Fabrication of compact superconducting lowpass filters for ultrasensitive detectors

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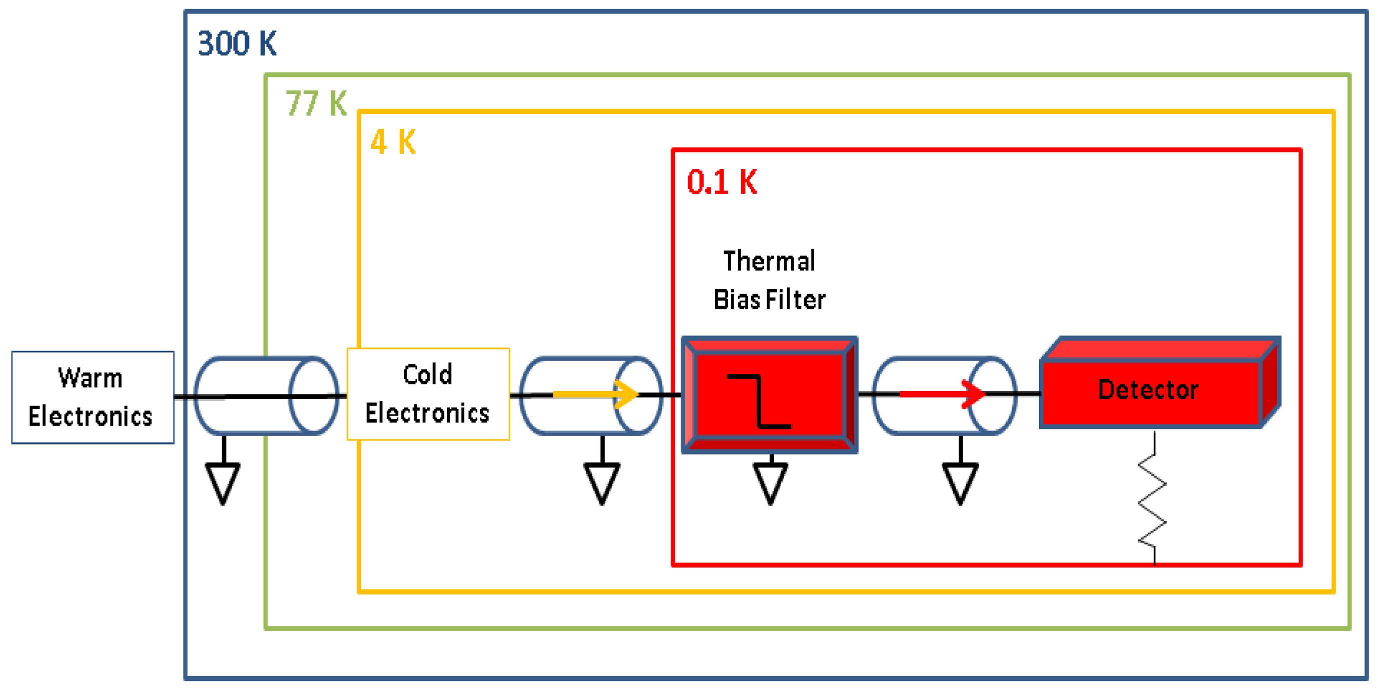
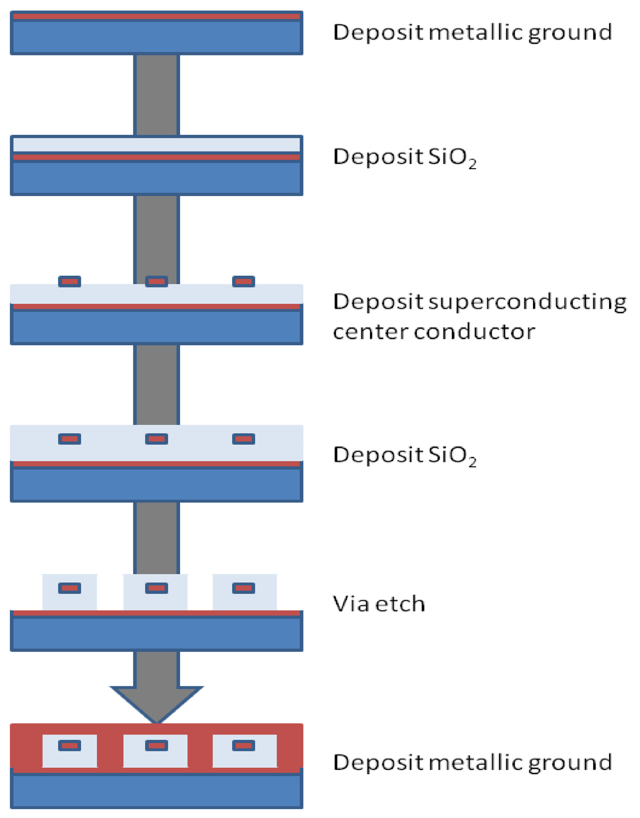
Introduction: Block radiation propagating through bias lines from reaching the detector with a filter

