**News Release**

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# Hitachi develops new qubit control method to stabilize and extend lifetimes by a hundred-fold and more, accelerating development of quantum computers

*Noise cancelling effect confirmed for qubits in silicon quantum computers*

**Tokyo, June 17, 2024** – Hitachi Ltd. (TSE: 6501; hereafter "Hitachi") has moved a step closer to practical implementation of silicon quantum computer[*1] by developing qubit control method that stabilizes qubits[*2], and has confirmed that the lifetime of a qubit (quantum information retention time or quantum coherence[*3]) can be extended by more than a hundred-fold and more.

At least around one million qubits are considered necessary for a quantum computer to perform useful calculations, which is the reason why large-scale integration of qubits is said to be one of the key challenges of quantum computers. Along with this are the need to develop technology for precise control of qubits and the implementation of error correction[*4]. Silicon quantum computer, which has been the subject of Hitachi's research and development, has high expectations for its compatibility with large-scale integration. However, the nuclear spin[*5] of semiconductor atom generates noise and destabilizes qubits, complicating the implementation of quantum algorithms[*6] and error correction.

Hitachi's newly developed method modulates microwave phases used in qubit control to partially cancel the noise inside a semiconductor, stabilizing qubits and making it possible to extend their lifetime by a hundred times and more (Figure 1). This result is a significant step forward, not just in large-scale qubit integration, but also in the implementation of quantum algorithms and error correction and will spur the pace of research to bring practical implementation of a quantum computer that much closer.

Some of the results of the research will be presented at the 2024 IEEE Symposium on VLSI Technology and Circuits in Hawaii, from June 16 to 20.

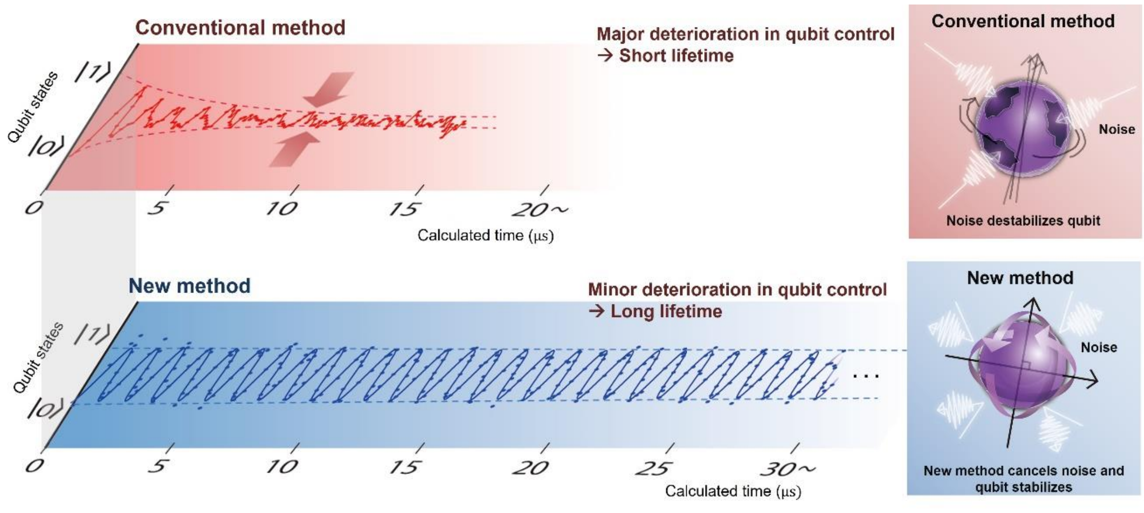


Figure 1

Upper: Qubit control results for conventional method (qubit spin destabilized by noise)

Lower: Qubit control results for new method (effect of noise reduced, movement stabilized, and qubit lifetime extended)

*1 Silicon quantum computer: A quantum computer based on the method of using electron spin inside silicon as a qubit.

*2 Qubit: A qubit (or quantum bit) is the basic unit of information in quantum computing. Making use of the superposition principle of quantum mechanics, a qubit can represent states of both 0 and 1 in any proportion

*3 Quantum coherence: The degree of quantum superposition between different quantum states. An index that shows the lifetime of a qubit.

