Fabrication of high coherence superconducting qubits

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Scaling up qubit circuits and achieving high coherence relative to gate speed is imperative to realizing the full power of quantum computing. In this work we demonstrate superconducting transmons with coherence times ranging from 25 to 90 µs, significantly longer than typical gate speeds, from 10 to 200 ns for single and two-qubit interactions.

The circuits were fabricated on intrinsic Si(001) substrates (Fig. 1_. The NBTiN metallization (gold color) was patterned optically. The CPW meander feedline (from Port 1 to Port 2), capacitively couples to readout resonators (R1-R6, only R1 labeled for clarity) which are then capacitively coupled to a large, concentric capacitor shunt. The capacitor plates are connected together with a small Josephson junction that was fabricated using a two-step e-beam overlap process [1] to form transmon qubits, Q1-Q6. Some of the methods used to enhance the coherence include using a nitride pre-treatment of the substrate prior to metallization, post-treatment of the circuit with buffered oxide etch, and extensive wire-bonding. Variations of coherence between qubits was about a factor of 2, and can be understood in, for example, one case (the shortest) as being due to damage during wire-bonding. Fluctuations are hypothesized to be due to coupling of the qubits to two-level systems around the junctions [2].

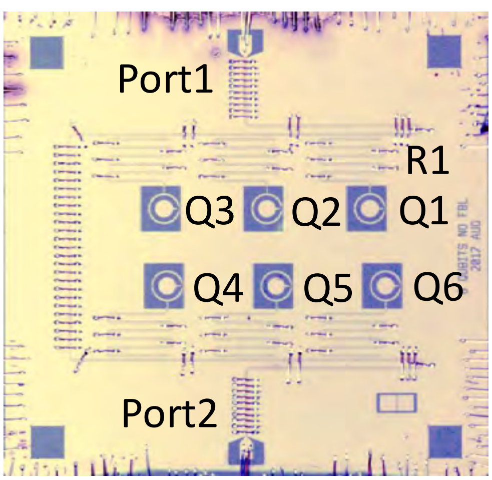

Figure 1: Six qubit test chip, 7.5x7.5 mm².

[1] X. Wu, et al., Applied Physics Letters 111 (3), 032602.
[2] S. Schlor, et al., arXiv:1901.05352

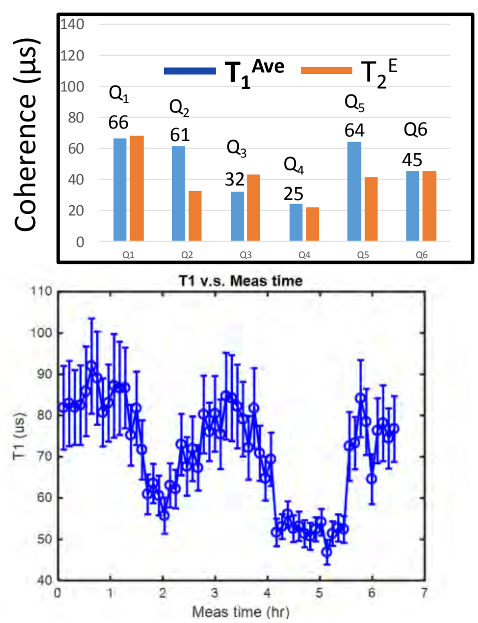

Figure 1: Top-Average coherence of qubits measured over 6 hours.
Bottom- Variation of Q1 coherence.

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