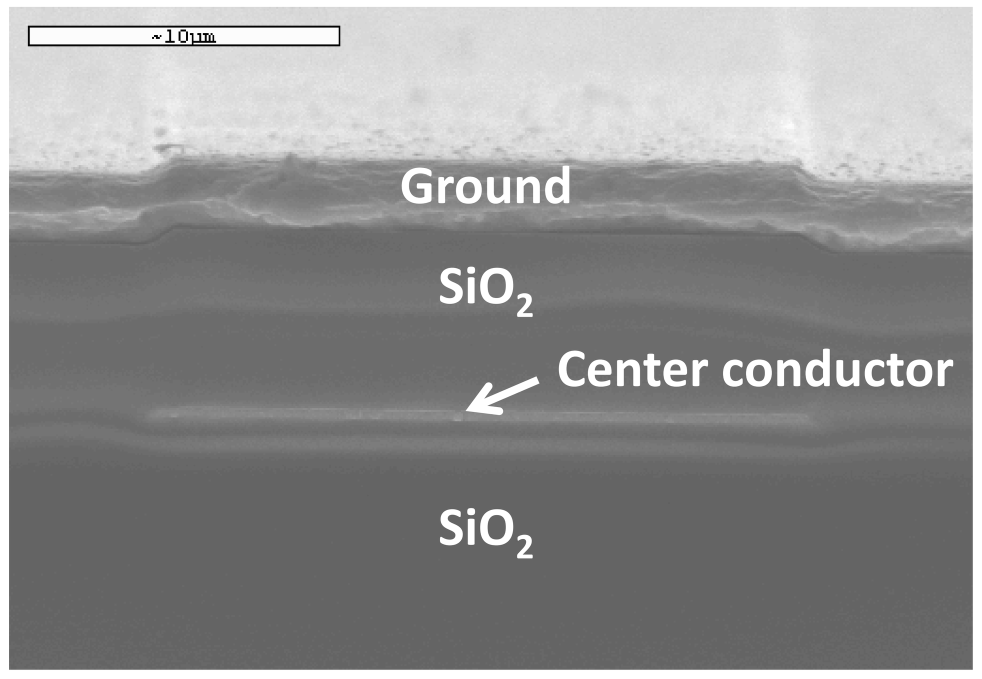
It is extremely important for current and future far-infrared and sub-millimeter ultrasensitive detectors, which include transition edge sensors (TES) and microwave kinetic inductance detectors, to be adequately filtered from stray electromagnetic radiation in order to achieve their optimal performance. One means of filtering stray radiation is to block leakage associated with electrical connections in the detector environment. Here we discuss a fabrication methodology for realizing non-dissipative planar filters imbedded in the wall of the detector enclosure to limit wave propagation modes up to far-infrared frequencies. Our methodology consists of fabricating a boxed stripline transmission line, in which a superconducting (Nb, Mo, or Al) transmission line is encased in a silicon dioxide dielectric insulator coated with a metallic shell. We report on achieved attenuation and return loss and find that it replicates the simulated data to a high degree.



