Comparison of Materials for Superconducting Coplanar-Waveguide Resonators on 200 mm Silicon Substrates

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In superconducting circuits for quantum computing Al, Nb, and Ta are among the most used materials for coplanar waveguide resonators reaching internal quality factors of up to several million [1,2, 3, 4]. However, many breakthroughs are developed in academic research environments using processes and materials not suitable for large-scale industrial CMOS fabrication. Fraunhofer EMFT is fabricating high yield and industry grade superconducting circuits including qubits on 200 mm wafer using CMOS compatible fabrication methods to transfer and scale research to industry [5, 6]. In this work we compare our standard Al process with Nb, Ta and AlSi based resonators fabricated with CMOS compatible fabrication methods on 200 mm substrates. AlSi is commonly used in industry to prevent silicon spiking into aluminium at higher temperatures and thus specifically interesting for large scale applications. We will present the internal quality factors as function of the photon number and substrate leakage for different resonator materials and substrates to give a comparative overview of material-substrate combinations relevant for scalable, industry-grade superconducting quantum hardware.

References

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[2] E. V. Zikiy *et al.*, *Scientific Reports*, **13** (2023) 15536.
[3] M. P. Bland et al., Nature, 647 (2025) 343–348.
[4] M. Bal et al., npj Quantum Information, 10 (2024) 43.
[5] T. Mayer et al., arXiv, 2505.08424 (2025).
[6] S. J. K. Lang et al., arXiv, 2601.04082 (2026).

Figures

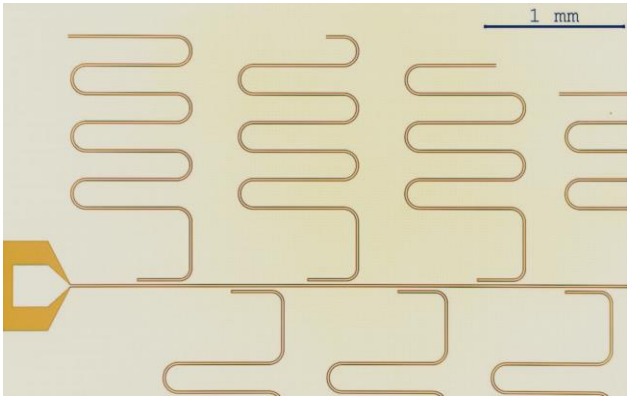

Figure 1: Microscope image of fabricated Al resonators with feedline and base layer on a silicon substrate.

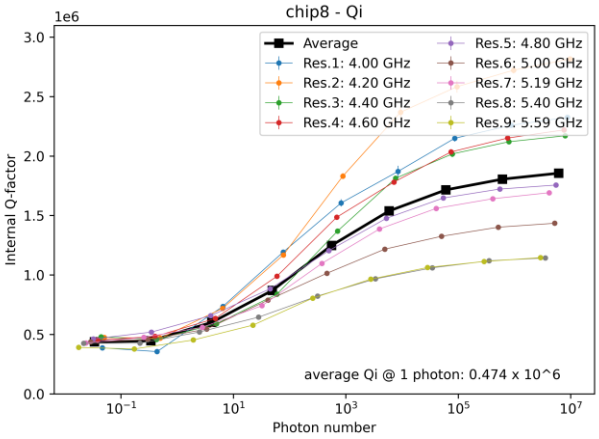

Figure 2: Internal quality factor Qi of the Al resonator as a function of photon number.