CASE STUDY

Diraq

How semiconductor infrastructure could make quantum computers more accessible

Image courtesy of Diraq

Quantum computers work differently from the laptop or phone in your pocket. Where a regular computer uses ones and zeros to convey information, quantum computers use quantum bits, or qubits, that can exist in a combination of one and zero until they are measured.

This particular property makes them extraordinarily good and fast at solving certain problems that regular computers can't.

However, manufacturing quantum computers comes with many challenges. Quantum computers need millions of qubits to function and are extremely fragile. Many types of qubits require conditions colder than deep space – around absolute zero – to work. In practice, this means quantum computers may struggle to fit into existing infrastructure.

Diraq is a Sydney-founded company working to close that gap.

Dr Abi Klopper, Diraq's Technical Communications Strategist, explained that the company is "forming qubits out of modified silicon transistors," which are the same semiconductor devices used in everyday computer chips but designed to control quantum information.

"We are using all the same techniques and materials that have been developed over the past 70 years for semiconductors, rather than developing bespoke processes. And, instead of messing with unusual materials, we can just use silicon. What that means for us is that we can get a density of qubits that no other modality can," said Dr Abi Klopper.

Temperature and size are where designing qubits using semiconductor technology pays off again. Diraq's qubits operate at around one kelvin – roughly a hundred times warmer than some other modalities. Combined with Diraq's ability to fit more qubits onto a single chip, this makes the system easy to install into existing premises and far less energy-intensive to run.

Diraq has already installed a Diraq system in a data centre in Sydney as a proof of principle that it can slot nicely into existing infrastructure without much change. "There's almost nothing that needs to be changed throughout the data centre to install a Diraq system," Dr Abi Klopper explained. "By using the semiconductor industry, we're minimising costs, minimising power and maximising accessibility."

Since Diraq's team first published the technology underpinning its silicon spin qubit design in 2014, it has progressively scaled to reach 8 qubits on a single chip this year. A 150,000-qubit chip is targeted for 2029 and more than 2 million qubits by 2031.

"Because we're using semiconductor foundry lines, and because we've got this reproducible, well-worn industry path to building our chips, the next step is hundreds and then thousands," Dr Abi Klopper said.

Reflecting on what it would take to scale further in Australia, Diraq pointed out Australian funding remains a limitation for the sector. However, Diraq sees advanced packaging as an entry point for growing Australia's semiconductor sector. For example, Australia could build a globally competitive advanced packaging capability first, then work towards a smaller-scale foundry.

"We could start with high-quality, world-class packaging capabilities, then build towards a more affordable, less advanced tier-2 foundry. Over time, as the industry grows, it may eventually make sense to establish a tier-1 foundry in Australia," Dr Andrew Dzurak, CEO of Diraq said.

"But whatever we build needs to be cutting-edge, so Australian and international customers will want to access it, rather than go offshore."

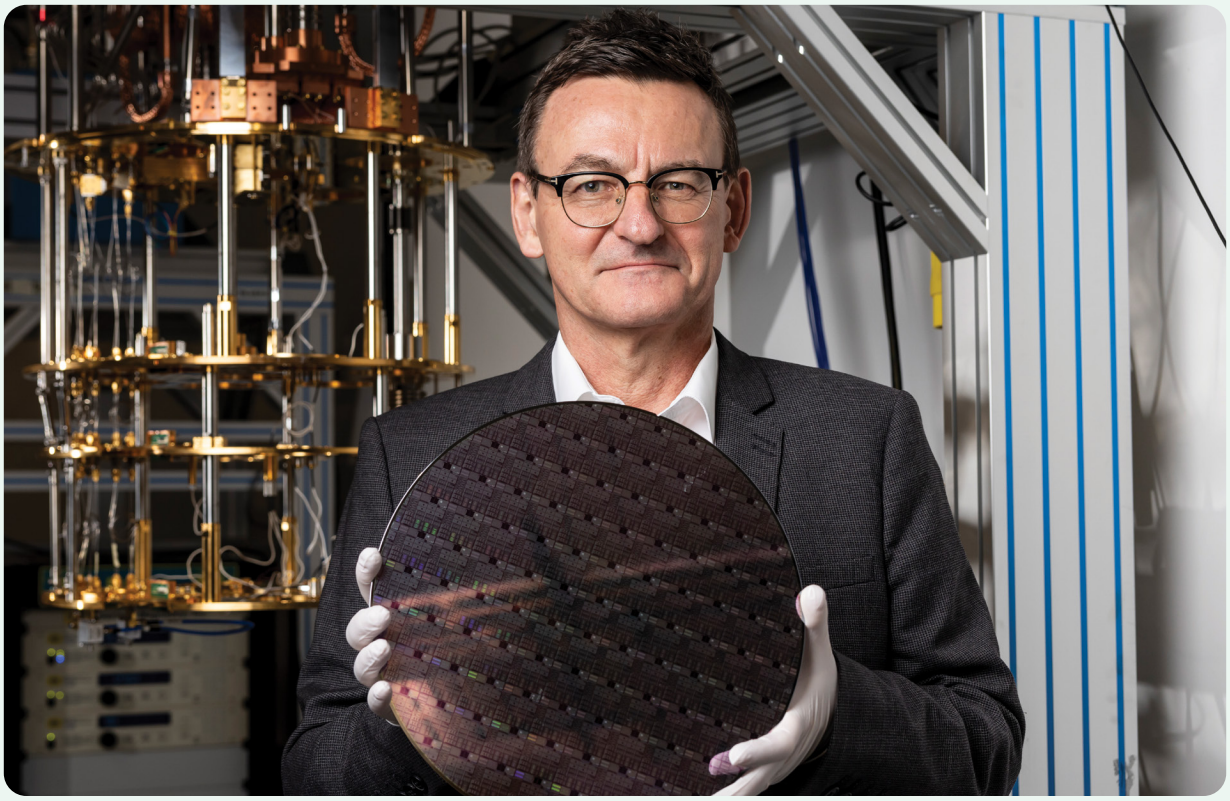

Image courtesy of Diraq. Diraq CEO & Founder holding Diraq's wafer.