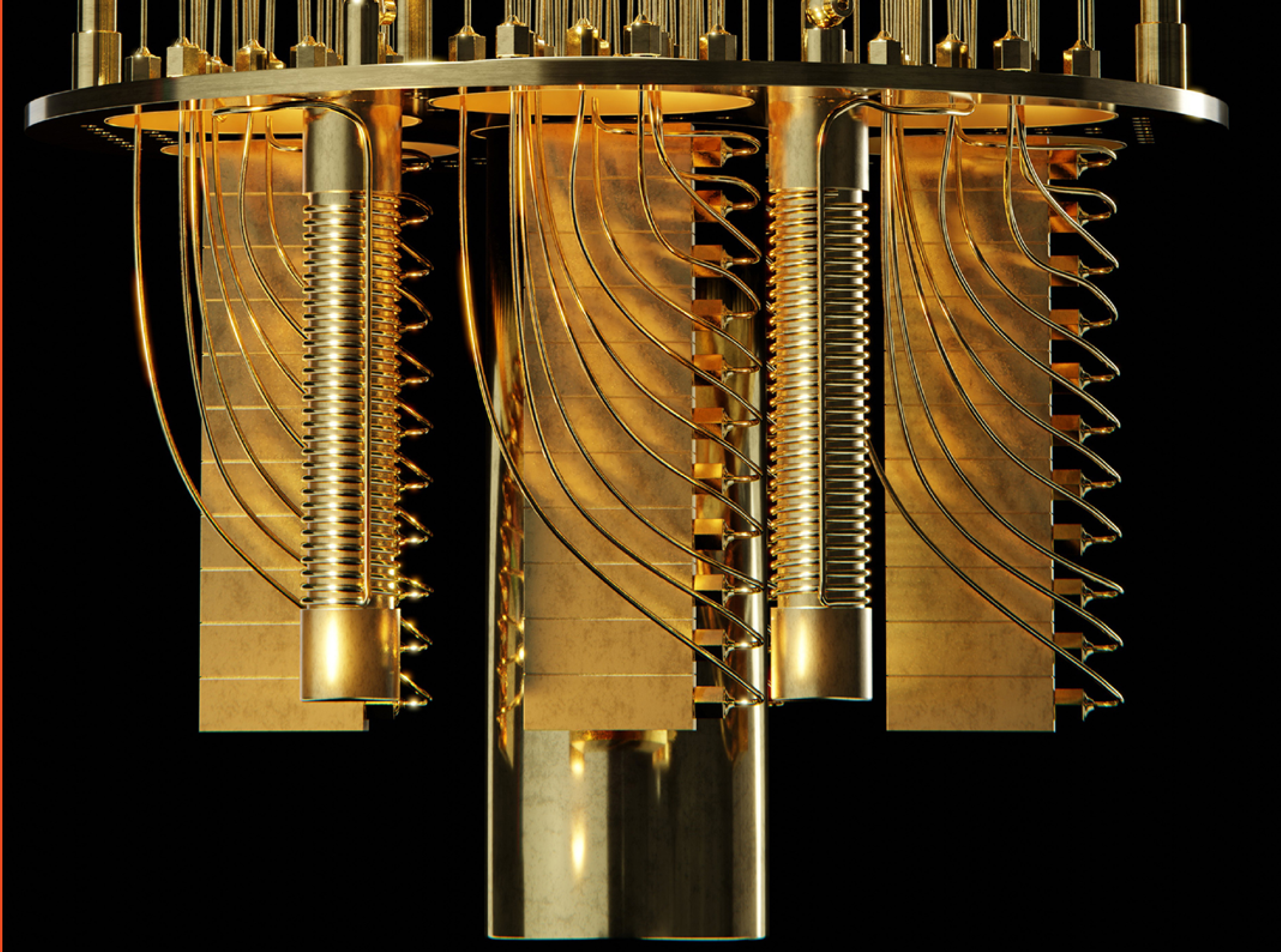


Making

Research and Prototype Foundry

Fabrication at micro and nano scale

The Research and Prototype Foundry, based in Sydney Nanoscience Hub, offers instruments for the fabrication of devices and structures with features on the micro and nanoscale, with specialised processes allowing users to prototype new optical, electronic, microfluidic, and quantum science and technology devices.

