

Development of planar devices based on Al/AlOx/Al Josephson Junctions

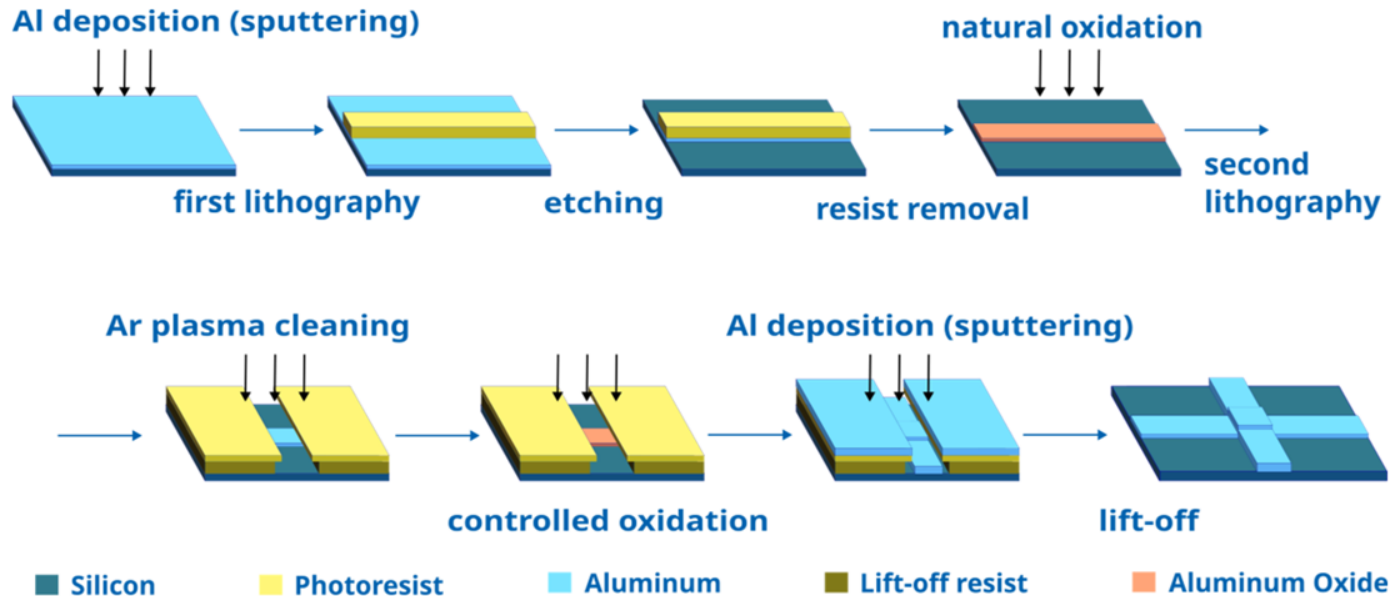
Alessandro Irace
Quartet meeting wp4



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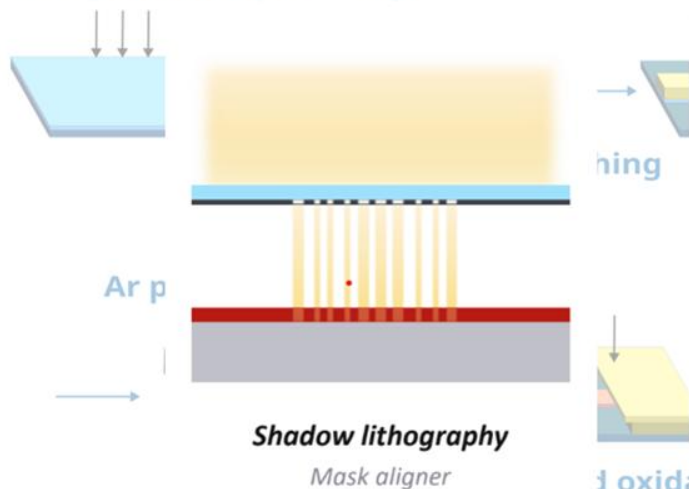
Fabrication process (for Josephson junctions)



