Researchers find the missing photonic link to enable an all-silicon quantum internet

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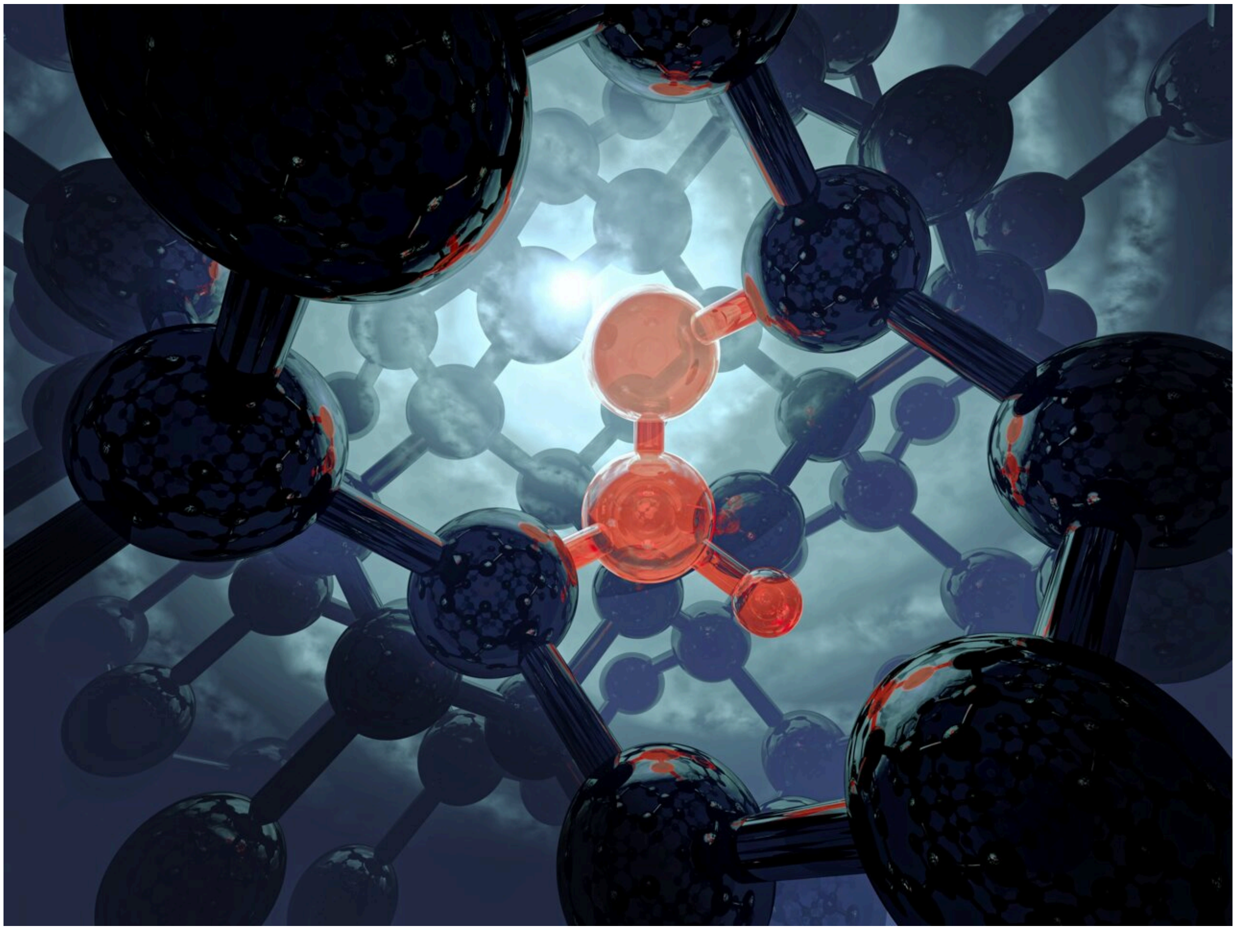


