Single-electron qubits on solid neon

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Utilizing the quantum states of trapped electrons on cryogenic rare gases, like helium and neon, has been long pursued. The ultraclean rare gas interface can protect the electron qubit from environmental disturbance to achieve long coherence time. For example, decoherence channels like two-level systems within material substrates in the circuit quantum electrodynamics (QED) architecture poses threats to the quantum data stability and system scalability. In this talk, I will showcase the utilization of thin solid neon film as a clean interface for single electron qubits within quantum circuits. This breakthrough enabled us to significantly enhance the lifetime, control preciseness, and scalability of traditional electron charge qubits by minimizing the impact of environmental distrubances. We achieve strong coupling between the trapped single-electron qubits and microwave photons in an on-chip superconducting resonator[1]. The measured relaxation time T_1 and coherence time T_2 are both on the order of 0.1 milliseconds, supporting high-fidelity single-shot qubit readout (F_{read} = 98.1%) and control (F_{gate} = 99.97%)[2]. We further demonstrate the progress towards achieving two-qubit entanglement by remotely coupling two electrons to the same resonator.

Looking ahead, we envision building scalable and hybridized quantum devices via synergetic engineering of electron qubits and quantum nanofabrication techniques. It includes the control of the growth of thin solid neon films, the deterministic loading of electrons emitted in low-energy and cryo-compatible electron sources, and the 3D packaging and integration of quantum chips. With the development of nanofarbication technologies for quantum information science, this novel electron qubits could be an ideal solid-state qubit platform for applications in quantum computing and quantum memory.

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1. Xianjing Zhou et al., "Single Electrons on Solid Neon as a Solid-State Qubit Platform," Nature 605, 46–50 (2022).
2. Xianjing Zhou*., Xinhao Li*, et al. "Electron charge qubit with 0.1 millisecond coherence time". Nat. Phys. 20, 116–122 (2024) [*Equal Contribution]