An addressable quantum dot qubit with fault-tolerant control-fidelity

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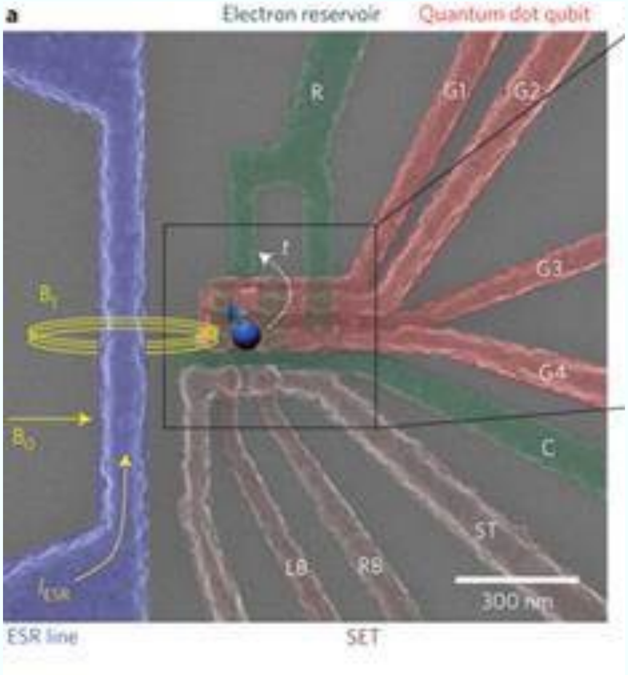

False coloured SEM image.

Exciting progress towards spin-based quantum computing has recently been made with qubits realized using nitrogen vacancy centres in diamond and phosphorus atoms in silicon. For example, long coherence times were made possible by the presence of spin-free isotopes of carbon4 and silicon. However, despite promising single-atom nanotechnologies there remain substantial challenges in coupling such qubits and addressing them individually. Conversely, lithographically defined quantum dots have an exchange coupling that can be precisely engineered but strong coupling to noise has severely limited their dephasing times and control fidelities. Here, we combine the best aspects of both spin qubit schemes and demonstrate a gate-addressable quantum dot qubit in isotopically engineered silicon with a control fidelity of 99.6%, obtained via Clifford-based randomized benchmarking and consistent with that required for fault-tolerant quantum computing7,8. This qubit has dephasing time T2* = 120 μs and coherence time T2 = 28 ms, both orders of magnitude larger than in other types of semiconductor qubit. By gate-voltage-tuning the electron g*-factor we can Stark shift the electron spin resonance frequency by more than 3,000 times the 2.4 kHz electron spin resonance line width, providing a direct route to large-scale arrays of addressable high-fidelity qubits that are compatible with existing manufacturing technologies.

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