A Two Channel Silicon Quantum Dot and an Experimental Setup for Spin Qubits

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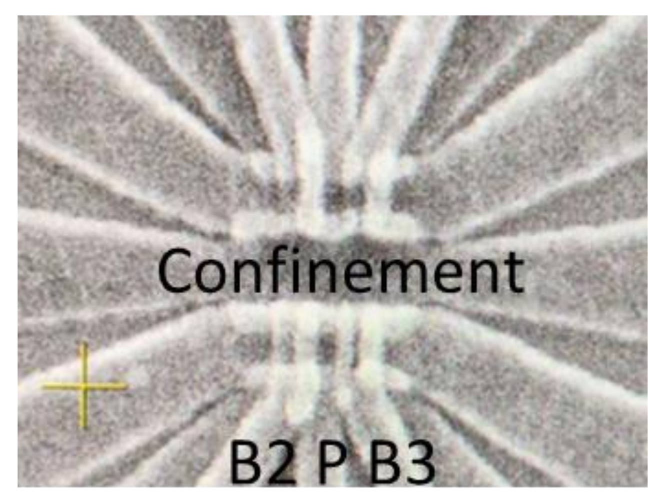
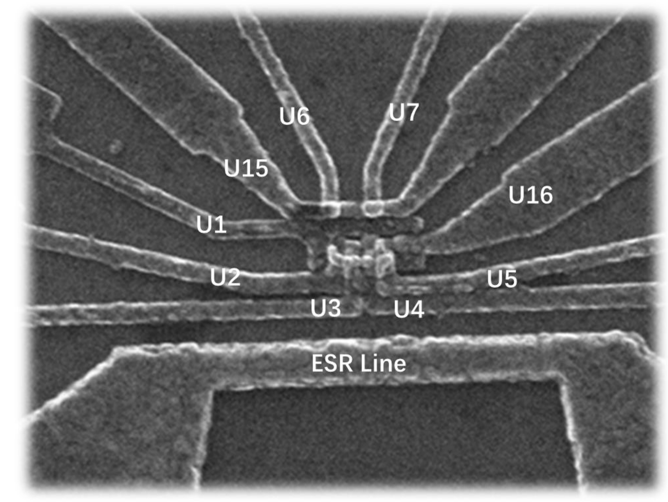
Motivation/Objective

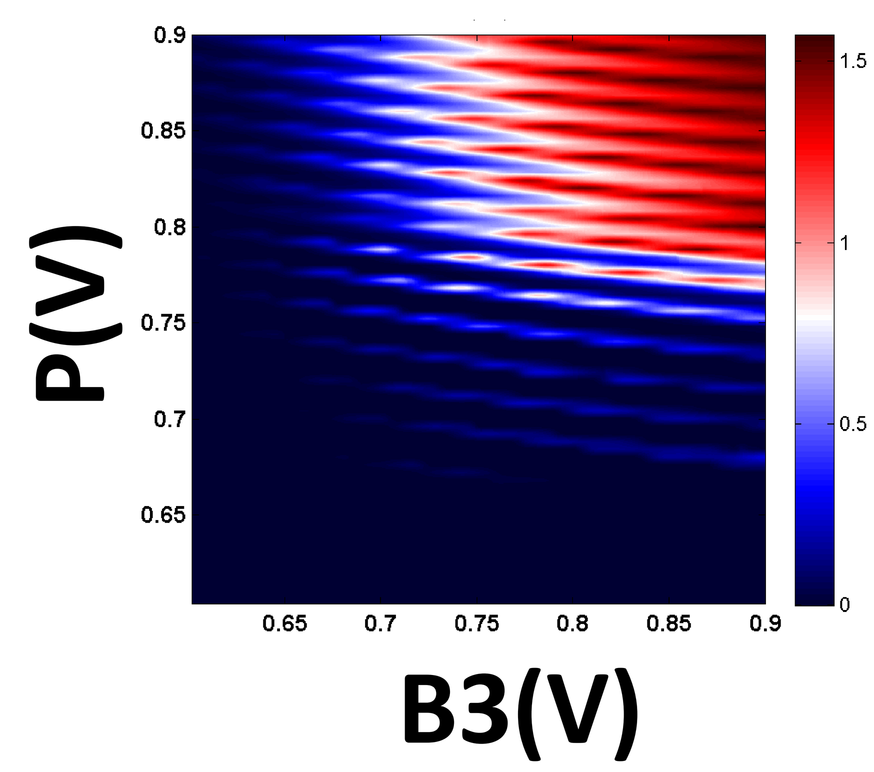
- Spin qubits based on silicon quantum dots (QDs) provide a promising platform for large-scale quantum computation due to the long spin coherence times. In isotopically engineered silicon , hyperfine interaction is totally suppressed , leading to the realization of high-fidelity single and two-qubit gates.[1-2]
- Design and fabrication of two types of two channel silicon quantum dots and observation of charge stability diagrams.
- Buildup of an experimental setup for spin qubits and real-time detection of electron tunneling at different gate voltage. The electron temperature and a quantitative description of the SNR are extracted from the experimental data [3].

