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Improvement of dielectric loss in superconducting microwave resonators

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Experiment and results

Previously we have studied the dielectric loss in superconducting microwave resonator circuit integrated with superconducting quantum bit on single crystal MgO (100) substrate. The main reason that we use MgO substrate is to fabricate high quality epitaxial Josephson junction for superconducting qubit circuit as the epitaxial junction is the ideal basic element for superconducting qubit application. Even though SiO_2 from the junction insulation layer can also contribute significant loss, we determined that the loss was mainly due to the MgO substrate.

In this letter, we report an improvement of dielectric loss in superconducting TiN (200) resonator. The TiN (200) thin film was deposited on single-crystal Si (100) substrates by dc magnetron sputtering. The native SiO2/SiO thin films was removed by chemical wet etching in hydrogen fluoride before the dc sputtering process. The hydrogen terminated Si (100) substrate was kept at 800℃ during the TiN thin film deposition. The TiN (200) thin film was patterned into a half-wavelength coplanar waveguide resonator with resonance frequency of 10 GHz. The dielectric loss (inverse to the loaded quality factor) (Fig. 1) is obtained from Lorentzian fit of the resonators' transmission S-parameters S_{21}. The TiN (200) resonator demonstrates the lowest dielectric loss among all other candidate materials during our conducted research. It suggests that TiN (200) thin film is suitable for future qubit application.

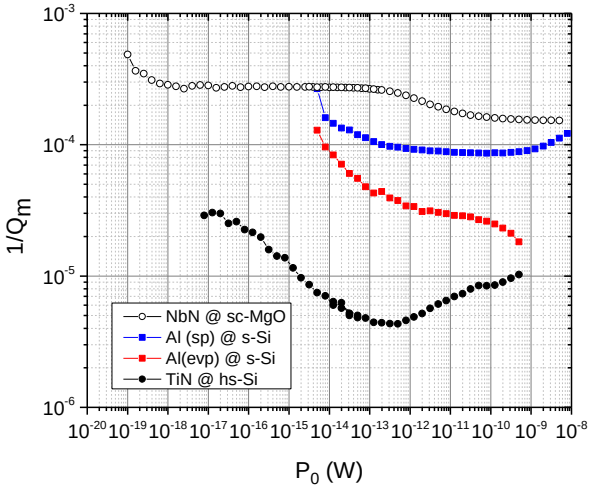

Figure 1 Dielectric loss of different superconducting microwave resonators on various substrates obtained at 300 mK.