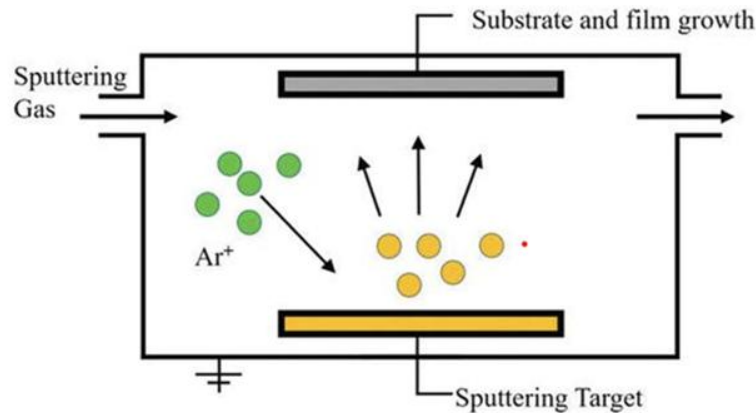
- Optical lithography
UV light mask aligner
- Etching
Al-selective acids bath
- Sputtering
DC Magnetron @ RT
- Lift-off
Lift-off resist-selective solvent bath

Fabrication process

Al deposition (sputtering)



natural oxidation

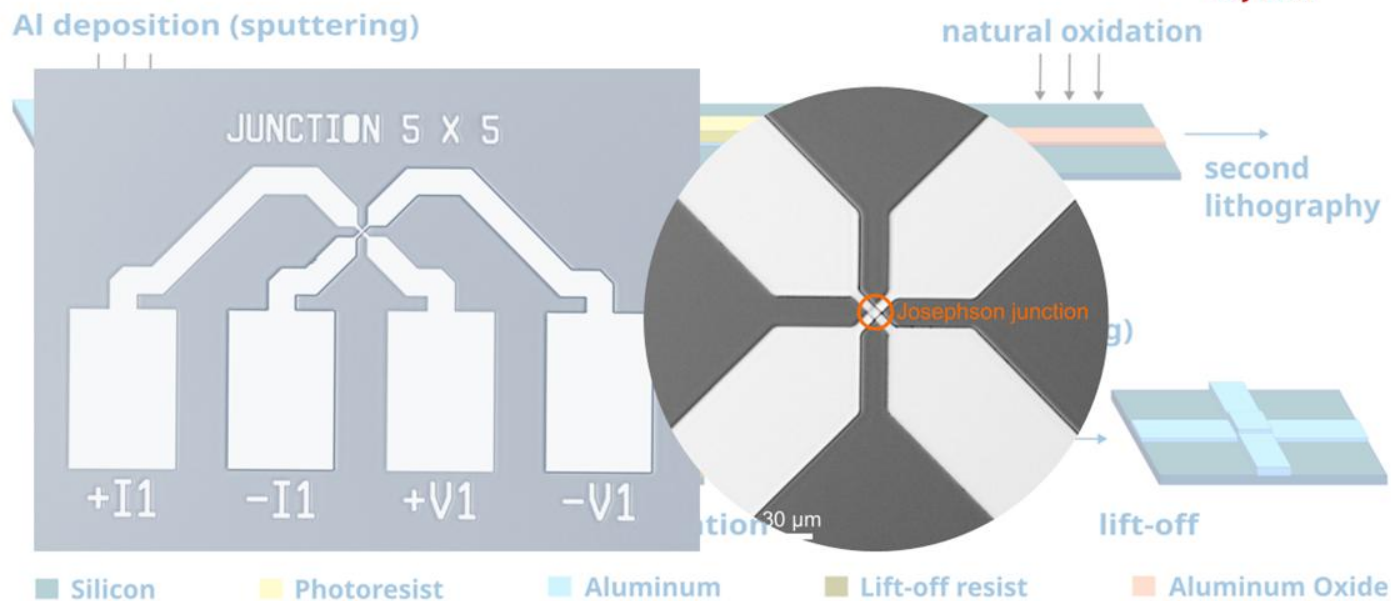


■ Silicon ■ Photoresist ■ Aluminum ■ Lift-off resist ■ Aluminum Oxide

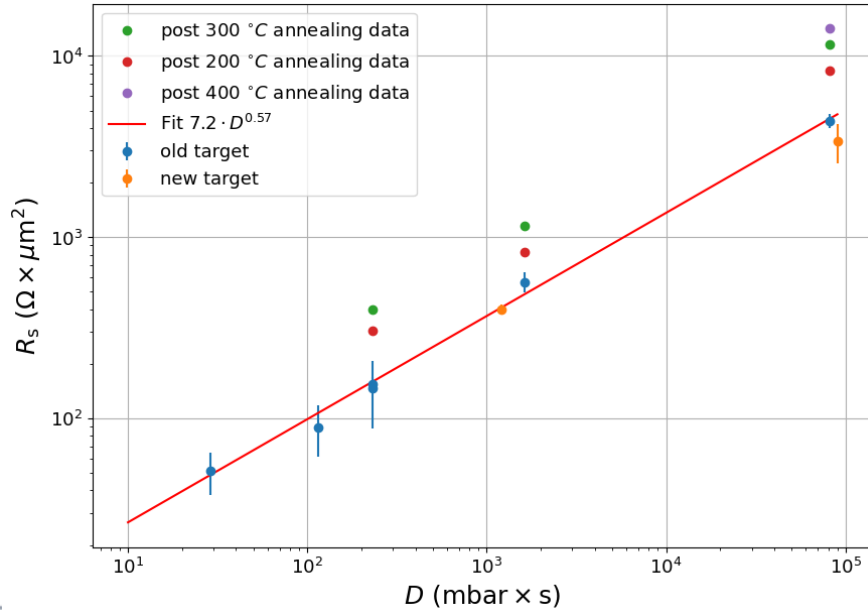
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Fabrication process

Different from Dolan style!!!



