Superconducting microwave resonators for spin-photon coupling in silicon.

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Atom-bound electronic systems in silicon form an exciting platform for quantum technologies. A current objective is to develop dopant-based qubit systems presenting a finite electric dipole and intrinsic spin-orbit, such as hole-bound acceptors [1,2] or electron-nuclear system in donor-based double quantum dots [3], since they are amenable to all electric drive and coupling to superconducting microwave resonators. Such spin-photon coupling is expected to enhance qubit readout performance, and it also opens way to coupling spin qubits at long distances and facilitate large-scale qubit integration.

To do so, it is necessary to tune the resonator properties such as resonant frequency, quality factors and kinetic inductance through precise geometry and material engineering [4,5] for each desired application. Superconducting films with high kinetic inductance result in large electric field mode volumes that enhance the coupling to quantum systems. This property can also be used to tune the resonator frequency [5]. Here, we fabricate thin films of amorphous tungsten silicide films with different compositions and characterize their critical temperature, resistivity and kinetic inductance. Kinetic inductances as high as 90 pH/square can be achieved, from which superconducting microwave resonators can be fabricated. We observe quality factors above one hundred thousand and strong resilience to in plane magnetic fields necessary for qubit operation and electron spin resonance on dopant ensembles.

[1] Joe Salfi *et al.*, PRL 116, 246801 (2016)
[2] Takashi Kobayashi *et al.*, NATURE MATERIALS VOL 20 , (2021)
[3] Edyta N. Osica *et al.,* Phys. Rev. Applied (2022)
[4] M. Göppl *et al.*, JOURNAL OF APPLIED PHYSICS 104, 113904 (2008)
[5] Sumedh Mahashabde *et al.*, PHYSICAL REVIEW APPLIED 14, 044040 (2020)