Core Research Facilities

Research & Prototype Foundry

Case Studies

THE UNIVERSITY OF SYDNEY

RESEARCH AND PROTOTYPE FOUNDRY

The Research and Prototype Foundry (RPF) is a nanofabrication facility which offers instruments and specialist expertise for the fabrication of devices and structures with critical features on the micro and nanoscale. Users run specialised processes to make devices and prototype new ideas.

New nano device lights the way for quantum development

Using light for information processing is increasingly important for both the fidelity and speed of communications. However, efficiently miniaturising devices so that they can manipulate and concentrate light at the nanoscale remains a formidable challenge for both researchers and industrialists.

Utilising the world-leading capability at the **Research and Prototype Foundry**, the Sydney Nano Institute's Dr. Alessandro Tuniz (School of Physics, Faculty of Science) has created a hybrid waveguide device that could potentially solve this problem. The device rotates and then focuses light to an incredibly fine point – all within a monolithic chip.

This process is normally achieved through separate components, but in Dr Tuniz's solution, each module has been integrated within a single chip using widely available fabrication processes and standard materials. This makes industrial scalability plausible and this is a future direction. This device was built in the **Research and Prototype Foundry** cleanroom, utilising specialised electron beam lithography equipment and an atomic force microscope.

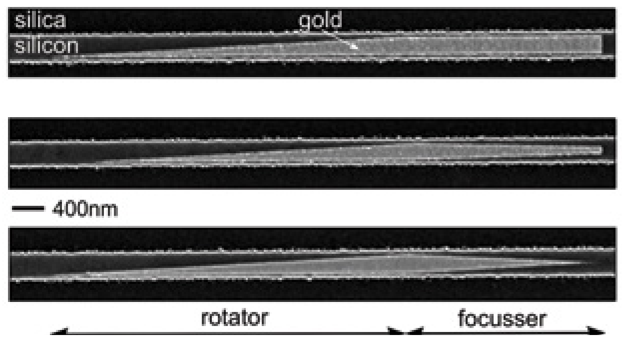
In developing his device, Dr Tuniz has built a bridge between industry-standard silicon photonic systems and metal-based waveguides, which concentrate light in areas that are 100 times smaller while retaining efficiency.

The new device has the potential to be used in quantum information systems, nano-spectroscopy, nano-scale detectors, and atomic scale sensing.

User access scheme success

Dr Tuniz received a Core Research Facilities *User Access Scheme* grant in 2018 to enable his initial access to the **Research and Prototype Foundry** to support his proof-of-concept work. This preliminary work ultimately led to Dr Tuniz's successful 2020 Australian Research Council, Discovery Early Career Researcher Award application.