RT measurements



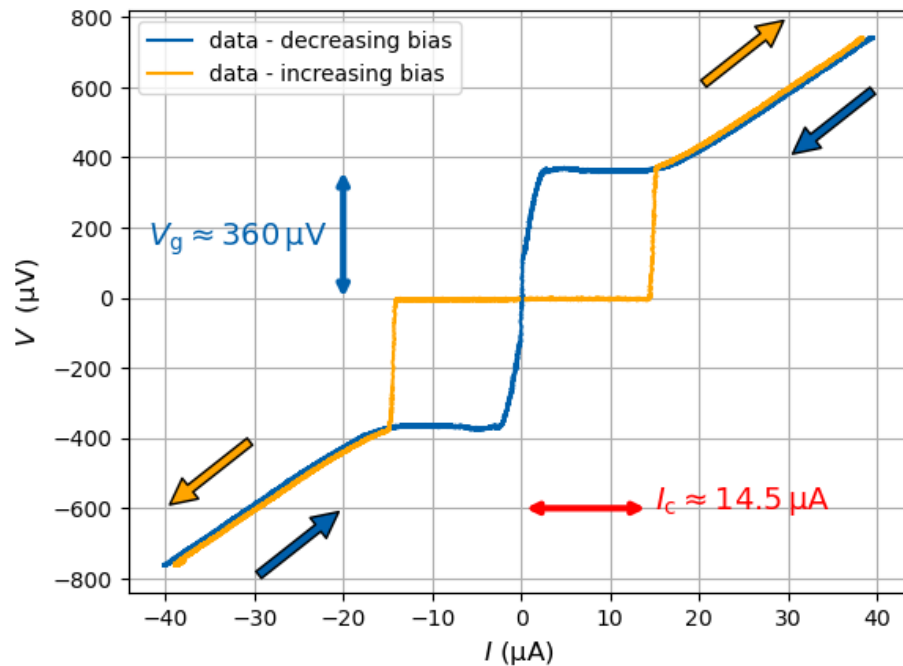
Ambegaokar-Baratoff formula

$$I_c R_N = \frac{\pi}{4} V_g$$

Josephson energy

$$E_j = \frac{\Phi_0 I_c}{2\pi}$$

mK Measurements



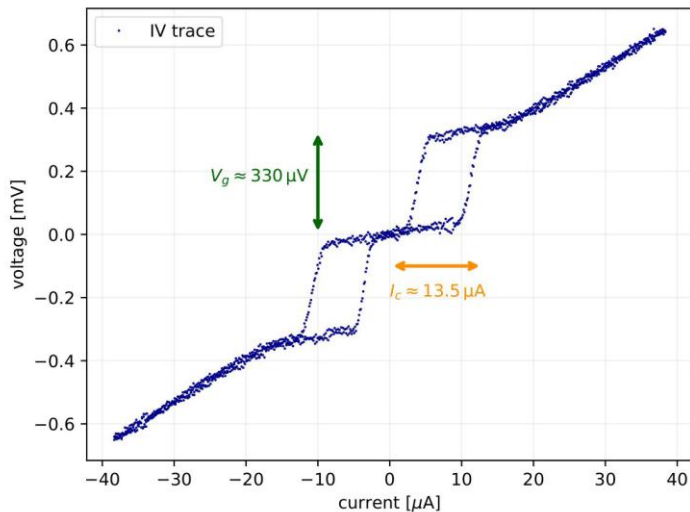
mK Measurements

Amplification-Free System (credit to Marcello Faggionato)

mfaggionato@fbk.eu

Sound Card for High-Fidelity Music Applications:

- DAC-ADC both with 2 channels