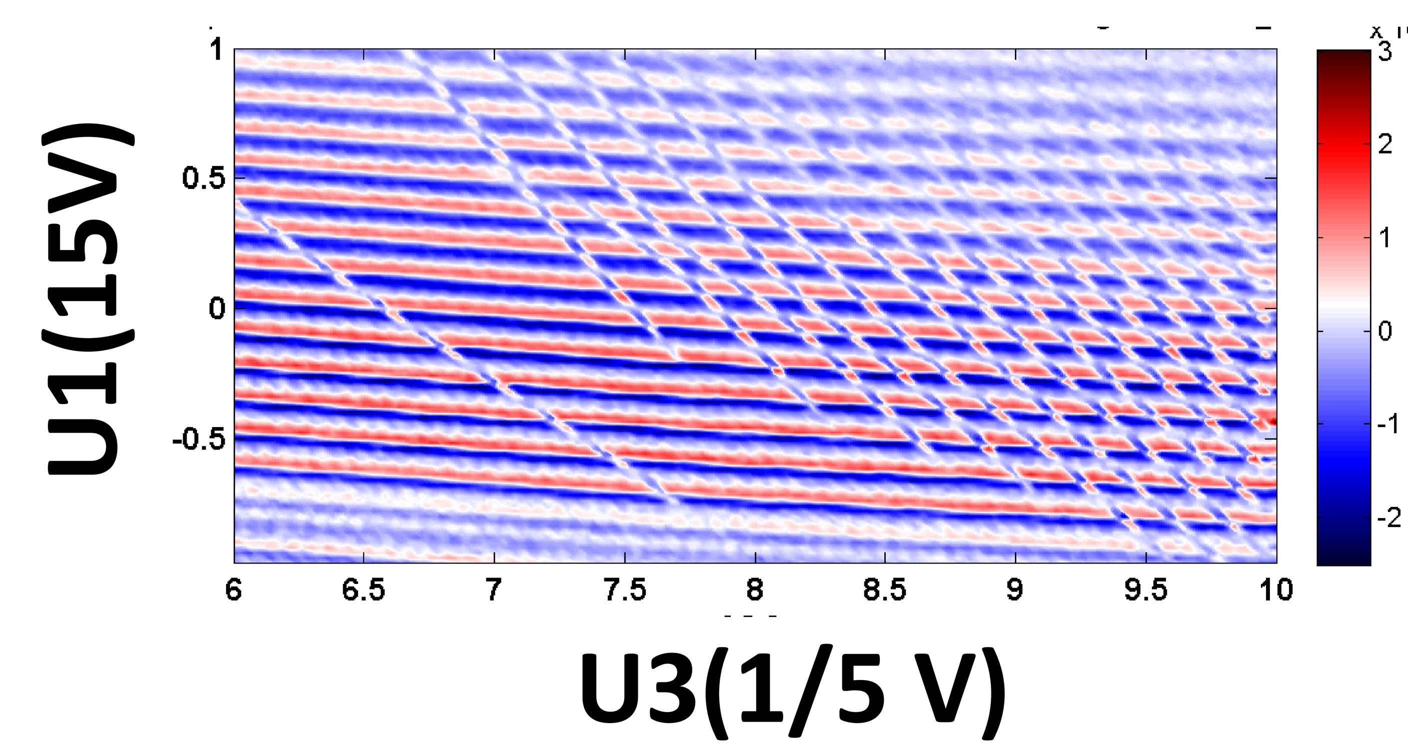
Design and characterization of a two channel silicon quantum dot



