

Sydney Microscopy and Microanalysis

Micro, nano and atomic-scale exploration

Sydney Microscopy and Microanalysis enables insights into how the world operates at the scale of living cells, tissue, molecules, crystals and even individual atoms.

Reducing drag to save fuel

Challenge

With growing imperatives to reduce fossil fuel consumption globally, both governments and industry have an active interest in improving the efficiency of their fleets across air, water and land. Australian start-up MicroTau has been conducting research and development in this area with the aim of boosting efficiency by reducing surface drag in transport.

Research

Microscopic patterns found on many plants and animals have functional properties that have evolved over millions of years. For example, sharks have thousands of microscopic overlapping 'scales' that reduce drag, allowing them to glide swiftly and silently through the water. Inspired by this phenomenon, MicroTau developed an innovative technique to create drag-reducing microstructures using UV curable coatings that can be applied to aeroplanes and ships. The company is also collaborating with Professor Chiara Neto (School of Chemistry, Faculty of Science; ARC Future Fellow) and her team to investigate the use of functional microstructures for ship anti-fouling. This work also aims to reduce drag by deterring marine life from attaching to ships. Both projects have been enabled by Sydney Microscopy and Microanalysis, where scanning electron microscopes were used to examine and compare different microstructures.

Results

MicroTau's technique for producing functional microstructures, known as Direct Contactless Microfabrication (DCM), is now patented. While initially developed for the US Air Force, MicroTau's drag reduction products have the potential to save commercial aviation and shipping over US\$34 billion in fuel costs and 225 million tonnes of CO2 emissions annually. Meanwhile, MicroTau's ship anti-fouling work with Professor Neto's team is progressing, and a full-time PhD student was recently engaged to enable this ongoing collaboration. Sydney Microscopy and Microanalysis continues to support MicroTau's development of new microstructures and techniques.

Funding sources include:

- Australian Research Council
- Defence Innovation Network

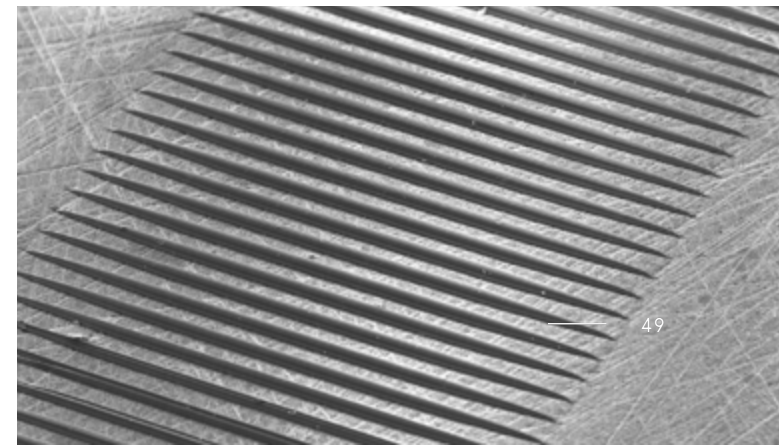
Story assistance from Microscopy Australia.



Find out more

sydney.edu.au/microscopy-microanalysis

Right: Scanning electron microscope image of MicroTau's riblets taken at Sydney Microscopy and Microanalysis.



Defending ourselves against COVID-19

Challenge

Since the emergence of COVID-19, researchers have been working to determine the mechanisms behind clinical variance in severity and outcomes for infected patients. Understanding the basis for these differences could help to predict outcomes and potentially lead to new COVID-19 treatments.

Research

A team of researchers, led by Professor Greg Neely (School of Life and Environmental Sciences, Faculty of Science; Charles Perkins Centre), set out to explore factors influencing how SARS-CoV-2 interacts with cells, hoping to shed light on the body's innate defence system.

When a person becomes infected with COVID-19, the SARS-CoV-2 virus uses its spike protein to attach to the outside of a host cell via a protein called ACE2. However, they found that the virus can also bind to a naturally occurring protein called LRRRC15. When it does this, the virus can no longer bind to ACE2, taking it out of circulation. The team used confocal microscopy at Sydney Microscopy and Microanalysis to help demonstrate this binding, with the assistance of platform scientist Dr Neftali Flores Rodriguez.

Results

Data from the study show that expression of LRRRC15 on cells that are not susceptible to SARS-CoV-2 infection could protect neighbouring ACE2+ SARS-CoV-2 target cells.