- 24 bit resolution
- 192 kHz sampling rate
- 110 dB SNR
- 2.15 Vrms maximum voltage input/ouput



Can we make a transmon out of these?

Yes, but to have a good one, we need a lower E_j/E_c ratio

We are working on 2 alternative solutions



Multiple-oxidation barrier



Direct Laser lithography

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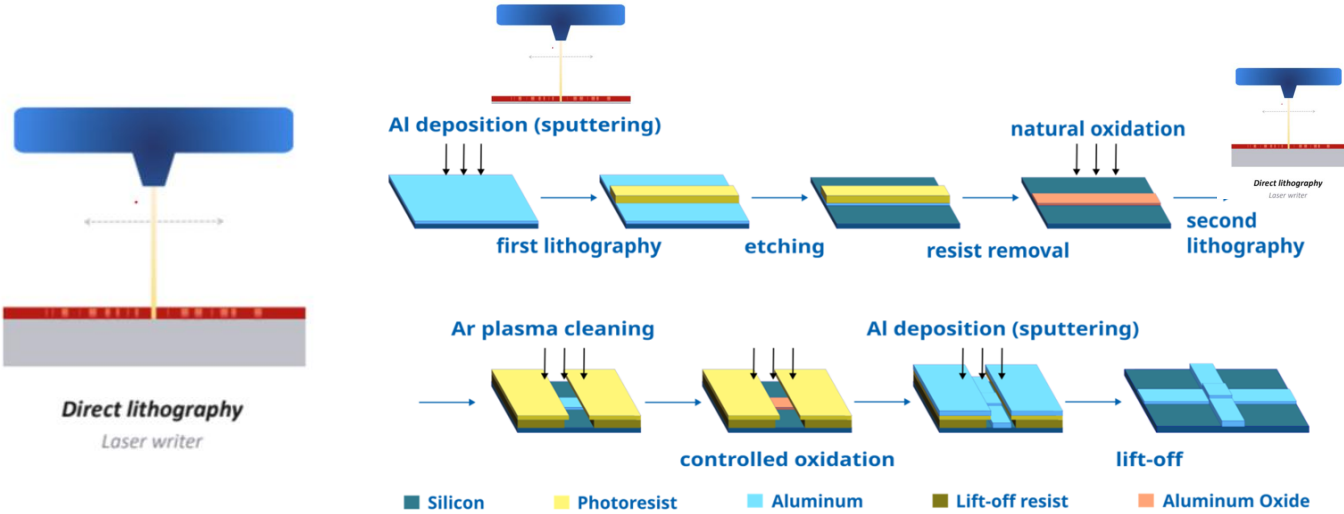