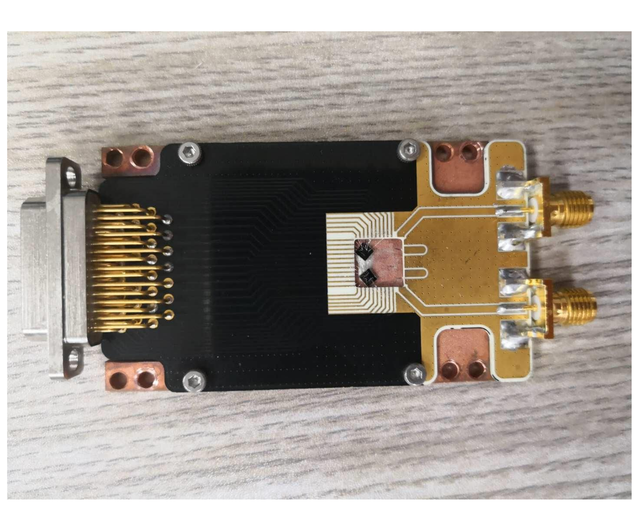


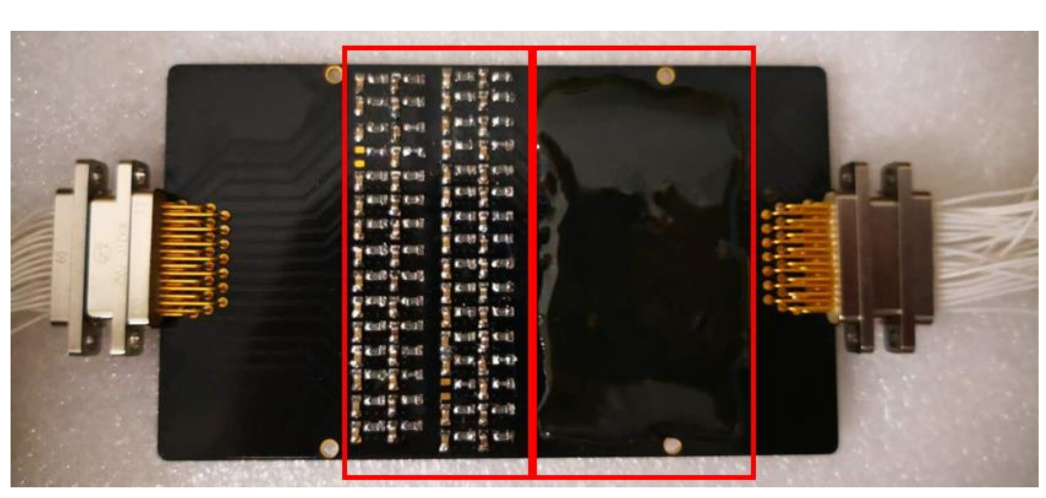
- Two different types of two channel silicon quantum dots were fabricated and corresponding charge stability diagrams were acquired.