Schematic illustrating typical ultrasensitive superconducting detector placement in relation to cryostat and our novel thermal bias.

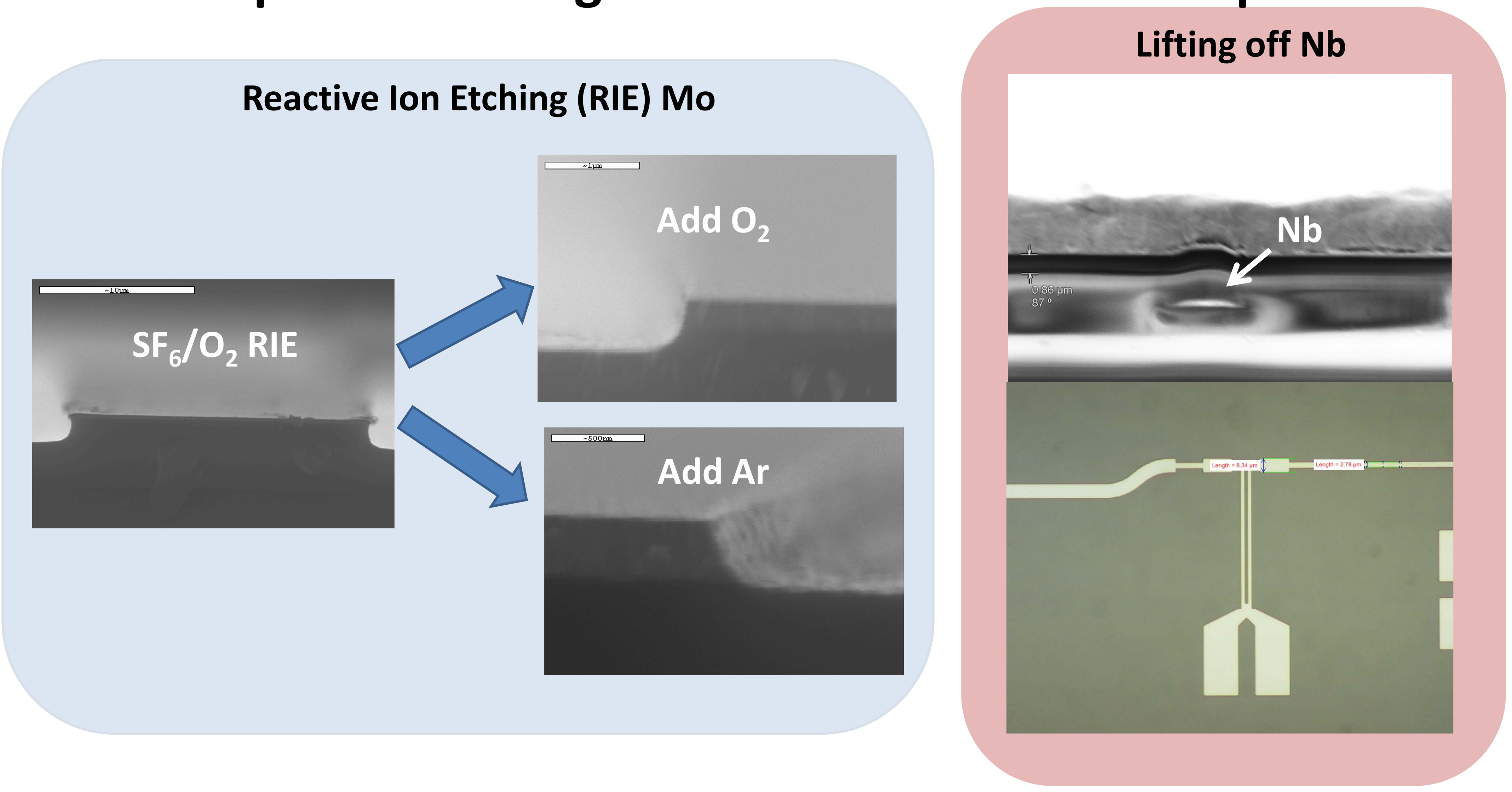
Filter Fabrication: Make a boxed stripline structure