Multiple-oxidation barrier



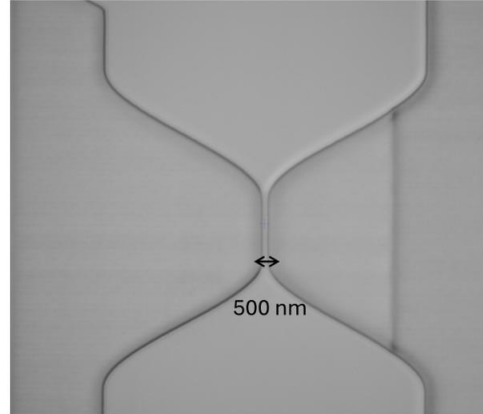
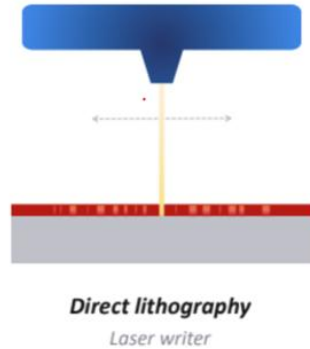
Direct Laser lithography

Fabrication - DWL66+



Fabrication - DLW66+

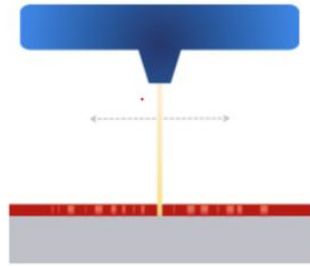
First layer looked very promising...



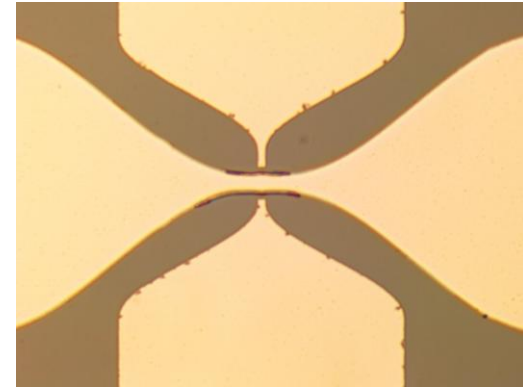
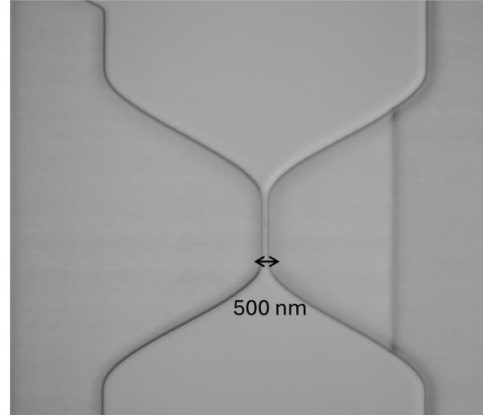
nominal resolution 300nm

Fabrication - DLW66+

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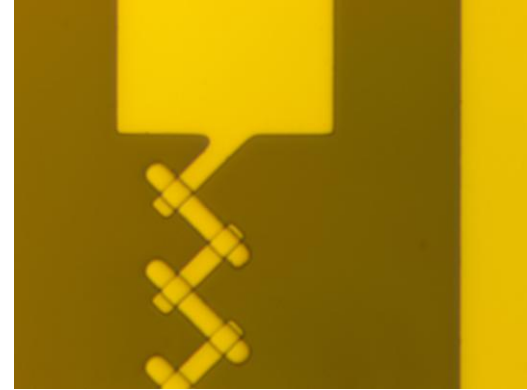
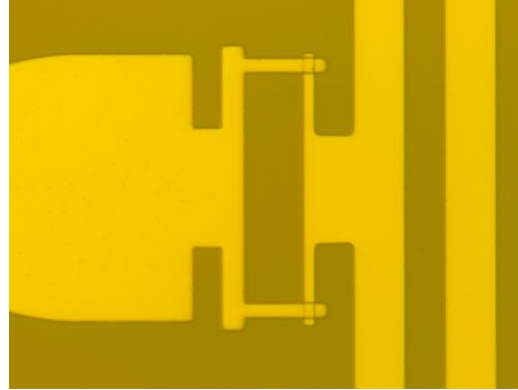
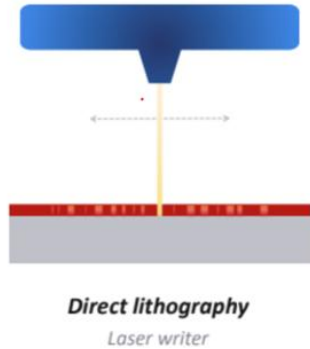
Direct lithography
Laser writer



but we had some problems with
the second one

Fabrication - DWL66+

After a lot of optimization and work in clean room now we can reproducibly fab junctions with a minimal area of $3 \times 3 \mu\text{m}$



