Interface Chemistry and Decoherence Processes in Superconducting Quantum Circuits

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Artificial atoms based on superconducting circuit elements including Josephson tunnel junctions and strip-line resonators can be used as "qubits" for quantum computation and simulations, and as platforms for studying quantum cavity electrodynamics and other quantum phenomena. The performance of these systems depends critically on achieving coherent lifetimes that are significantly longer than initialization and readout times. Significant progress has been made in increasing coherence over the last decade or two by better electromagnetic circuit design to control losses and cross-talk, by improved radio-frequency electronics [1], and by advances in shielding and measurement techniques [2]. Further progress can come from improvements in materials and fabrication and better control of interface chemistry [3].

We will report initial results on interfacial studies combining SEM, analytical STEM, and x-ray spectroscopy to understand substrate, vacuum and internal interfaces in both Al Josephson junctions and Nb resonator structures.

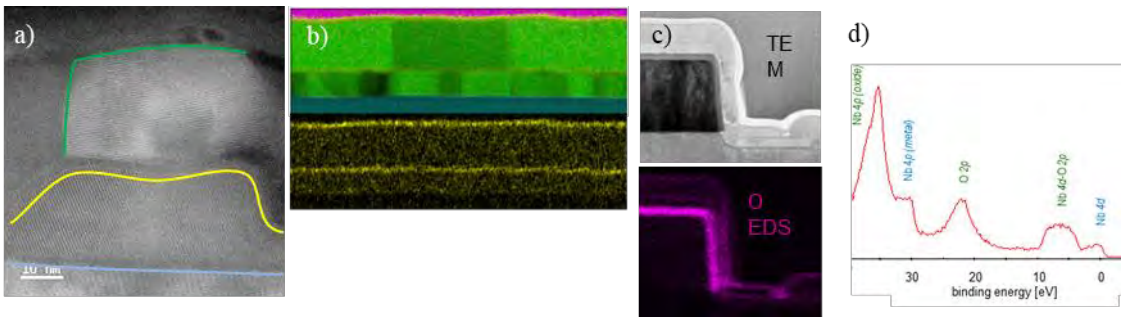

Figure 1 (a) STEM cross-section through polycrystalline Al/AlO_x/AlO Josephson junction. The yellow line indicates the tunnel junction, the blue line the Al/Si interface, and the green line an Al grain boundary in the top contact. (b) TEM/EDS cross section of a different junction. The Al grain structure (green) can be seen in the two Al layers, and the oxide distribution (yellow) from EDS is shown below. (c) TEM/EDS on an Nb strip-line resonator cross section showing surface oxide. (d) Valence band XPS of Nb surface showing hybridization of the Nb *4d* levels with O *2p*.

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