ANFF

NCRIS National Research Infrastructure for Australia An Australian Government Initiative

Find out more

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

Producing qubits in electronic devices

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE

Challenge

Quantum computing has the potential to solve problems of enormous complexity and scale. The catch? The components are so heat-sensitive that they need to be kept at temperatures close to -273°C.

Through work conducted at the Research and Prototype Foundry, quantum tech start-up Archer Materials developed ground-breaking components with potential for quantum computing at room temperature. This was a major milestone, but there was a barrier to scalability: they relied on a 40-nanometre carbon particle which proved extremely sensitive to physical manipulation. For a scalable product, Archer needs quantum bits, or qubits, that maintain integrity during and after circuit assembly.

Research

The R&D team at Archer ran extensive process development within the Research and Prototype Foundry cleanroom, making use of the facility's focused ion beam and scanning electron microscopes to understand the material's properties and their interactions at nano scale.

The ability to manoeuvre qubits with nanometre precision is crucial to quantum circuit assembly. With the help of technicians and instrument scientists from the Research and Prototype Foundry, including Senior Process Engineer Steven Moody, the team discovered that they could use custom focus-ion-beam-milled nanosized metal tips to 'pick up' and move the individual carbon nanoparticles successfully.

Results

The outstanding positional accuracy and control achieved through process development at the Research and Prototype Foundry enabled Archer to build scalable chip prototypes. The new process also allowed them to quickly build and test quantum information processing devices incorporating different qubit components, which is vital in building a chip for a practical quantum computer.

This breakthrough sets the stage for potential commercialisation and further advancements in quantum computing using carbon-based materials. The work was announced to investors and shareholders through the ASX platform (which is done routinely), underscoring the importance of ready access to research facilities in supporting innovation and shaping the future of technology.

Archer Materials is the only ASX-listed semiconductor company that is advancing quantum computing in electronic devices. Archer has a base in the Sydney Knowledge Hub.

Advancing solar cell efficiency

Challenge
Solar photovoltaic (conversion of sunlight into electricity) power capacity is predicted to surpass that of coal by 2027, becoming the largest energy source in the world and generating hundreds of billions of dollars globally as it becomes a vital pillar in the transition to a net-zero society. With standard silicon solar cells approaching their efficiency limit (29%), new approaches are needed to support the continued growth of this renewable power source.

Research
Silicon cells are good at converting lower-energy light to electricity but are not so good with higher-energy light. Tandem solar cells hold the most promise for overcoming the efficiency limit of silicon solar cells because they involve the stacking of a solar cell that is better at converting high-energy light to electricity onto a silicon cell. This allows the two cells to work in tandem, each converting light from different parts of the solar spectrum to electricity more efficiently.

Professor Anita Ho-Baillie (School of Physics, Faculty of Science; ARC Future Fellow) and her team explored an elegant approach to tandem silicon solar cells with metal halide perovskites using an ultra-thin indium tin oxide layer. The team experimented with the new tandem cell designs at the nanoscale to maximise efficiency gains.

The Research and Prototype Foundry provided access to the specialised facilities and technical support, led by Process Engineer Dr Yun Li, for part of the process sequence for the high-performance cell fabrication.

Results
As published in *Energy & Environmental Science*, Professor Ho-Baillie and her team broke new ground in terms of perovskite-silicon tandem solar cell efficiency with the new cell design using nanoscale indium tin oxide. Their champion cell achieved 27.2% power conversion efficiency, exceeding that of the best research silicon cell demonstrated to date, at 26.8%.

Funding sources include:

- Australian Centre for Advanced Photovoltaics
- Australian Renewable Energy Agency
- Australian Research Council
- University of Sydney

Above: The many layers of Professor Ho Baillie's silicon-perovskite tandem solar cells.