We are confident we can improve and reach at least $1 \mu\text{m}$ resolution in the near future

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We are working on 2 alternative solutions

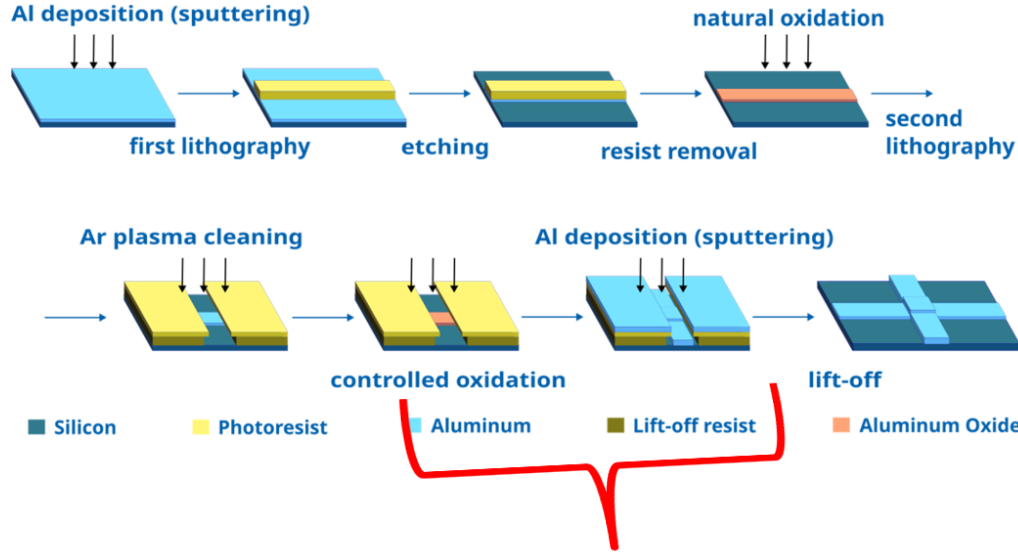


Multiple-oxidation barrier

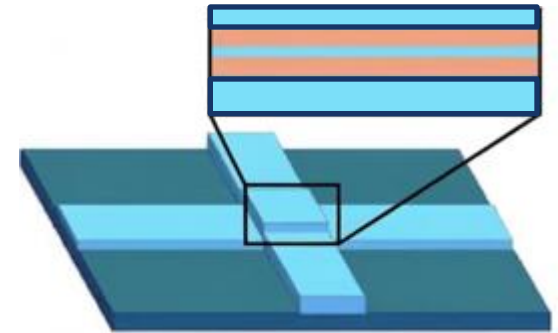
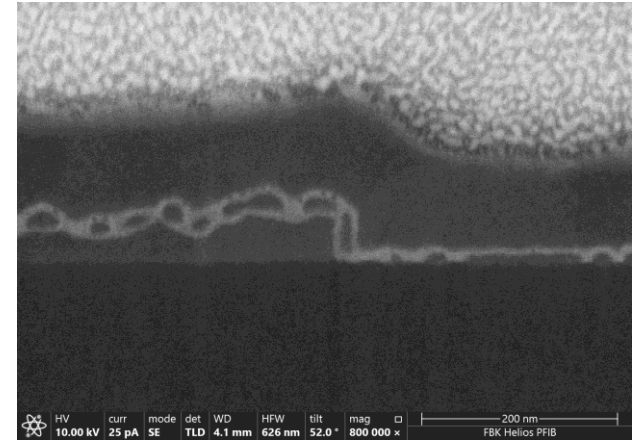


