Hole Spin Qubits in Ge and Si Nanowires

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I will present recent results on hole spin qubits in Ge and Si nanowires connected to superconducting striplines. The recent discovery [1] of an electrically induced spin-orbit interaction of Rashba type in the low-energy hole states of Ge/Si (core/shell) nanowires provides an attractive alternative to realize a tunable-coupling qubit. Similar results apply to pure Si nanowires. The qubit is encoded in two orthogonal dressed spin states of a hole confined in a nanowire quantum dot. Hole spins are particularly attractive since their p-wave orbitals have minimal overlap with the nuclei resulting in long coherence times and have recently been demonstrated to be compatible with industrial CMOS technology. Crucially the strong direct Rashba spin-orbit interaction (DRSOI) is controlled by an electric field applied perpendicular to the wire [1,2]. This enables the electrostatic control of the coupling between the spin degree of freedom and the electromagnetic field along the wire. Exploiting this feature we have proposed a scalable surface code architecture obtained by combining nanowire hole-spin qubits with a novel coplanar waveguide resonator grid structure [3]. The latter can be viewed as a generalization of the celebrated 1D quantum bus architecture to two dimensions. Furthermore, owing to the small size of the hole-spin qubits, a few tens of nanometers in length, they can be entirely embedded within the microwave resonators allowing for more compact resonator geometries with enhanced vacuum field strengths. The electrostatic fields required to tune the microwave-qubit coupling, are provided in situ by voltage biasing the resonator center conductor thus reducing the number of required leads.

References

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