Towards early detection of cardiovascular disease

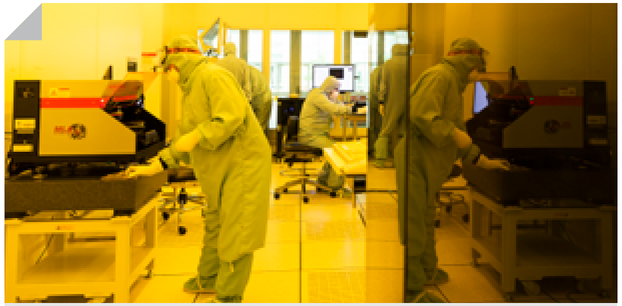
Challenge
Cardiovascular disease is the leading cause of death globally and can cost Australia around $12 billion in a single year. Early detection could deliver enormous benefits but clinical prediction can be complex and challenging. Associate Professor Arnold Lining Ju (School of Biomedical Engineering, Faculty of Engineering) is working on a device for detecting changes in the blood associated with cardiovascular disease in hope of improving health outcomes.

Research
Cardiovascular disease is characterised by blood clots, which are often preceded by subtle changes in the blood that are best observed at microscopic volume and scale. Dr Ju and his team wanted to develop a simple, effective tool to monitor for these changes by simulating clotting conditions. To do this, they designed a microscopic device with ultra-fine channels that act like blood vessels, and with protrusions in the channels to mimic clots.

With the assistance of Process Engineer Ethel Ilagan, the team fabricated the device at the Research and Prototype Foundry, where cutting-edge light exposure techniques allowed fast and accurate creation of the required structures with micron-level resolution.

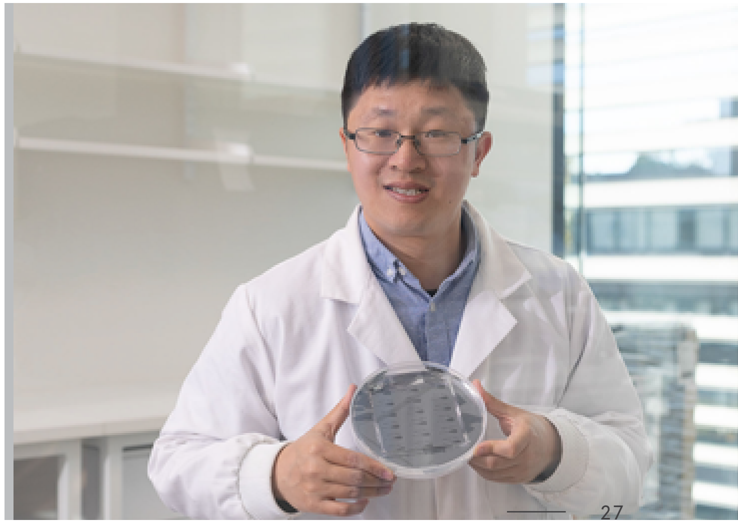
Results
The microfluidic device successfully enabled the study of clot formation in a small, convenient platform, and is extremely promising for both medical and research use. This achievement brought Dr Ju and team closer to their goal of creating a test for detecting cardiovascular disease within minutes, using a single drop of blood. Dr Ju was recently awarded a highly prestigious $8 million Snow Fellowship in recognition of the importance of this research, which has the potential to uncover new cellular mechanisms within the body. Dr Ju's work has received major media coverage and been published in journals including *Royal Society of Chemistry*.

Funding sources include:
- Australian Research Council
- National Health and Medical Research Council
- National Heart Foundation of Australia
- NSW Health
- Ramaciotti Foundation
- University of Sydney



Did you know?

At the Research and Prototype Foundry, micro and nano-scale devices are made in a 'cleanroom'. A cleanroom is a laboratory where the environment is strictly controlled to eliminate contaminants such as humidity and dust. The Research and Prototype Foundry's cleanrooms appear yellow because they filter out blue light, which can cause certain materials to harden.



Right: Associate Professor Arnold Lining Ju with his groundbreaking microfluidic devices produced at Research and Prototype Foundry.