Direct Laser lithography

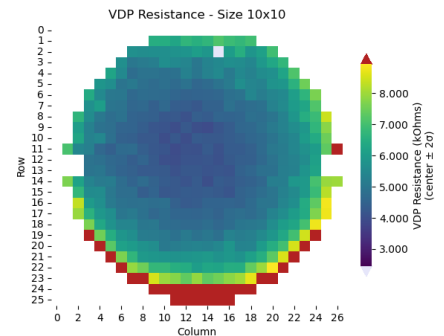
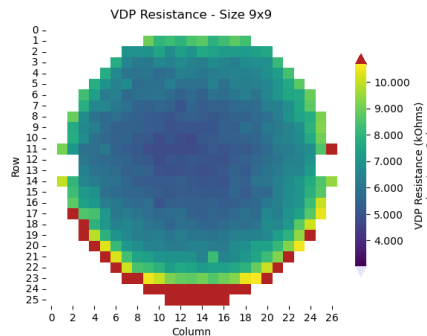
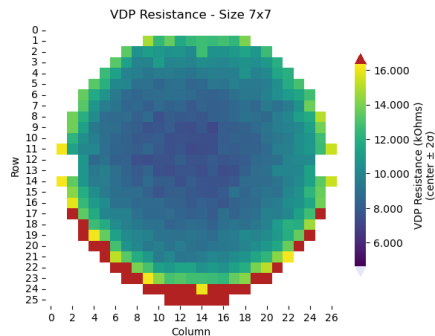
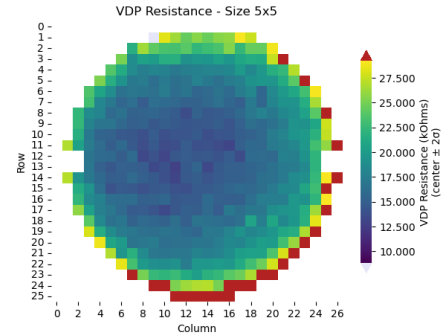
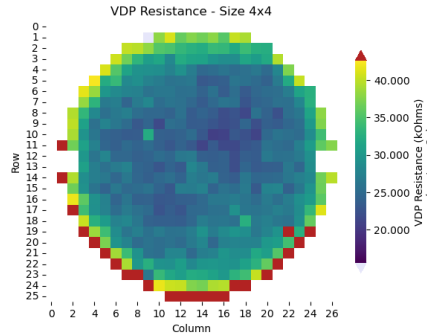
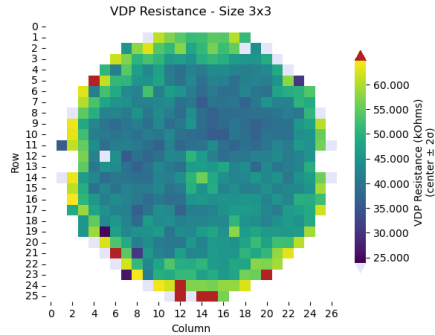
Fabrication – Multi-Ox



These 2 steps happen multiple times in succession to make the oxide barrier thicker

