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Fabrication and Testing of AlN Josephson Junction Qubits RADOSLAW BIALCZAK, University of California, Santa Barbara, MARKUS ANSMANN, NADAV KATZ, ERIK LUCERO, ROBERT MCDERMOTT, MATTHEW NEELEY, MATTHIAS STEFFEN, EWA WEIG, ANDREW CLELAND, JOHN MARTINIS — Recently, it has been shown that a major source of decoherence in Josephson junction (JJ) qubits comes from coupling to two-level systems (TLS) in the dielectric materials used to construct these qubits. These TLS's result from defects in the dielectric material. In our previous work we have shown that the energy relaxation times of our JJ phase qubits improve 20-fold when we substitute SiO2 with SiN as the dielectric material used for cross-over wiring. This shows that nitride based dielectrics might be less prone to defects and suggests that the next logical step would be to replace the Al2O3 tunnel barrier dielectric of the JJ with AlN. We have used atomic nitrogen to successfully fabricate a JJ phase qubit with AlN as the JJ tunnel barrier material. Through spectroscopy measurements, we have found that qubits made with AlN as the tunnel barrier material have only slightly lower concentrations of defects compared with previously studied qubits made with Al2O3 grown by natural oxidation. Also, the measured T1 times for these AlN qubits were low ($\sim$15ns). This agrees with theoretical predictions of Ioffe et al. which state that piezoelectric materials, such as AlN, might have other loss mechanisms due to phonon radiation.

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