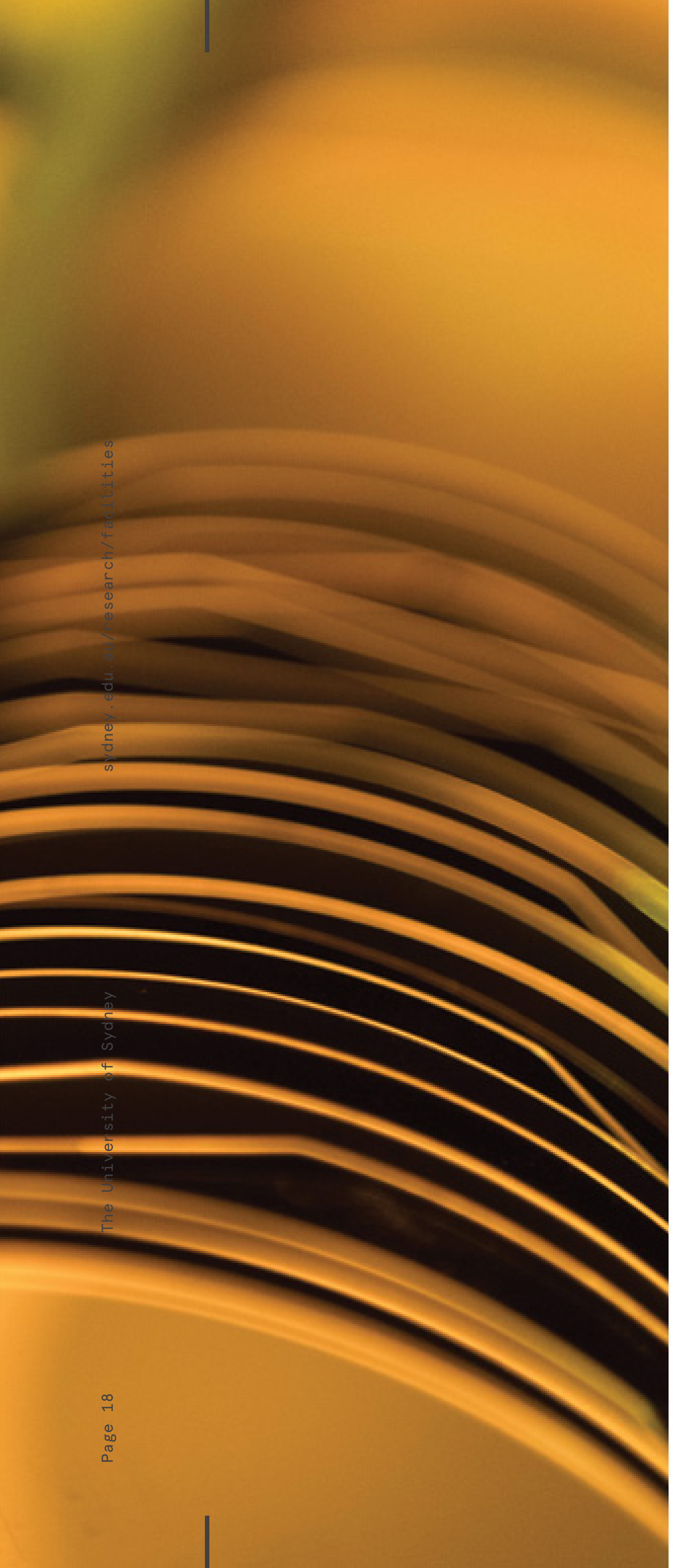
The outcomes and implications of his device were published in *Nature Communications*.



Scanning electron micrograph (top view) of silicon on insulator waveguides post processed with hybrid plasmonic waveguide circuits

Find out more

- sydney.edu.au/research/facilities/research-and-prototype-foundry



Using microchips to understand heart disease

Heart disease affects 1.2 million Australians every year and is the number one cause of deaths worldwide. Dr Lining Arnold Ju (School of Biomedical Engineering, Faculty of Engineering and Heart Research Institute) and his research team have been seeking to better understand blood clotting in heart disease through microfluidics and nano health – an emerging capability within the **Research and Prototype Foundry.**

One cell at a time

Dr Ju, with the support of **Research and Prototype Foundry** staff, built a microfluidic chip that was able to simulate the narrowing of blood vessels – a key cause of blood clots. This allowed Dr Ju's team to directly observe the mechanical forces that influence blood clotting on a molecular level.

Published in *Nature Materials*, the research was able to describe mechanically driven platelet activation and why that causes platelets to aggregate and cause clots.

> This research could inform the design of efficient anti-thrombotic approaches that reduce biomechanical blood clotting.

Beginning as a small project funded via the Core Research Facilities *User Access Scheme*, Dr Ju's promising research into the biomechanical properties of clotting has been formally recognised via an Australian Research Council Discovery Early Career Researcher Award (2019), a Tall Poppy Award (2020) and being placed as a finalist in the Eureka Prize (2020).

Dr Ju and his research team are taking their research to the next level, continuing to work with **Research and Prototype Foundry** to make microfluidic chips to examine biomechanical regulation of blood cells for both healthy and diabetic patients.