A single T centre qubit in the silicon lattice (render), which supports the first single spin to ever be optically observed in silicon. The constituents of the T centre (two carbon atoms and a hydrogen atom) are shown as orange, and the optically-addressable electron spin is in shining pale blue. Credit: Photonic

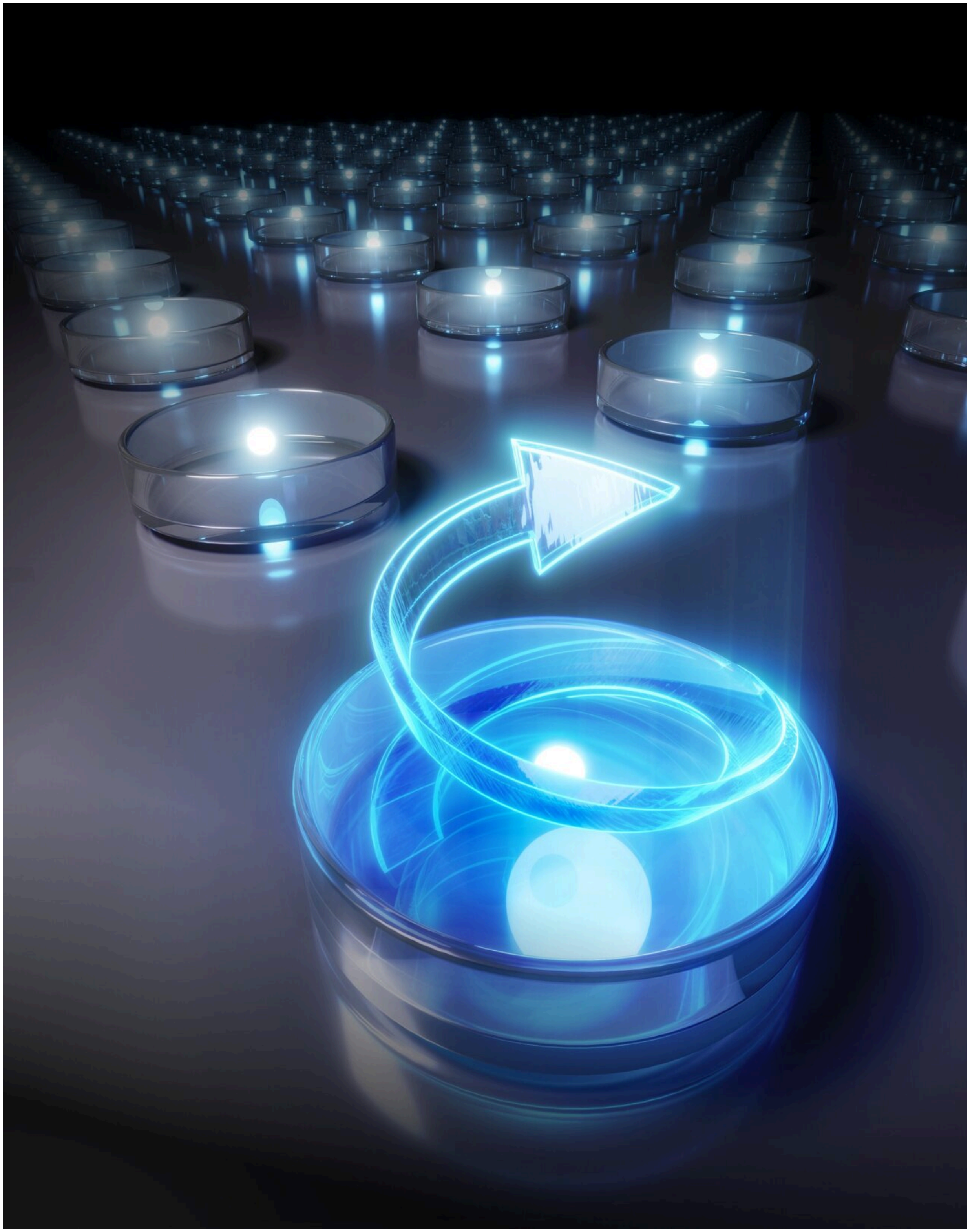
Researchers at Simon Fraser University have made a crucial breakthrough in the development of quantum technology.

