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High-Q 3D niobium λ/4 coaxial cavities for quantum applications inspired by SRF technologies

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High-Q three-dimensional (3D) superconducting cavities are often used for quantum application including dielectric constant measurement, quantum memory[1], and dark matter detection[2]. In these experiments, a high-Q cavity is integrated with a superconducting qubit, which yields circuit-based Quantum Electrodynamics (cQED) architecture. The cavity geometry employed for quantum applications is radically different from that used for particle accelerators like a TESLA cavity. Most recently 3D cQED platforms are composed of a λ/4 coaxial cavity[1] which permits strong enough coupling between the superconducting qubit and the coaxial cavity to manipulate the quantum state of the cavity whilst sustaining internal Q factors of 1e9[3]. However, the best internal Q factor for these types of cavities is still an order of magnitude smaller than TESLA cavities. The origin of the reduced internal Q factor for λ/4 coaxial cavities has still not been clarified. One prominent candidate for the source of loss stems from the fact that 3D cQED devices for quantum applications are operated in the low-power limit, which is insufficient to saturate oxide defects on the cavity surface. In this study, various surface treatments are investigated with the aim to improve the lifetimes of 5.5 GHz λ/4 coaxial cavities. The internal Q factor after each treatment will be reported in this study and the most effective methods to fabricate a high-Q cavity for quantum applications will be discussed.

I have read and accept the Privacy Policy Statement

Yes

Footnotes

[1] M. Reagor, et al., PRB 94, 014506 (2016).
[2] K. Nakazono, et al., arXiv:2505.15619 (2025).
[3] A. Oriani, et al., arXiv:2403.00286 (2024).

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Author: TAKENAKA, Takaaki (NTT Basic Research Laboratories)

Co-authors: Dr MAHBOOB, Imran (NTT Basic Research Laboratories); Dr SAITO, Shiro (NTT Basic Research Laboratories); KUBO, Takayuki (High Energy Accelerator Research Organization); SAEKI, Takayuki (High Energy Accelerator Research Organization)

Presenter: TAKENAKA, Takaaki (NTT Basic Research Laboratories)

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