Vacuum-Gap Microstrips for Impedance-Matching Traveling-Wave Parametric Amplifiers

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In traveling-wave parametric amplifiers [1] (TWPAs), low-loss capacitors are necessary to provide 50Ω impedance matching to the increased inductance that is brought in by the nonlinear elements used for amplification, be it Josephson junctions or high kinetic inductance materials. Dielectric loss coming from those capacitors is usually associated with additional noise, exceeding the quantum limit of amplification. Here [2] we report on the development of a fabrication process for vacuum-gap microstrips, a design in which the ground plane is suspended in close proximity above the center conductor without the support of a dielectric. In addition to high-capacitance transmission lines, this architecture also enables air-bridges and compact parallel-plate capacitors. The performance of the fabrication is examined using distributed resonators made from aluminum and sputtered granular aluminum [3] in a cryogenic dilution refrigerator setup. We show quality factors on par with the fabrication processes used in state-of-the-art TWPAs. Also, we examine a periodically loaded aluminum + granular aluminum transmission line, showing large kinetic inductance and DC-tunability, making it a very promising candidate for the implementation of a quantum-limited TWPA.

References

[1] M. Esposito et al., Applied Physics Letters, 119 (2019) 120501
[2] C. Schlager, R. Albert and G. Kirchmair, arXiv:2503.07431(2025)

Figures

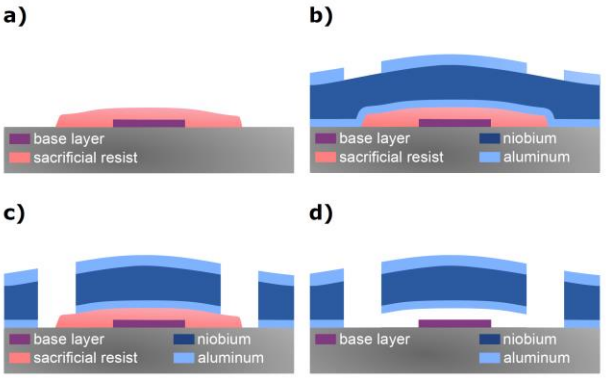

Figure 1: Schematic depiction of the developed fabrication process. **(a)** An 80nm thick layer of resist covers the base layer as a sacrificial placeholder. **(b)** The triple-layer ground plane is deposited on top with holes patterned in the topmost aluminum layer. **(c)** The aluminum mask enables the etching of access holes down to the sacrificial resist. **(d)** Through the holes the resist is removed by organic solvents before the vacuum-gap microstrip is released by critical-point drying.

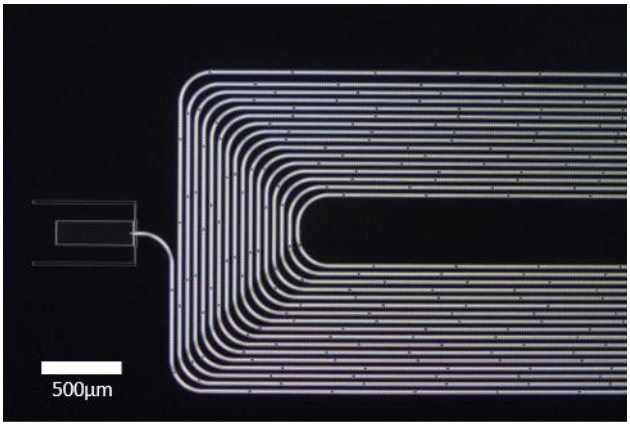

Figure 2: Optical dark-field image of an aluminum transmission line, periodically loaded with granular aluminum sections (darker patches along the line).