The Australian National Fabrication Facility

151 Wellington Road, Clayton 3168, Australia

Providing micro and nano fabrication facilities for Australian researchers.

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ANFF

Quantum computing at higher temperatures

UNSW-led research published today in Nature has demonstrates a silicon quantum computing chip that operates at higher temperatures than ever before.

The proof of concept device provides a way to reduce the cost of cooling by orders of magnitude and is a significant step towards overcoming one of the fundamental roadblocks to building a practical quantum computer.

Managing the temperature of a quantum computer's components is essential for it to operate without errors. In a silicon quantum bit (qubit), single trapped electrons are used to represent binary code and allow the quantum computer to perform calculations – any unwanted heat in the system reduces control over these particles and drastically reduces the reliability of the device.

Current promising qubit architectures have to be cooled to approximately 0.1 Kelvin, only a fraction more than the lowest possible temperature in the universe. It requires extraordinary amounts of equipment, energy and money to maintain these temperatures, which makes their cost extremely high.

This new research, conducted by an international team led by Professor Andrew Dzurak at UNSW, demonstrates a design that allows the devices to operate at temperatures around 1.5K, an increase of 15 times. "This is still very cold, but is a temperature that can be achieved using just a few thousand dollars' worth of refrigeration, rather than the millions of dollars needed to cool chips to 0.1 Kelvin," explains Dzurak.

The team's novel architecture allows the single trapped electrons in the qubit to remain in near complete isolation from the rest of the system, while still allowing the data stored on the qubits to be read out.

It relies on a concept called electron tunnelling, a quantum phenomenon that allows these fundamental particles to pass through what would be classically considered as a solid wall. What's particularly interesting to teams working with quantum computers is that the tunnelling can be selective, tuned to only allow specific electrons through. This provides the team with a way to check whether each qubit is producing the desired result while maintaining the component's integrity.

Until now, the qubit readout process had meant that it was near impossible to maintain the selectivity of the electrons that can tunnel when temperature increased, thus ruining the chance of an accurate readout from the qubit.

This latest research, however, demonstrates a way around the problem by introducing tighter control over the "other" side of the wall, i.e. the point the electron is trying to tunnel towards, that means the technology can still operate at higher temperatures.

What's more, the device is produced using conventional fabrication techniques meaning it can be replicated in existing semiconductor 'chip' foundries. As with the majority of the work conducted by Professor Dzurak's team, these devices are built with ANFF-NSW's Silicon-MOS fabrication line, using similar processes to those currently used to produce conventional computing components. This means there are already production lines in place that can be adapted to produce the new QC components at scale, using existing semiconductor foundries once these devices are perfected.

There are other hurdles to overcome in advancing this technology, but handling the heat has been one of the largest. And, while 1.5K means that some refrigeration is still needed, it will be many times cheaper. The research finally opens a doorway towards full-scale quantum computing at more manageable temperatures.

The team is now working to transfer the manufacturing process from the ANFF research laboratories to industrial chip manufacturing plants that will be required to make quantum computer chips with the millions of qubits needed for global challenges, such as the computer-aided design of new medicines to fight disease.

--- LINKS ---

View the UNSW press release here.

View the paper published in Nature here.

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About ANFF

Established under the National Collaborative Research Infrastructure Strategy (NCRIS), the Australian National Fabrication Facility (ANFF) provides academia and industry with access to more than 500 state-of-the-art micro/nanofabrication facilities spread across 21 Australian locations.

For more than a decade, ANFF has been enabling research through a mixture of training, expert support and direct access.

The capability provided by ANFF enables users to process hard materials (metals, composites and ceramics) and soft materials (polymers and polymer-biological moieties) and transform these into structures that have application in sensors, medical devices, nanophotonics and nanoelectronics. www.anff.org.au

Contacts

Niall Byrne

+ 61 417 131 977

niall@scienceinpublic.com.au

Andrew Masterson

+61 488 777 179

andrew@scienceinpublic.com.au

Lachlan Gilbert

+61 404 192 367

lachlan.gilbert@unsw.edu.au

Tom Eddershaw

+61 452 434 767

tom.eddershaw@anff.org.au

For Interview

Professor Andrew Dzurak

+61 432 405 434

a.dzurak@unsw.edu.au