A Quantum Computing Revolution Is Started by an Ultra-Pure Silicon Chip

Posted by Okachinepa 05/07/2024

Courtesy of SynEvol
Credit: University of Melbourne/ University of Manchester

A revolutionary method for producing extremely pure silicon has been developed by researchers from the Universities of Manchester and Melbourne, taking the development of powerful quantum computers one significant step closer.

The researchers claim that the newly developed method for creating ultra-pure silicon makes it the ideal building block for producing quantum computers on a large scale and with excellent accuracy.

The innovation, which uses qubits of phosphorous atoms implanted into crystals of pure stable silicon, was reported in Communication Materials, a Nature journal. According to project co-supervisor Professor David Jamieson of the University of Melbourne, this could overcome a critical obstacle to quantum computing by extending the duration of infamously fragile quantum coherence.

Because of fragile quantum coherence, computation errors accumulate quickly. Professor Jamieson stated, "With the robust coherence our new technique provides, quantum computers could solve some problems that would take conventional or 'classical' computers - even supercomputers - centuries, in hours or minutes."

The fundamental units of quantum computing, known as qubits, are sensitive to minute alterations in their surroundings, such as variations in temperature. Current quantum computers can only sustain error-free coherence for a very short period of time, even when they are run in peaceful refrigerators close to absolute zero (minus 273 degrees Celsius).

Ultra-pure silicon, according to University of Manchester co-supervisor Professor Richard Curry, made it possible to build high-performance qubit devices, which are a crucial step toward the development of scalable quantum computers.

We have successfully created a crucial "brick" required for the construction of a quantum computer based on silicon. To create a technology that could revolutionize humankind, this is an essential first step, according to Professor Curry.

The key benefit of silicon chip quantum computing, according to lead author and joint Cookson Scholar of the Universities of Manchester and Melbourne, Ravi Acharya, is that it makes use of the same fundamental methods as modern computer chips.

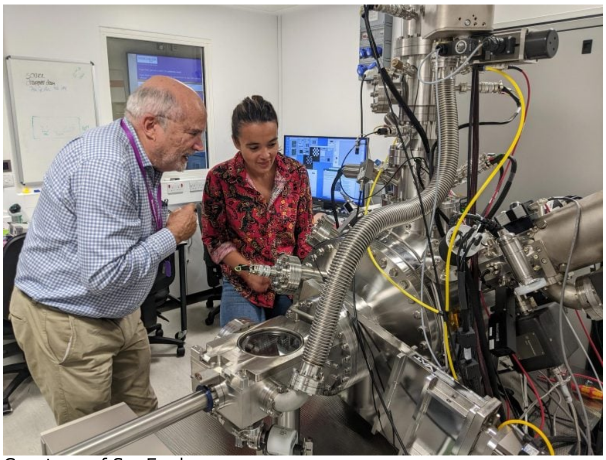
"Billions of transistors make up an average computer's electronic chip; these transistors can also be used to build qubits for silicon-based quantum devices. The purity of the silicon starting material has been a limiting factor in the creation of high-quality silicon qubits thus far. We have the breakthrough purity here to fix this issue.

According to Professor Jamieson, the recently developed computer chips made of highly pure silicon house and safeguard qubits, allowing them to maintain quantum coherence for extended periods of time and reducing the need for error correction in complex operations.

"Our methodology paves the way for dependable quantum computing, which holds great potential for revolutionizing various aspects of society such as artificial intelligence, safe data and communication, medication and vaccine development, energy consumption, transportation, and production," the speaker stated.

The foundation material for today's information technology industry is silicon, which is derived from beach sand. It is a plentiful and adaptable semiconductor that, depending on what other chemicals are added to it, can function as an insulator or a conductor of electrical current.

Professor Jamieson stated, "While some are experimenting with other materials, we think silicon is the best option for quantum computer chips that will allow the long-lasting coherence needed for trustworthy quantum computations."



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The issue is that while silicon found in nature largely consists of the desired isotope silicon-28, there is also roughly 4.5 percent silicon-29. According to him, silicon-29 has an additional neutron in the nucleus of each atom that functions as a tiny rogue magnet, shattering quantum coherence and causing computer mistakes.

In order to reduce silicon-29 from 4.5 percent to two parts per million (0.0002 percent), the researchers focused a high-speed, concentrated beam of pure silicon-28 on a silicon chip. This caused silicon-28 to gradually replace the silicon-29 atoms in the chip.

Professor Jamieson stated, "The good news is that we can now use an ion implanter, a common machine found in any semiconductor fabrication lab, tuned to a specific configuration that we designed, to purify silicon to this level."

In previously published work, the University of Melbourne set and maintains the world record for single-qubit coherence of 30 seconds using less pure silicon in collaboration with the ARC Centre of Excellence for Quantum Computation and Communication Technology. Complex quantum calculations can be completed in a reasonable amount of time—30 seconds.

According to Professor Jamieson, errors happened in milliseconds due to broken coherence, even though the largest quantum computers currently in use had over 1000 qubits.

The next challenge will be to show that we can maintain quantum coherence for numerous qubits at once after producing incredibly pure silicon-28. For certain applications, a dependable quantum computer with just 30 qubits may be more powerful than modern supercomputers, he claimed.

The Australian and UK governments provided research money to assist this most recent work. A Wolfson Visiting Fellowship from the Royal Society supports Professor Jamieson's work with the University of Manchester.

According to a 2020 CSIRO report, Australia may generate $2.5 billion in revenue annually and 10,000 employment using quantum computing by 2040.