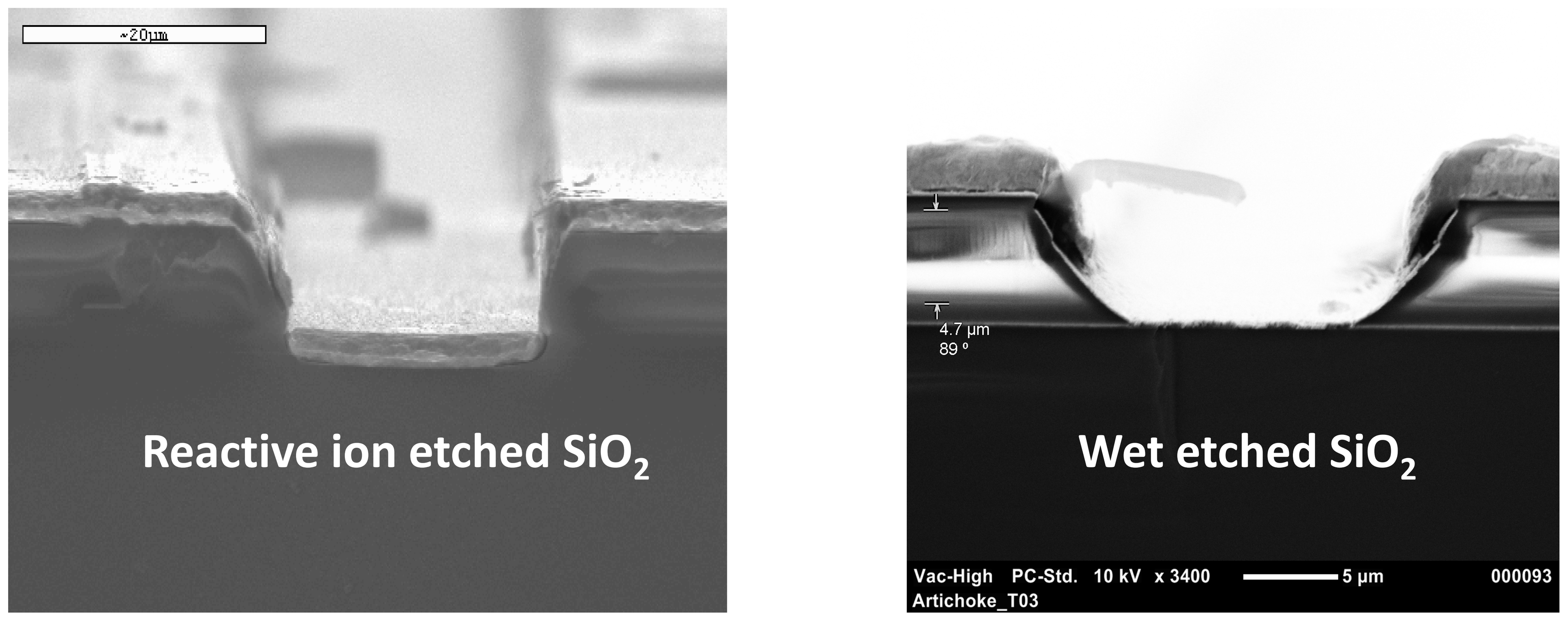
(LEFT) Fabrication flow; (RIGHT) Cross section scanning electron micrograph of boxed stripline structure.

