CP-02-01

Electron and hole spin qubits in silicon

Leon C. Camenzind

QFSRG, CEMS RIKEN

Abstract

Silicon-based spin qubits offer promise for large-scale quantum processing, thanks to their compatibility with industrial nanofabrication, small size, fast processing, and long coherence times.

The Quantum Function System Research Group (QFSRG) at RIKEN achieved impressive results with electron spin qubits in isotopically purified silicon-28 quantum wells. We surpassed the fault-tolerant threshold of 99% fidelity for critical operations, implemented quantum error correction, and introduced a novel shuttling-based quantum link.

In a collaboration between the University of Basel and IBM Research, we demonstrated that fin field-effect transistors (finFET) in natural silicon can host hole spin qubits. These qubits operate above 4 Kelvin, a temperature at which there is an improved potential for scalability using integrated quantum circuit solutions. Furthermore, we demonstrated fast electrical control, high fidelity single-qubit gate operations, and achieved two-qubit gates with anisotropic exchange interaction.

The results of these two projects mark significant steps towards scalable electron and hole spin qubits in silicon. Recognizing the need for millions of qubits for fault-tolerant quantum computing, the semiconductor industry is increasingly investing in spin qubits. By leveraging existing semiconductor fabrication techniques for mass production, the scalability of spin-based quantum computing is becoming more feasible, capitalizing on the inherent advantages of spin qubits.