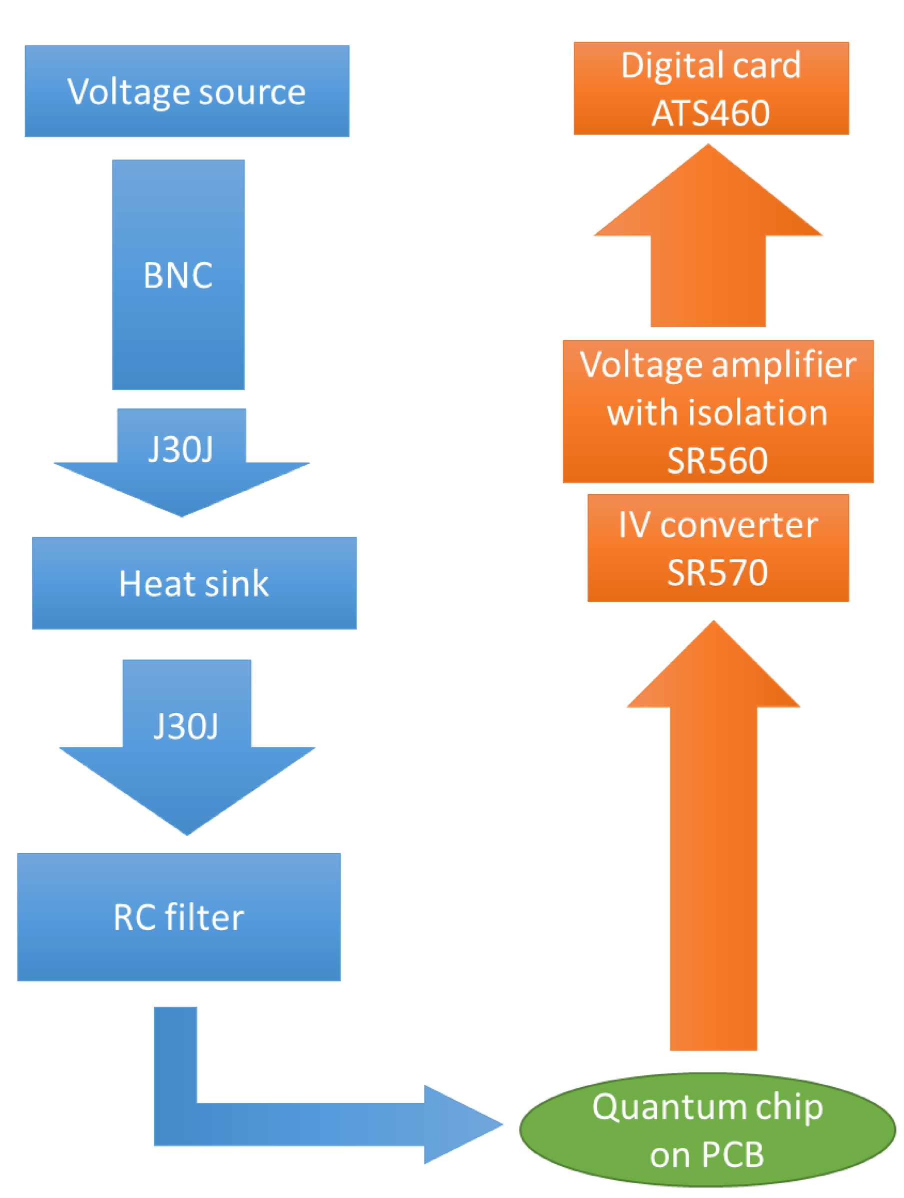




Experimental setup for spin qubits

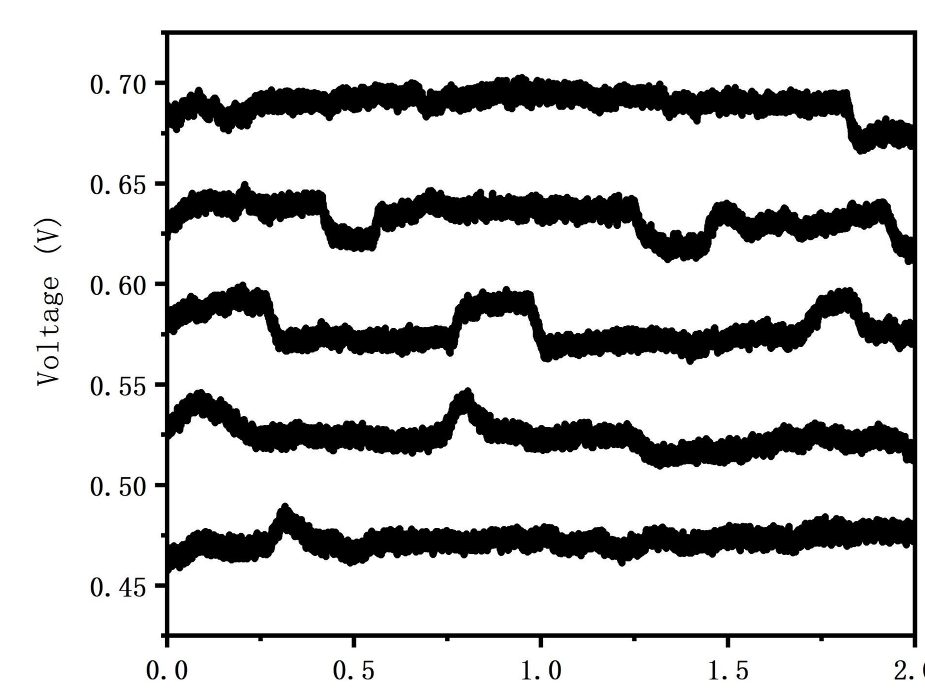




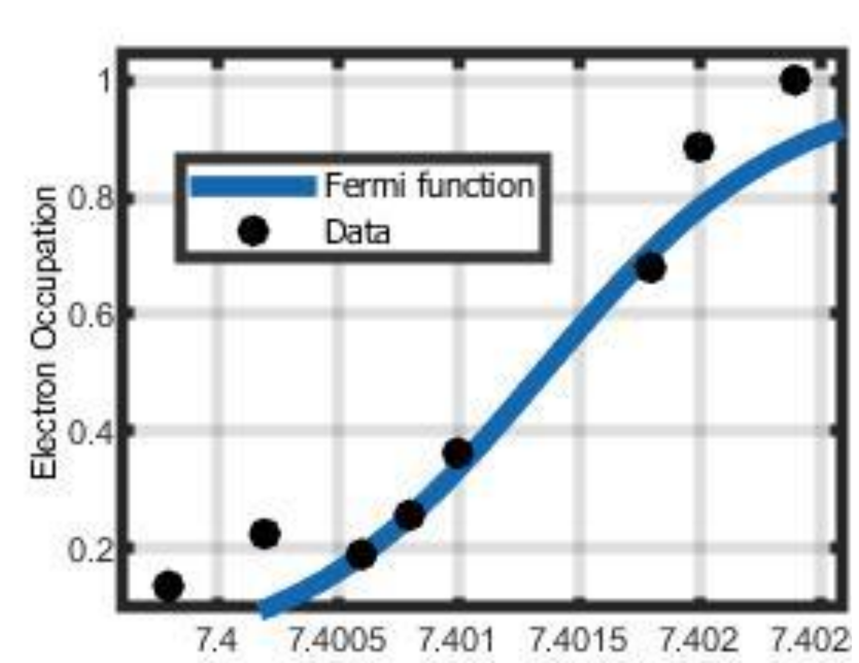


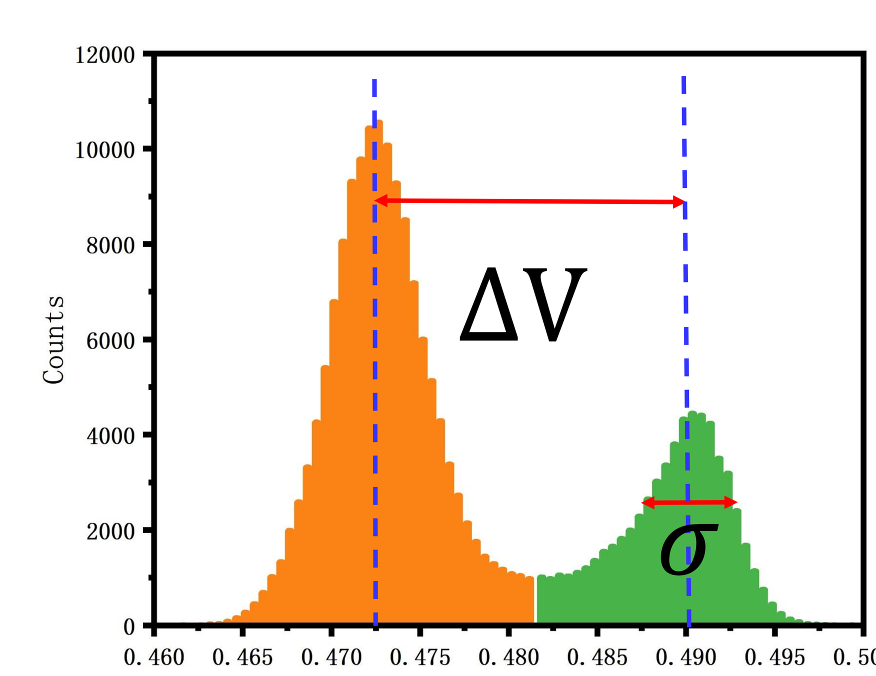
- PCB for quantum chips with 31 pins for DC and 2 SMAs for AC control.
- RC filter with optional Cu powder filter.
- Illustration of the experimental setup for DC control and single shot readout of spin qubits.

Experimental Results of the cryogenic setup



- Real time detection of electron tunneling at different gate voltage, the traces are offset by 50 mV for clarity. The dwell time in the N+1 charge state increases as the gate voltage is made more positive.
- Time-averaged electron occupation, and the date are fit to get the electron temperature of 119 mK.
- A histogram of a two second time series exhibits two Gaussian peaks, yielding SNR=ΔV/σ =0.018/0.00572=3.15.





Future Directions

- Single shot readout of spin qubits.
- T1 and T2 measurement of spin qubits.
- Implementation of single- and two- qubit logic gates.

References

[1] M. Veldhorst, A.S. Dzurak *et al.*, Nature Nanotechnology **9**, 981 (2014).

[2] M. Veldhorst, C.H. Yang, and A.S. Dzurak *et al.*, Nature **526**, 410 (2015).

[3] D. M. Zajac, T. M. Hazard, X. Mi and *et al.*, Phys. Rev. Applied 6(5), 054013 (2016).