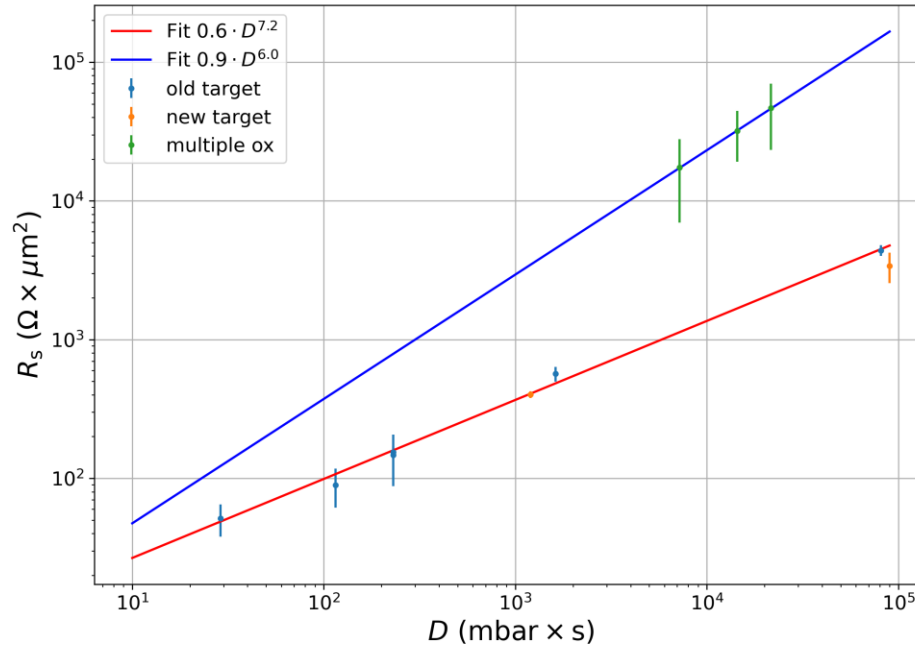


RT measurements – two oxidation steps

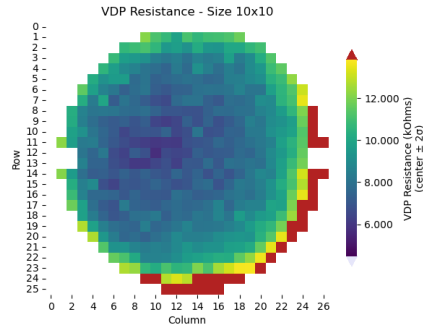
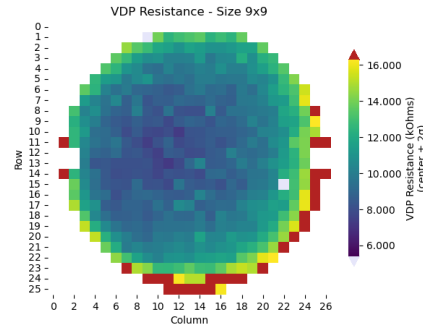
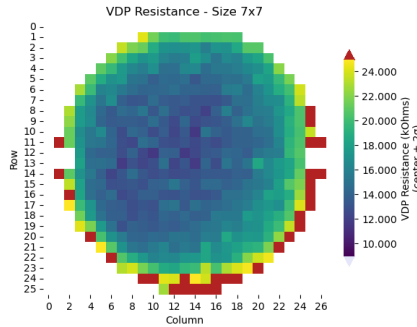
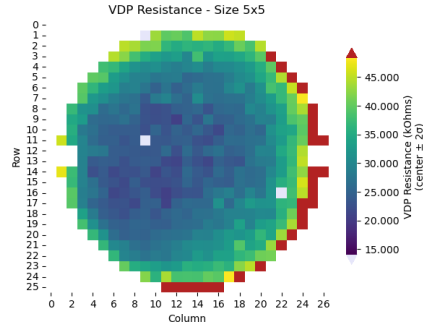
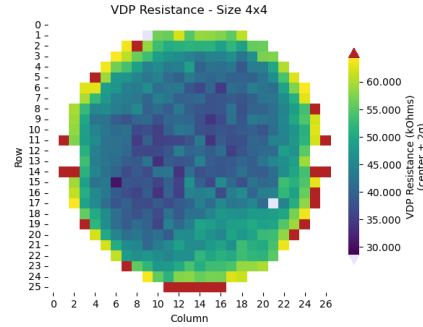
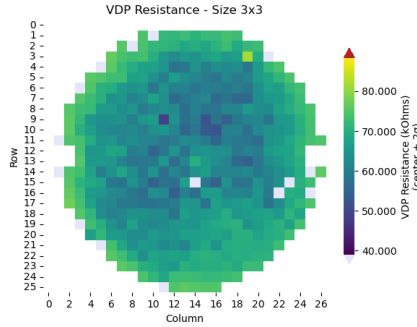


RT measurements – two oxidation steps

Improper to put on same plot but good to give an idea





RT measurements – four oxidation steps



Next steps

- mK measurements of multi-ox JJs
- Push down the size of DWL JJs while try to increase the oxidation dose close to saturation
- Finalize a transmon design based on the above passages

Other devices

- JPAs 
- JJ arrays resonators (fabbed to be measured soon)
- J-TWPAs in collab with 

Thank you!!