Their research, published in *Nature* today, describes their observations of more than 150,000 silicon "T center" photon-spin qubits, an important milestone that unlocks immediate opportunities to construct massively scalable quantum computers and the quantum internet that will connect them.

Quantum computing has enormous potential to provide computing power well beyond the capabilities of today's supercomputers, which could enable advances in many other fields, including chemistry, materials science, medicine and cybersecurity.

In order to make this a reality, it is necessary to produce both stable, long-lived qubits that provide processing power, as well as the communications technology that enables these qubits to link together at scale.

Past research has indicated that silicon can produce some of the most stable and long-lived qubits in the industry. Now the research published by Daniel Higginbottom, Alex Kurkjian, and co-authors provides proof of principle that T centers, a specific luminescent defect in silicon, can provide a "photonic link" between qubits. This comes out of the SFU Silicon Quantum Technology Lab in SFU's Physics Department, co-led by Stephanie Simmons, Canada Research Chair in Silicon Quantum Technologies and Michael Thewalt, Professor Emeritus.

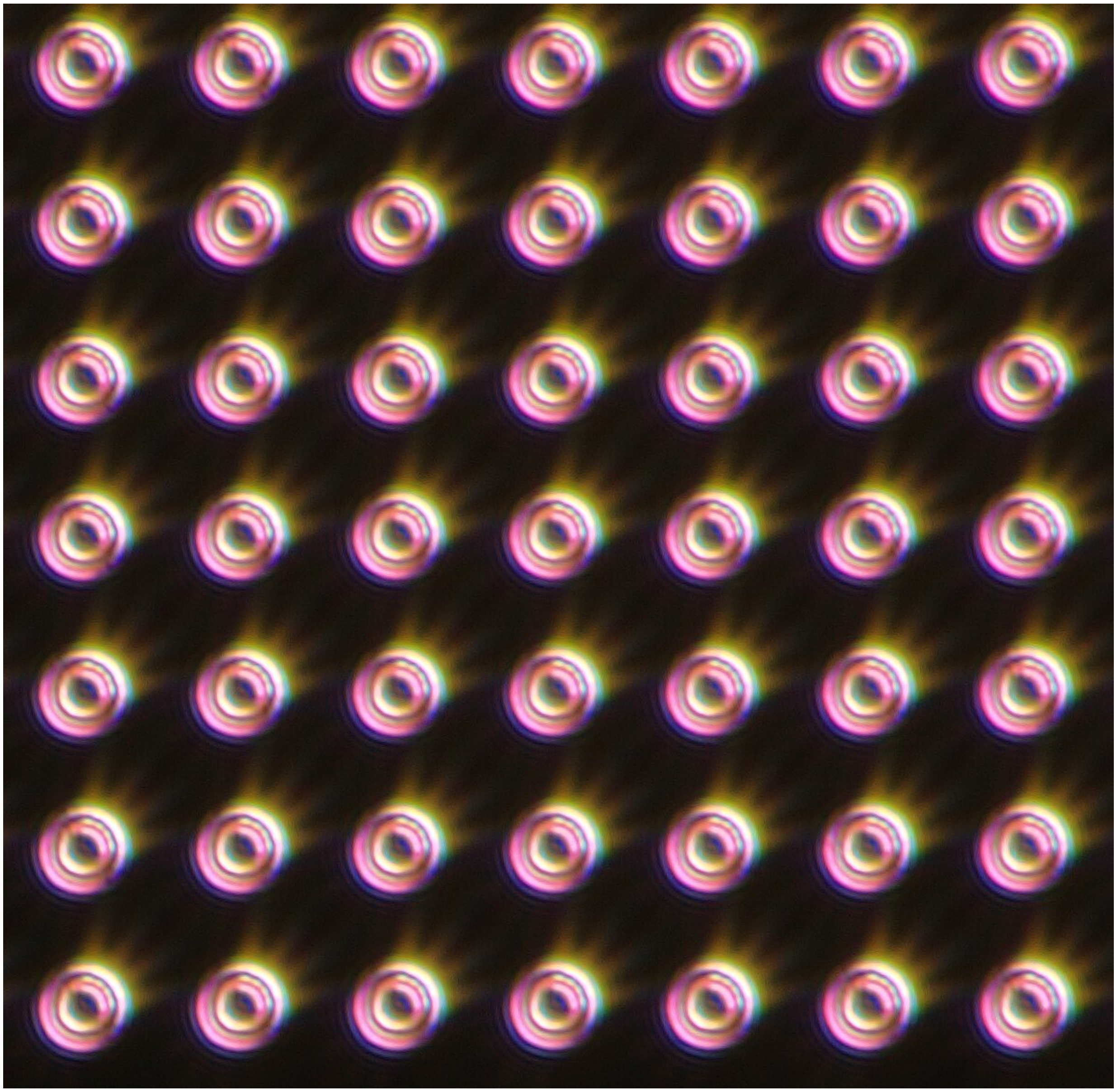


An array of integrated photonic devices, used to perform the first all-optical single-spin measurement in silicon. A single luminescent spin is rendered at the center of each ‘micropuck’. A spiraling arrow indicates photonic coupling from one of these spin qubits. Credit: Photonic

"This work is the first measurement of single T centers in isolation, and actually, the first measurement of any single spin in silicon to be performed with only optical measurements," says Stephanie Simmons.

"An emitter like the T center that combines high-performance spin qubits and optical photon generation is ideal to make scalable, distributed, quantum computers, because they can handle the processing and the communications together, rather than needing to interface two different quantum technologies, one for processing and one for communications," Simmons says.

