UHV compatible hard-mask technology for superconducting qubits

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The identification of pristine superconducting materials and low loss fabrication techniques is critical for improving superconducting qubit lifetimes and achieving scalable architectures for quantum computing [1].
We present a fabrication technique based on the concept of stencil lithography [2] that decouples mask fabrication from substrate preparation and is compatible with MBE/UHV systems. Josephson Junctions and capacitor pads are created by metal evaporation through an inorganic silicon-membrane mask, hence eliminating organic residues and nanofabrication-related contamination.
The mask is defined using advanced dry etching techniques (CORE [3]) allowing for high flexibility in the desired qubit and cQED design. The masks are reusable, easy to clean and present a scalable method for fully in-situ fabrication of superconducting devices.

References

[1] Devoret, M.H., and R. J. Schoelkopf, Science 339.6124 (2013): 1169-1174
[2] Gray, S., Weimer, PK., RCA Review, RCA Corporation 20 (3) (1959): 413–425
[3] Nguyen, V.T.H., et al. ECS Journal of Solid State Science and Technology 9.2 (2020): 024002

Figures

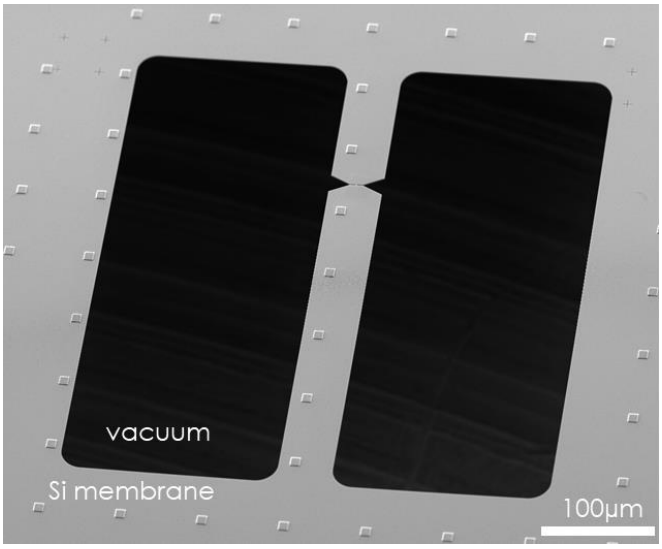

Figure 1: SEM Image of silicon stencil mask with for patterning of capacitor pads and a single Josephson junction

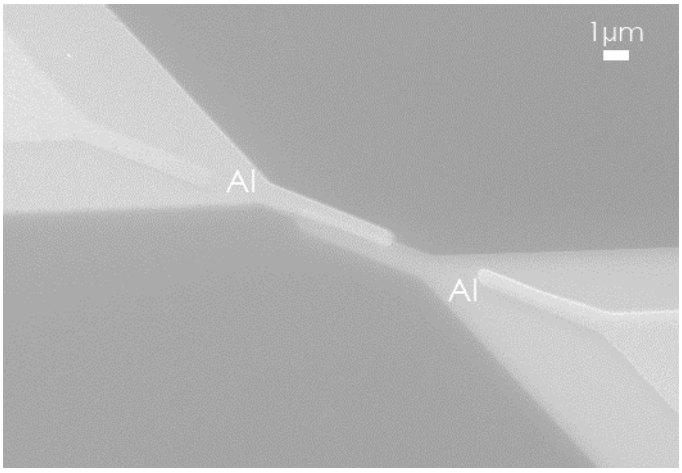

Figure 2: SEM Image of an Al/AlOx/Al junction created by shadow evaporation through a silicon stencil mask