Coherence properties of NbN-based superconducting qubits

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In superconducting qubits containing aluminum-based Josephson junctions (JJs), a major concern is the decoherence from microscopic two-level systems in amorphous aluminum oxide. As alternative materials for the JJs of the qubits, we introduce fully epitaxial nitride JJs consisting of NbN/AlN/NbN tri-layer. We have fabricated a capacitively-shunted flux qubit coupled to a half-wavelength coplanar waveguide resonator. By employing a Si substrate with TiN buffer layer instead of the conventional MgO substrate for the epitaxial growth of the NbN film, our nitride qubit has demonstrated a significant improvement in coherence times, such as T_1 = 16.3 μs and T_2 = 21.5 μs [1], which are more than an order of magnitude longer than those reported in the literature using MgO substrates [2]. These results are an important step towards constructing a new platform for superconducting quantum hardware. This work was supported by JST CREST (Grant No. JPMJCR1775), JSPS KAKENHI (JP19H05615), JST ERATO (JPMJER1601) and partially by MEXT Q-LEAP (JPMXS0120319794 and JPMXS0118068682).

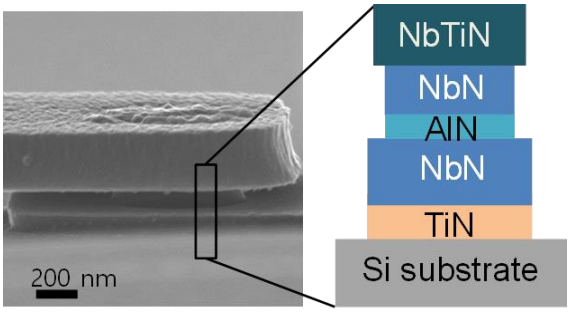

Fig 1. Scanning electron microscope image and schematic view of all-nitride Josephson junction forming qubit

[1] S. Kim et al., Communications Materials 2, 98 (2021).
[2] Y. Nakamura et al., Appl. Phys. Lett. 99, 212502 (2011).