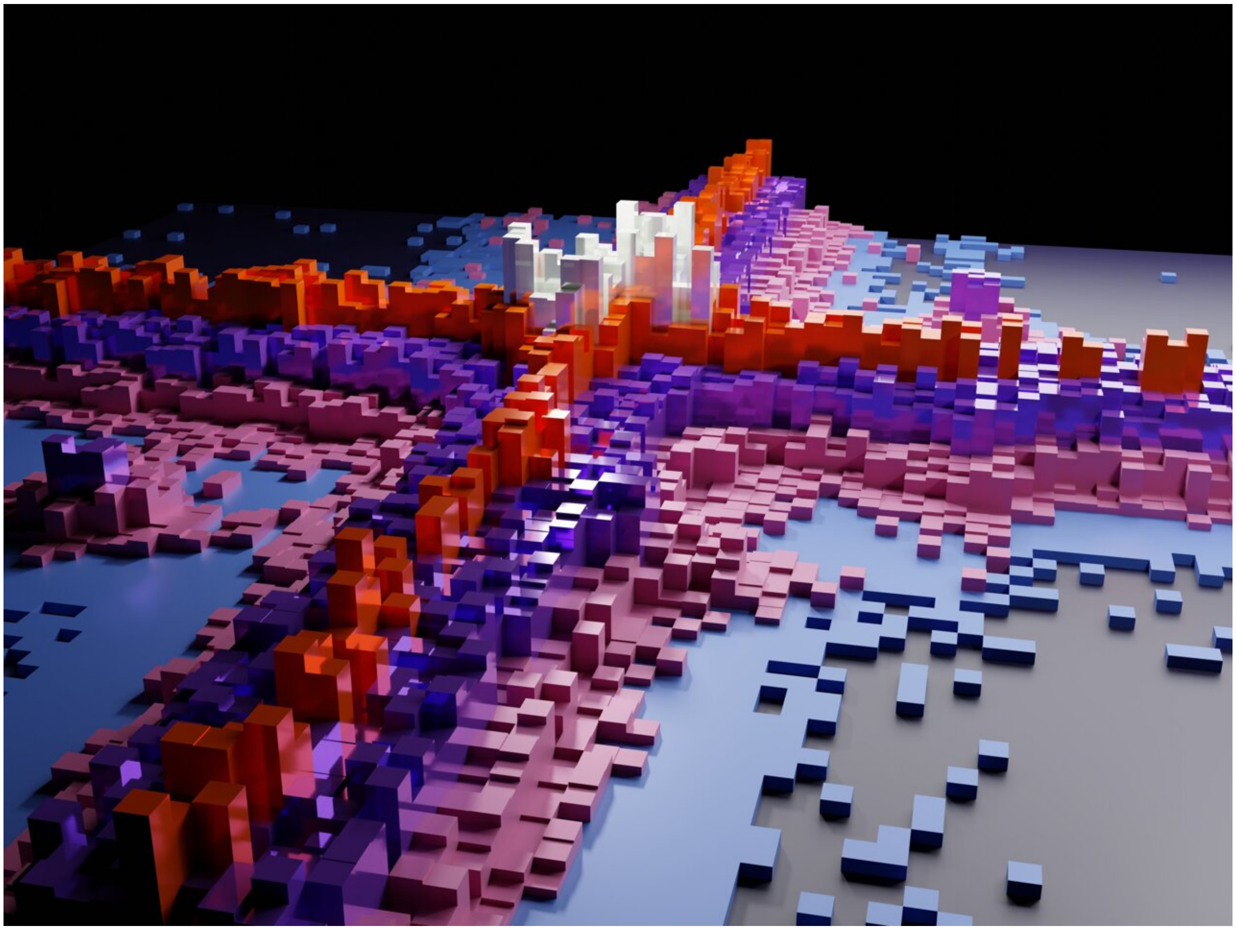
In addition, T centers have the advantage of emitting light at the same wavelength that today's metropolitan fiber communications and telecom networking equipment use.