*4 Error correction: Technology for correcting errors occurring in the process of quantum calculation. A theoretical qubit is represented by multiple qubits (redundancy) and the redundant qubits are used to detect or estimate error.

*5 Nuclear spin: Spin on an atomic nucleus. When electron spin is used as a qubit, nuclear spin interacts and causes qubit instability.

*6 Quantum algorithm: A quantum computer-specific calculation algorithm. Said to be capable of solving problems that a normal computer is unable to solve in a useful period of time.

## Background to the research

A variety of different methods have been proposed for building quantum computers. Hitachi's R&D has leveraged its already-mature semiconductor technology to develop silicon quantum computers, which is said to have an advantage in large-scale integration of qubits . To date, Hitachi has developed a two-dimensional silicon qubit array[*7,8], which enables integration of silicon qubits using a lattice-type array, and has proposed a shuttling qubit method, which enables efficient control of qubits[*9]. In 2024, Hitachi confirmed the basic action of the silicon quantum computer, making it public at the American Physical Society's March Meeting 2024, convened in Minnesota[*10].

*7 Two-dimensional qubit array: A basic structure which arranges qubits in a two-dimensional array.

*8 N. Lee et al., "16 x 8 quantum dot array operation at cryogenic temperatures," Jpn. J. Appl. Phys. 61 SC1040, 2023.

*9 June 12, 2023 Hitachi news release "Hitachi Proposes a New Qubit Control Method Suited to Large-Scale Integration Toward Practical Realization of a Silicon Quantum Computer."

*10 T. Kuno et al. "Adiabatic Electron Spin Resonance Inversion in an FDSOI Quantum Dot Array." Bulletin of the American Physical Society (2024).

## Features of the developed technology

In a silicon quantum computer, a single electron is enclosed in a nanostructure called a "quantum dot" formed in a silicon device, and its rotation (spin) is used as a qubit. Traditionally, however, nuclear spin of semiconductor atoms generates noise and destabilizes electron rotation, shortening qubit lifetime. To implement quantum algorithms and error correction going forward, there is a need to secure sufficient calculation time by reducing the effect of noise and stabilizing qubits.

In discussions with researchers at the Hitachi Cambridge Laboratory established in University of Cambridge in UK, it became apparent that the Concatenated Continuous Driving (CCD)*[11] qubit manipulation method developed at the laboratory showed promise for partially cancelling external noise. Research team at Hitachi's Research and Development Group became the first in the world to implement CCD qubit manipulation in silicon quantum computer qubits by modulating the microwave phases used for qubit manipulation. The noise is reduced and qubit lifetime is substantially extended by CCD qubit manipulation.

By experimentally applying this CCD qubit manipulation method to silicon quantum computers, the team confirmed that the method can stabilize qubits and extend their lifetime by more than hundred-fold. This result shows that silicon quantum computers have superior characteristics of both large-scale qubit integration and qubit stability. In addition to large-scale qubit integration, Hitachi will aim for early practical implementation of a quantum computer by speeding up R&D into implementation of quantum algorithms and error correction going forward.

*11 A. J. Ramsay et al. "Coherence protection of spin qubits in hexagonal boron nitride." Nature Communications 14,461 (2023).

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**About Hitachi, Ltd.**
Hitachi drives Social Innovation Business, creating a sustainable society through the use of data and technology. We solve customers' and society's challenges with Lumada solutions leveraging IT, OT (Operational Technology) and products. Hitachi operates under the 3 business sectors of “Digital Systems & Services” – supporting our customers’ digital transformation; “Green Energy & Mobility” – contributing to a decarbonized society through energy and railway systems, and “Connective Industries” – connecting products through digital technology to provide solutions in various industries. Driven by Digital, Green, and Innovation, we aim for growth through co-creation with our customers. The company’s revenues as 3 sectors for fiscal year 2023 (ended March 31, 2024) totaled 8,564.3 billion yen, with 573 consolidated subsidiaries and approximately 270,000 employees worldwide. For more information on Hitachi, please visit the company's website at https://www.hitachi.com.

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