Fabrication Development: Want superconducting center conductor with sloped sidewall



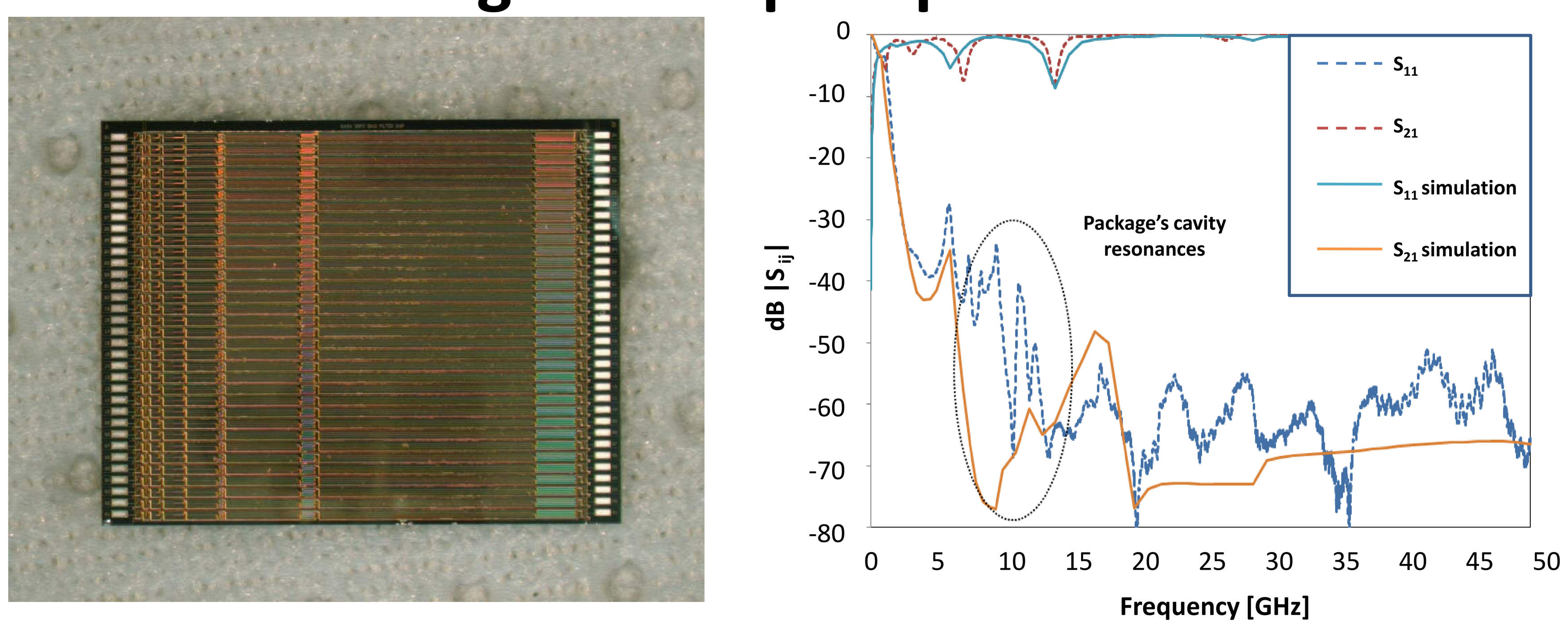
(LEFT) The effect of the addition of additional gasses to our straight sidewall Mo etch recipe. (RIGHT) Fabrication of Nb lines with sloped sidewall via liftoff.

Fabrication Development: Want to etch through 6 μm of SiO2 for via fabrication



Cross section scanning electron micrographs dry (LEFT) and wet etched (RIGHT) SiO_2. The metallic ground is deposited or electroplated in the etched regions.

Conclusions: Compact filters can be realized and exhibit good lowpass performance



(LEFT) Plan view image of filter chip. The chip contains a 1x34 filter array and its dimensions are 6.72mm x 9.77mm x 0.32 mm. (RIGHT) Microwave response of a filter measured at 4.2 K.