Optimization of Fabrication Conditions for Ultra High-Q TiN Superconducting Coplanar Waveguide Resonators

情通機構　○丘　偉，牧瀬　圭正，寺井　弘高
NICT　○Wei Qiu, Kazumasa Makise, Hirotaka Terai
E-mail: qiuwei@nict.go.jp

Experiment and results

Fabrication of high-Q, thus to eliminate TLS related loss in superconducting resonator has become an essential step to achieve high quality, long coherence time in superconducting quantum circuit using superconducting quantum bit as an basic element. In nitride based superconducting qubit, the TLS related loss is dominated by lossy MgO substrate [1-3]. We report in this letter our success in developing high-Q TiN resonator. The TiN film has been deposited on ultra-high resistivity Si substrate (>100,000 Ω cm) by reactive dc-magnetron sputtering in a load-locked sputtering system with a background pressure better than 5×10^{-9} Torr. The sputtering system is capable of substrate heating up to 1000 °C. All wafers have been cleaned by dipping into hydrofluoric (HF) acid to remove native oxide layer on Si surface prior to the TiN deposition. From measuring R-T characteristics, dc electrical properties of TiN films, such as Tc, resistivity, and penetration depth, are largely affected by the fabrication conditions. The TiN resonator devices are photo-patterned to half-wave coplanar waveguide with a nominal resonance frequency near 10 GHz by i-line stepper. With the optimized fabrication conditions, the internal quality factor of one million was determined by measuring S-parameters at 10 mK in dilution refrigerator according to the experimental setup showed in Figure 1.

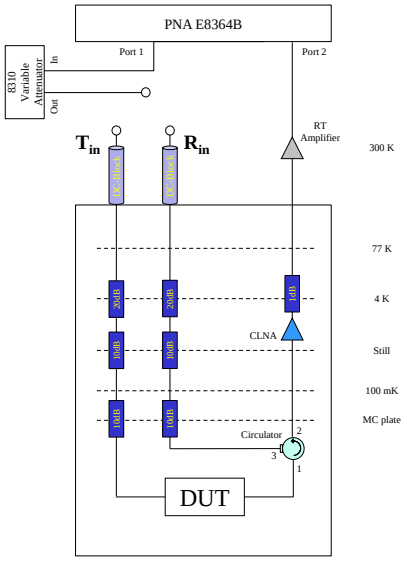

Fig. 1. Experimental setup for S-parameter measurement of TiN resonator.

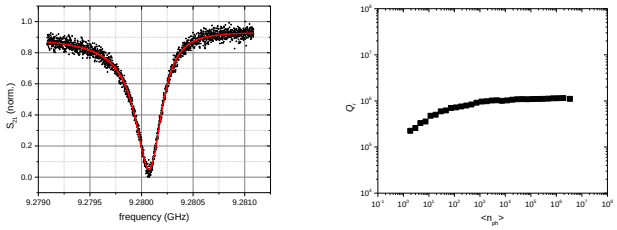

Fig. 2. An example of measured resonator reflection (left) and overall photon power dependence of resonator internal Q_i.

Reference

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