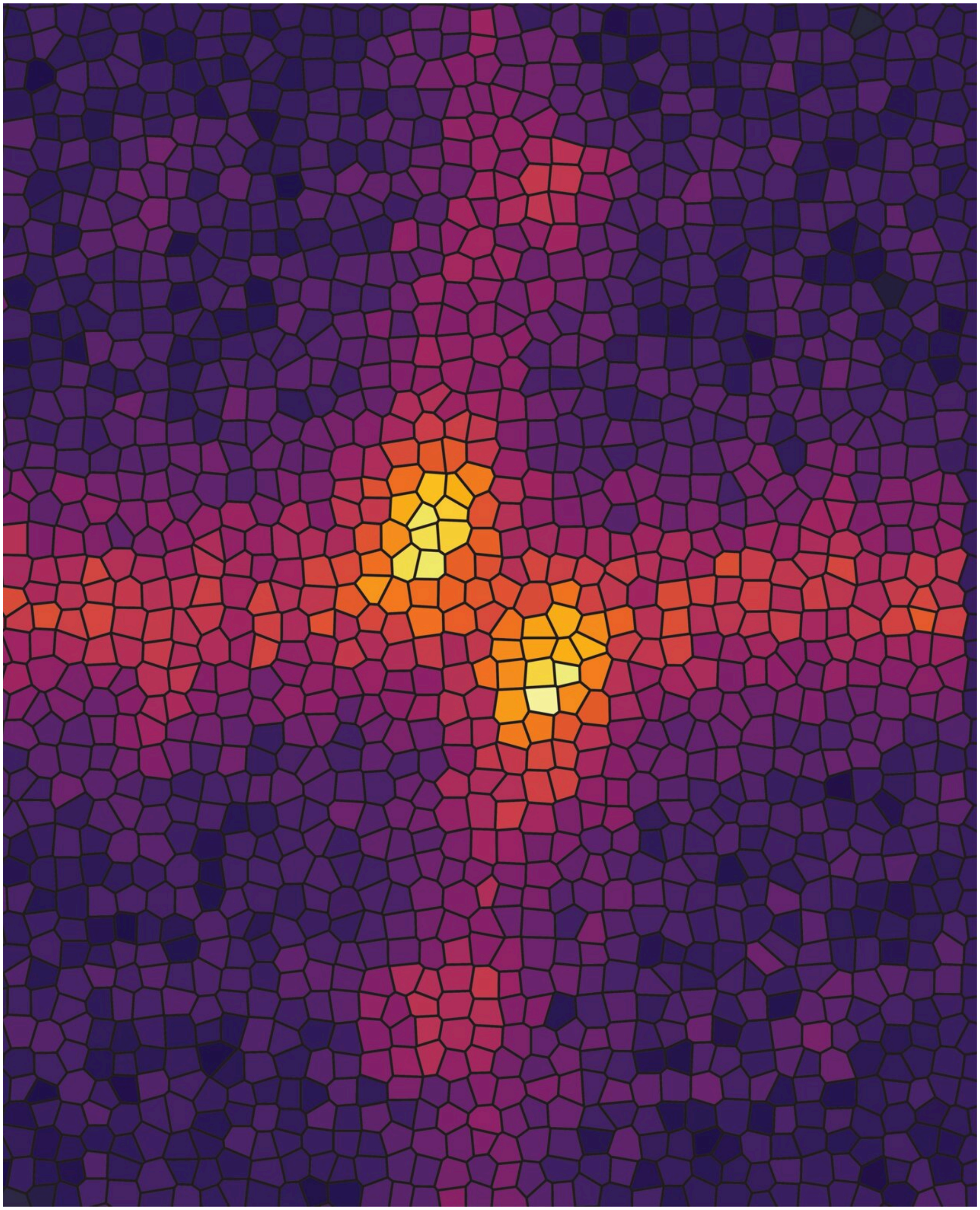
An optical microscope image of an array of integrated photonic devices, used to perform the first all-optical single-spin measurement in silicon. Tens of thousands of such ‘micropuck’ devices were fabricated on a single silicon photonic chip. Credit: Photonic

"With T centers, you can build quantum processors that inherently communicate with other processors," Simmons says. "When your silicon qubit can communicate by emitting photons (light) in the same band used in data centers and fiber networks, you get these same benefits for connecting the millions of qubits needed for quantum computing."

Developing quantum technology using silicon provides opportunities to rapidly scale quantum computing. The global semiconductor industry is already able to inexpensively manufacture silicon computer chips at scale, with a staggering degree of precision. This technology forms the backbone of modern computing and networking, from smartphones to the world's most powerful supercomputers.



The data revealing the first optical observation of spins in silicon. Two-laser scans of a single spin reveal signature spin-split central peaks; here the experimental data is visualized as an extruded mosaic. Credit: Photonic



The data revealing the first optical observation of spins in silicon. Two-laser scans of a single spin reveal signature spin-split central peaks; here the experimental data is visualized as a mosaic heatmap. Credit: Photonic

"By finding a way to create quantum computing processors in silicon, you can take advantage of all of the years of development, knowledge, and infrastructure used to manufacture conventional computers, rather than creating a whole new industry for quantum manufacturing," Simmons says. "This represents an almost insurmountable competitive advantage in the international race for a quantum computer."

More information: Stephanie Simmons, Optical observation of single spins in silicon, *Nature* (2022). DOI: 10.1038/s41586-022-04821-y. www.nature.com/articles/s41586-022-04821-y

Provided by Simon Fraser University

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