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Optimizing silicon nitride for superconducting quantum circuits[1]
HANHEE PAIK, KEVIN OSBORN, Laboratory for Physical Sciences — Amorphous dielectrics are prevalent in lithographic circuits, but their presence can decohere superconducting qubits. We investigate the relationship between stoichiometry and low- temperature loss in silicon nitride dielectric films, where two- level system defects are unsaturated. The silicon nitride films are deposited by plasma-enhanced chemical vapor deposition at 300 degrees celsius, with silane and nitrogen as precursor gases. The precursor gas ratio is changed and film density, crystalline order, stress, and hydrogen incorporation are measured. Hydrogen, silicon and nitrogen content are monitored with FTIR spectroscopy. The loss is measured at low-field strengths at temperature of 30 mK with lumped-element superconducting resonators, where silicon nitride is used as the dielectric within a parallel-plate capacitor. Our data show that N-rich silicon nitride with a high concentration of nitrogen-hydrogen bonds exhibit a factor of 10 higher loss tangent than Si-rich films. The loss of the better film rivals other on-chip insulating techniques, and allows us to fabricate Josephson junctions next to silicon nitride with a negligible loss contribution from this dielectric.

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Hanhee Paik
Laboratory for Physical Sciences

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