Advances in Silicon-based Quantum Computing

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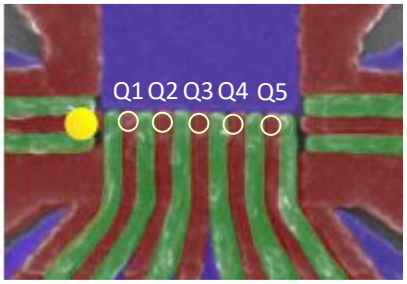

Figure 1: Five qubit device in ^{28}Si/SiGe

Silicon is a promising platform for implementing spin-qubits in quantum computation [1]. Key challenges for realizing practical spin-qubit processors include fault-tolerant qubit operation, quantum error correction, and the scalability of qubit architectures. We implement spin qubits in isotopically purified Si/SiGe quantum dots integrated with a micromagnet [2]. The micromagnet enables faster qubit control and provides additional flexibility for calibrating gate errors [3]. By leveraging this approach, single- and two-qubit gate operations are achieved with fidelities sufficiently high (> 99.99%) [4] to meet fault-tolerance requirements [5]. Here we review recent progress in qubit fidelities as a main topic, and strategies toward scalable Si spin-qubit systems are also discussed.

References

[1] D. Loss and D.P. DiVincenzo, Physical Review A 57 (1), 120–126 (1998) 120.
[2] M. Pioro-Ladrière et al., Nature Phys. 4 (2008) 776.
[3] A. Noiri et al., Nature 601 (2022) 338.
[4] Y.-H. Wu et al., npj Quantum Info. 10 (2024) 8: Y.-H. Wu et al., arXiv: 2507.11918 (2025).
[5] D.S. Wang, A.G. Fowler, and L.C.L. Hollenberg, Physical Review A 83 (2), (2011) 102.