Fabrication of High-Coherence Superconducting Qubits

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Superconducting qubits are a promising candidate for the fundamental logic element of a quantum information processor. When cooled to milliKelvin temperatures, these lithographically-defined electronic circuits behave as "artificial atoms," featuring an anharmonic spectrum of quantized energy levels arising from the non-linear inductance of Josephson tunnel junctions. Over the past 15 years, advances in the fabrication, materials, and design of superconducting qubits have led to significant improvements in their coherence time[2], which is a key metric to characterize their quantum mechanical performance. Such high-coherence superconducting qubits are now being engineered for quantum annealing and gate-based computing applications.

Here I will describe our work at MIT Lincoln Laboratory to fabricate high-coherence superconducting qubits. I will discuss our process flows, which include patterning by photolithography and electron beam lithography to fabricate shadow-evaporated aluminum Josephson junctions and high-quality-factor circuit elements (e.g., capacitors, resonators). I also will highlight aspects of our work related to the materials growth and characterization of high-quality superconducting titanium nitride and aluminum films, as well as the development of 3D-integrated superconducting circuits.

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[2] Oliver and Welander, MRS Bulletin **38** (10), 816 (2013).