Granular aluminium superinductors for cQED experiments on planar Germanium

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High kinetic inductance superconductors are gaining increasing interest for the realisation of qubits, amplifiers and detectors. Their high impedance enables large zero-point fluctuations of the voltage, boosting the coupling rates of microwave photons to spin qubits [1] culminating with the first long-distance gate between spin qubits [2]. Fully exploiting the potential of such disordered or granular superconductors is challenging, as their inductance and, therefore, impedance at high values are difficult to control explaining the rather low impedance achieved in quantum dot devices so far. Reproducible fabrication of microwave coplanar waveguides with impedances exceeding 13 kΩ (Fig. 1) is now possible using a newly developed technique with in-situ control of the sheet normal state resistance during the deposition process [3]. We have integrated such a high impedance granular aluminium resonator with a germanium double quantum dot and demonstrated strong charge-photon coupling with a rate of $gc/2\pi$ = (566 ± 2) MHz (Fig. 2) [3]. In this talk, I will present the performance of the granular aluminium resonators as well as our first strong hole photon coupling results. I will then discuss our progress towards achieving strong hole-spin photon coupling on planar Germanium.

References

[1] Yu, C.X. et al, *Nat. Nanotechnol.* 18, 741–746 (2023)
[2] Dijkema, J. et al. *Nat. Phys.* 21, 168–174 (2025)
[3] Janik, M., Roux, K. et al, arXiv:2407.03079v1 (accepted in Nat. Comm.) (2025).

Figures

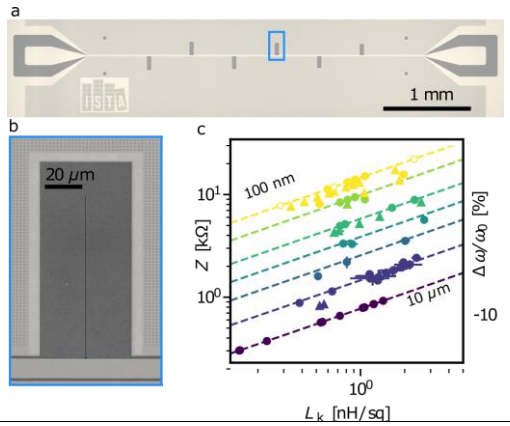

Figure 1: a) Optical and b) scanning electron microscope (SEM) images of six 200 nm-wide grAl resonators side-coupled to a feedline. c) Sheet kinetic inductance dependence of the characteristic impedance for different resonator widths.

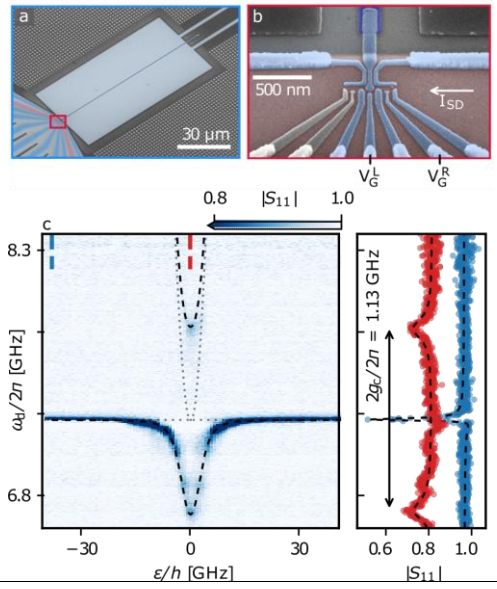

Figure 2: a) SEM image showing a device implementing a grAl reflection resonator with a triple quantum dot electrostatically defined by nine gates. b) SEM image showing the details of the region highlighted in red in (a). The grAl resonator centre conductor (dark blue), is 111 μm long and 200 nm-wide reaching an impedance of 7.9 kΩ. c) Resonator microwave spectroscopy as a function of drive frequency ω and DQD detuning ε. The linecuts along the frequency axes, taken at the detunings indicated by the dashed blue and red labels show the clear vacuum Rabi splitting at zero detuning.