Galaxy search

Looking for new galaxies far, far away has taken a leap forward thanks to recent innovations in telescope design. One of these innovations is "Hector" – a new dark-time instrument that will be incorporated into the Anglo-Australian Telescope (AAT) and will enable scientists to survey up to 15,000 galaxies!

Who is Hector?

Hector is comprised of 21 hexabundles – optical fibre imaging devices where the fibres have been modified and fused together in a hexagonal shape using a specially developed technique that enables more light to pass through. The hexabundles that are so integral to Hector were designed and constructed by Associate Professor Julia Bryant (School of Physics, Faculty of Science) and her research team, leveraging the expertise of the **Research and Prototype Foundry** staff.

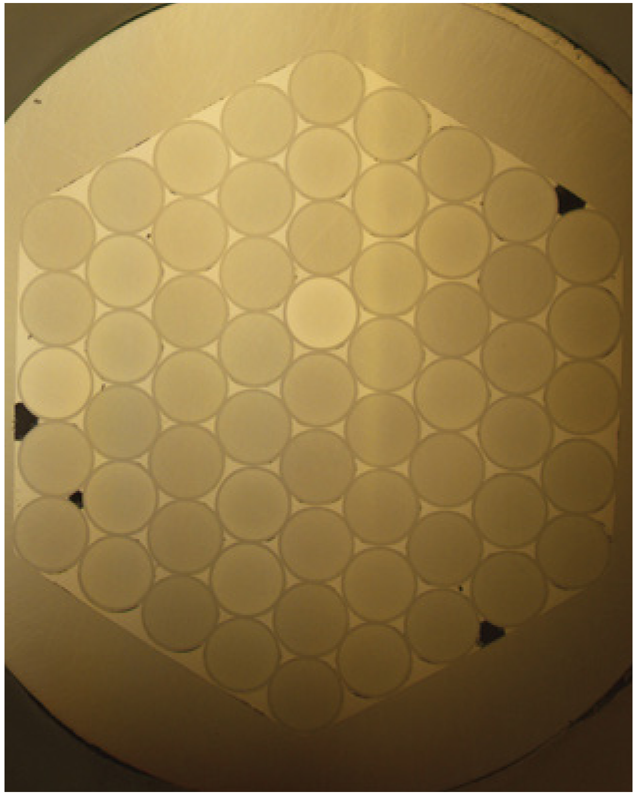
The research team, including Rebecca Brown and Adeline Haobing Wang (both School of Physics, Faculty of Science), collaborated with the **Research and Prototype Foundry** staff to develop a process for modifying commercial optical fibres using chemical etching. Commercial optical fibres have a core that captures the light, and which is surrounded by a protective cladding layer. Cladding on commercial optical fibres is about ten microns thick. In order to pack cores closer together and increase optical light collecting power, the research team shaved the cladding down to five microns by etching with Hydrofluoric acid (HF). This type of chemical etching is very effective but is difficult to replicate uniformly and thus produce the multiple standard-sized optical fibres needed for a hexabundle.

All bundled up

The **Research and Prototype Foundry** team built a holder to keep the optical fibres in place while etching was carried out on the facility's cleanroom. They also used a more dilute HF solution to exert more process control. Careful calibration of this process by the **Research and Prototype Foundry** staff, in collaboration with Associate Professor Bryant's group, resulted in the required highly controlled cladding thickness. This, in turn enabled the team to produce over 4,000 etched optical fibres. These hexabundles are part of an Australia Research Council Linkage Infrastructure and Equipment Facilities grant (2019).

The fibres fabricated at the Research and Prototype Foundry are due to be deployed on-sky at the AAT telescope when the complete Hector instrument is commissioned.

Additionally, the process developed for this project is now available to **Research and Prototype Foundry** users and will also be useful for research into semiconductors and photonics.



A 'hexabundle' which comprises 61 optical fibres fused into an imaging bundle.. Hexabundles are used on astronomical instruments on large telescopes to take spatially resolved spectra of galaxies. This hexabundle is part of the Hector instrument.

The University of Sydney

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