-earth size on the electronic structure of La1-xLuxVO3
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		V. Jovic, **K.E. Smith**, Z.H. Al-Azri, H. Idriss, and G.I.N. Waterhouse,	Chem. Sus. Chem.	Heterojunction Synergies in Au/TiO2 Photocatalysts; Implications for Solar Hydrogen Production
10.1039/c5dt03795f	2-s2.0-84948778369	Miller, R.G., Narayanaswamy, S., Clark, S.M., Dera, P., Jameson, G.B., **Tallon, J.L.**, **Brooker, S.**	Dalton Transactions	Pressure induced separation of phase-transition-triggered-abrupt vs. gradual components of spin crossover
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		Kerr-Phillips T E Woehling V Agniel R Nguyen G T M Vidal FKilmartin P **Travas-Sejdic J**	J Mater Chem	Electrospun rubber fibre mats with electrochemically controllable pore sizes
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10.1016/j.synthmet.2015.07.031	2-s2.0-84939797752	Rakić, A.A., Vukomanović, M., Trifunović, S., **Travas-Sejdic, J.,** Chaudhary, O.J., Horský, J., Ćirić-Marjanović, G.	Synthetic Metals	Solvent effects on dopant-free pH-falling polymerization of aniline
10.1021/acs.analchem.5b00335	2-s2.0-84928485011	Alsager, O.A., Kumar, S., Zhu, B., **Travas-Sejdic, J.,** McNatty, K.P., **Hodgkiss, J.M.**	Analytical Chemistry	Ultrasensitive colorimetric detection of 17-estradiol: The effect of shortening dna aptamer sequences
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http://dxdoiorg/101071/CH14513		Ciarán Dolan Briar Naysmith Simon F R Hinkley Ian M Sims Margaret A Brimble **David E Williams** and Jianyong Jin	Aust J Chem	Synthesis of Novel Triazole-Containing Phosphonate Polymers
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