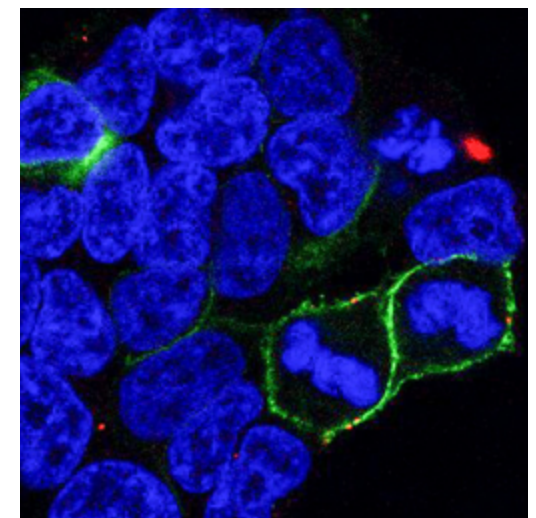
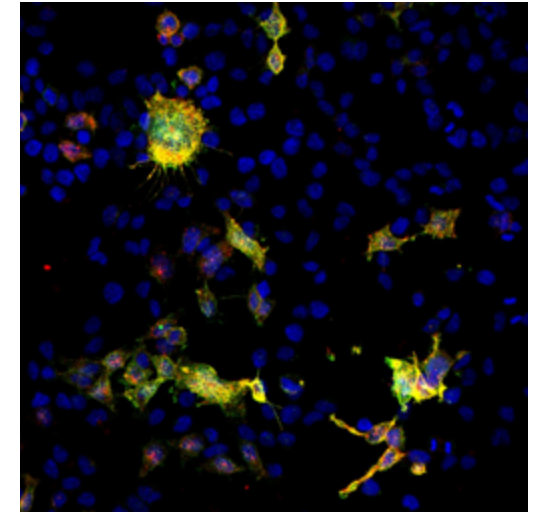
LRRRC15 is found at protective immune barriers in the body, such as the placenta, skin, mouth, throat and lymph nodes, but it isn't present in high levels in healthy lungs. However, the team also found that during COVID-19, the amount of LRRRC15 in the lungs increases, sticking to the viruses and creating a barrier that prevents them from infecting cells.

Similar results were also reported by two other research groups at the same time, which provides a robust confirmation of this study. Moreover, in an independent patient-focussed study that was also published at the same time, the authors reported that out of all proteins in the blood, LRRRC15 levels were the most important for predicting patient outcomes. High levels of blood LRRRC15 indicate less severe disease, and decreasing LRRRC15 levels indicate more severe COVID-19. Said Professor Neely, "We can now use this new receptor to design broad-acting drugs that can block viral infection or even suppress lung fibrosis." The study was published in *PLOS Biology*.

Funding sources include:

- National Health and Medical Research Council
- Swiss National Science Foundation
- University of Sydney

Story assistance from *Microscopy Australia*.



Above: Confocal image from the project showing cultured cells with LRRRC15 in yellow and green and the SARS-Cov-2 spike protein in red. Taken by Dr Cesar Moreno at Sydney Microscopy and Microanalysis.

Strengthening Australia's nano-biotechnology capability

Thanks to nano-biotechnology, samples as tiny as single cells or clusters of molecules can lead to medical diagnoses, and development of bespoke treatments can increase their efficacy. This emerging field is called precision medicine, and it is set to be a game-changer for treating cancer – the second-biggest killer globally – as well as infectious diseases. Precision medicine is now poised to take a significant stride forward thanks to a new research partnership with Bruker, a world-leading manufacturer of high-performance scientific instruments.

Australian-first research capability

Under the partnership, Sydney Microscopy and Microanalysis will acquire two new-generation atomic force microscopes made by Bruker – the first of their

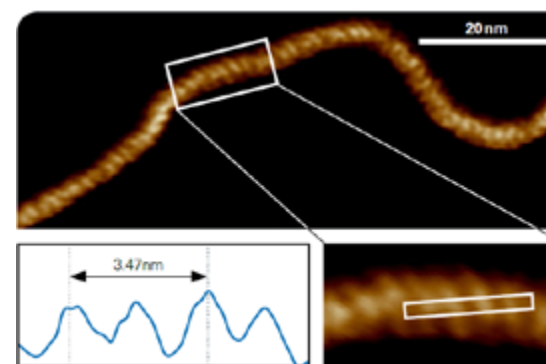
kind in Australia. The microscopes are customised to perform highest-resolution imaging of living biological samples, visualise dynamic molecular mechanisms and quantify cellular and biomolecular interactions. Advanced automation capabilities make them ideal for biomedical and preclinical research. The partnership will place Sydney Microscopy and Microanalysis in a leading position internationally to enable advances in nanomedicine, gene therapies and the early detection, treatment and prevention of disease.

Research applications

The driving force behind the partnership is Dr David Martinez Martin (School of Biomedical Engineering; Deputy Director, Sydney Microscopy and Microanalysis), who has had a long-standing collaboration with Bruker

in atomic force microscopy. As part of the partnership, Bruker will support nano-biotechnology research driven by Dr David Martinez Martin.

Further projects are set to follow. Atomic force microscopy allows scientists to analyse and manipulate live cells and materials at the nanoscale, even molecule by molecule, using a laser to measure the physical interaction of the microscope's sensor with a sample at the scale of a billionth of a metre. These cutting-edge capabilities will enable unprecedented exploration of biophysical properties of tissues, cells and molecules with the aim of developing the next generation of diagnostics and treatments.



Left: The profile of a DNA molecule seen through a Bruker atomic force microscope, showing the grooves of the double helix structure (represented by the troughs in the graph). The diameter of human DNA is approximately 2.5 nanometers, which is up to 72,000 times smaller than that of a human hair.

Left: Dr David Martinez Martin (third from left) and colleagues in a lab at Sydney Microscopy and Microanalysis, where the new atomic force microscopes will be located.