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Building small, fast and hot hole spin qubits in Si and Ge

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Abstract

Quantum computers hold the potential to execute complex tasks exponentially faster than classical computers. Hole spins in Ge/Si core/shell nanowires experience an exceptionally strong yet electrically tunable spin-orbit interaction, allowing unprecedented qubit control. We can tune the Rabi frequency with gate voltages, going from a fast manipulation to an idle mode, demonstrating a spin–orbit switch. We show spin-flip times as short as ~1 ns, approach the strong driving regime, due to a very strong spin-orbit interaction, with spin-orbit length down to a few nm. This qubit can also operate at 1.5 K, where we are also implementing an exchange based CROT 2Q gate.

One of the greatest challenges in quantum computing is achieving scalability, solved with the fin field-effect transistor (FinFET) in classical computing, integrating billions of transistors on silicon chips. Here, we show that silicon FinFETs can host hole spin qubits operating above 4 K, potentially allowing in-situ integration of qubit control electronics. We achieve fast all-electrical control and single-qubit gate fidelities at the fault-tolerance threshold. Further, we demonstrate a CROT 2Q gate with spin-orbit induced anisotropic exchange interaction, opening the door to high fidelity and fast 2Q gates.