Fabrication-induced decoherencein superconducting coplanar waveguide resonators

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High quality factor superconducting coplanar waveguide resonators (CPWR) provide crucial element-forquantum memory [1], parametric amplifiers [2] and quantum electrodynamics circuits [3]. Such applicationsarelimited by the CPWR intrinsic quality factor [4]. High quality factor coplanar resonators performance is sensitive to design, fabrication and characterization techniques that makeits manufacturing quite challenging. Recent studies show that devices relaxation time is drastically reduced by dielectric loss and fluctuations due to two-level system (TLS) tunneling defects [4].Using CPWR as sensitive probes, we investigate the sources of capacitive losses, arisen from imperfections at substrate-metal, substrate-vacuum, metal-vacuum interfaces and carefully optimize our manufacturing processes. RemovingTLS sources from the interfaces withadvancedsubstrate surface treatment, epitaxialaluminum films [5], non-damage etching anddevice post cleaning, wehas achieved CPWRs with extremely low dissipation.

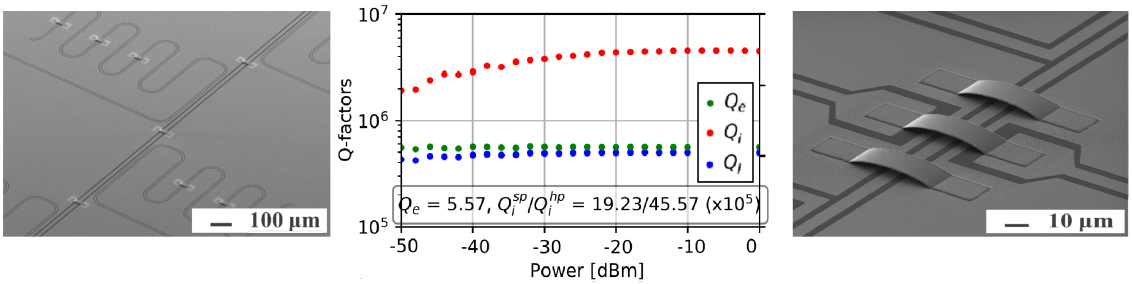

Figure 1: SEM image of CPW resonators with the airbridges capacitively coupled to the feed-line (left). Measured quality factors of resonators as a function of power (center). SEM image of the airbridges spanning the CPW (right).

Here, we present end-to-end manufacturing process and measurement setup of aluminum CPWRs on silicon substrate with internal quality factors overone million in single photon regime. We describe design features and characterize fabrication improvements as a function of CPWRs internal quality factor. Finally, we demonstrate the developed superconducting airbridgestechnology and its impact on resonators performance.

All the devices were fabricated at the BMSTU Nanofabrication Facility (FMN Laboratory, FMNS REC, ID 74300).

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