LTD-17

The Path to Achieving High Optical Coupling for HIRMES

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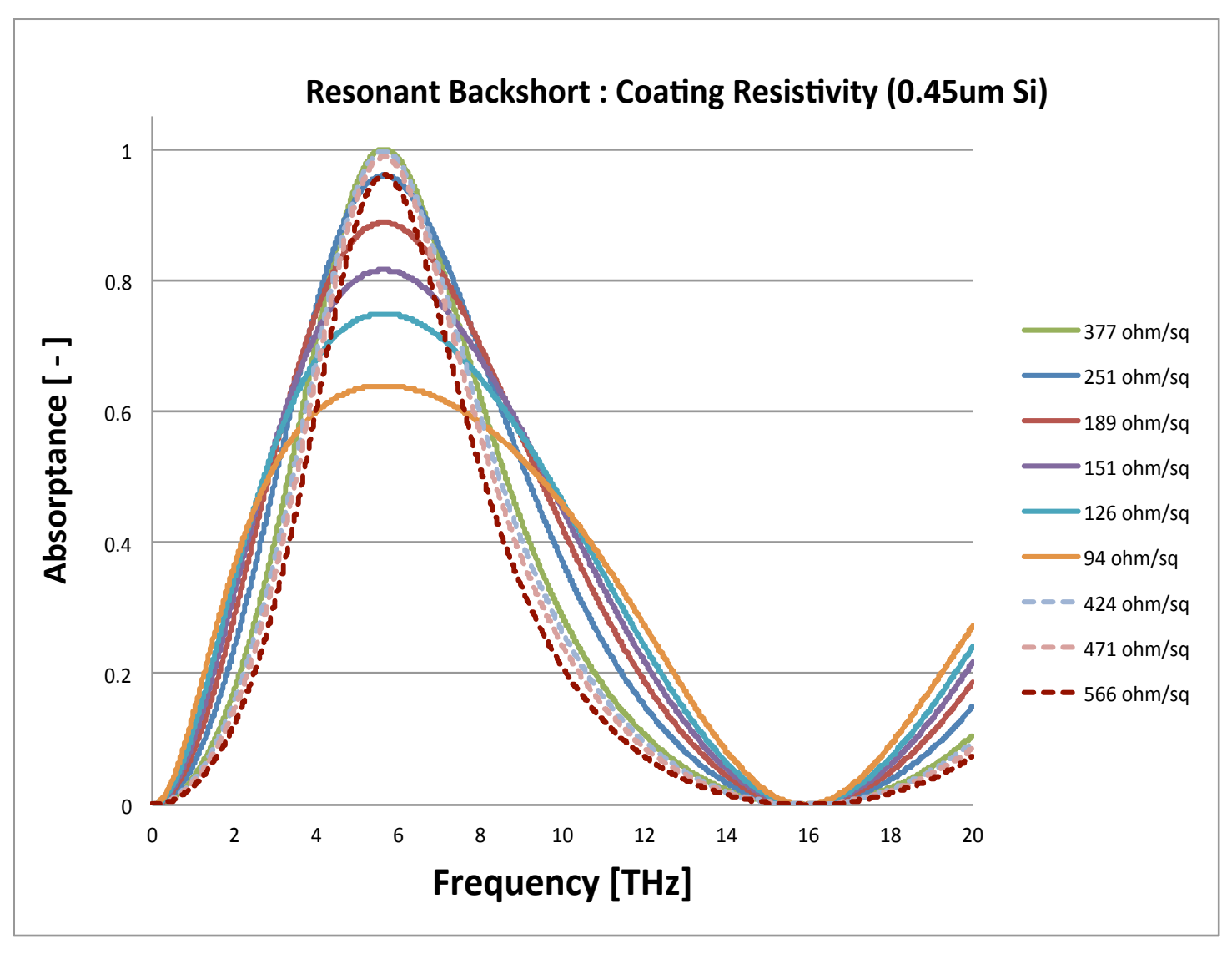
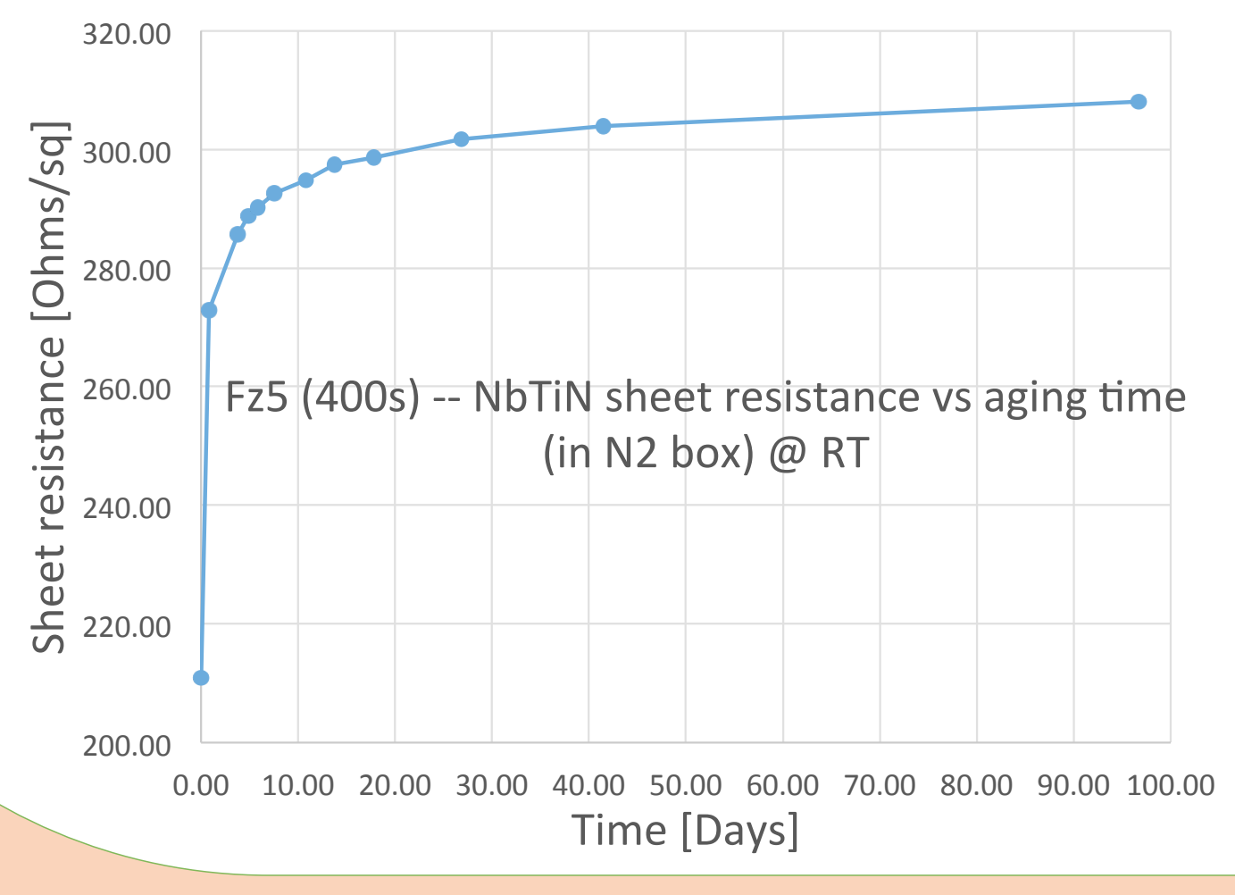
The high resolution mid-infrared spectrometer (HIRMES) is a high resolving power (R~100,000) instrument operating in the 25-122 micron spectral range and has two absorber-coupled transition edge sensor (TES) bolometric detector cameras. The detector pixels on one camera, the high resolution detector array, will be optically coupled to a quarter-wave backshort. Consequently, in order to achieve high optical efficiency, the absorber-coupled detector pixels need to be flat to within lambda/10. We have developed novel NbTiN low stress coatings and have demonstrated that the 1.4 mm x 1.7 mm optically active region on the 450 nm thick Si high resolution detector pixels is flat to within 5 microns, and these coatings have the required optical impedance across HIRMES operating band. Furthermore, these coatings have a superconducting transition temperature ~ 10 K, which allows them to simultaneously serve as an absorber in the desired signal band and a reject filter at long wavelengths. This attribute makes these coatings especially attractive for ultrasensitive absorber-coupled bolometric detector applications, because it decreases optical loading from out-of-band radiation.

ABSORBER COATINGS

High-Res Design

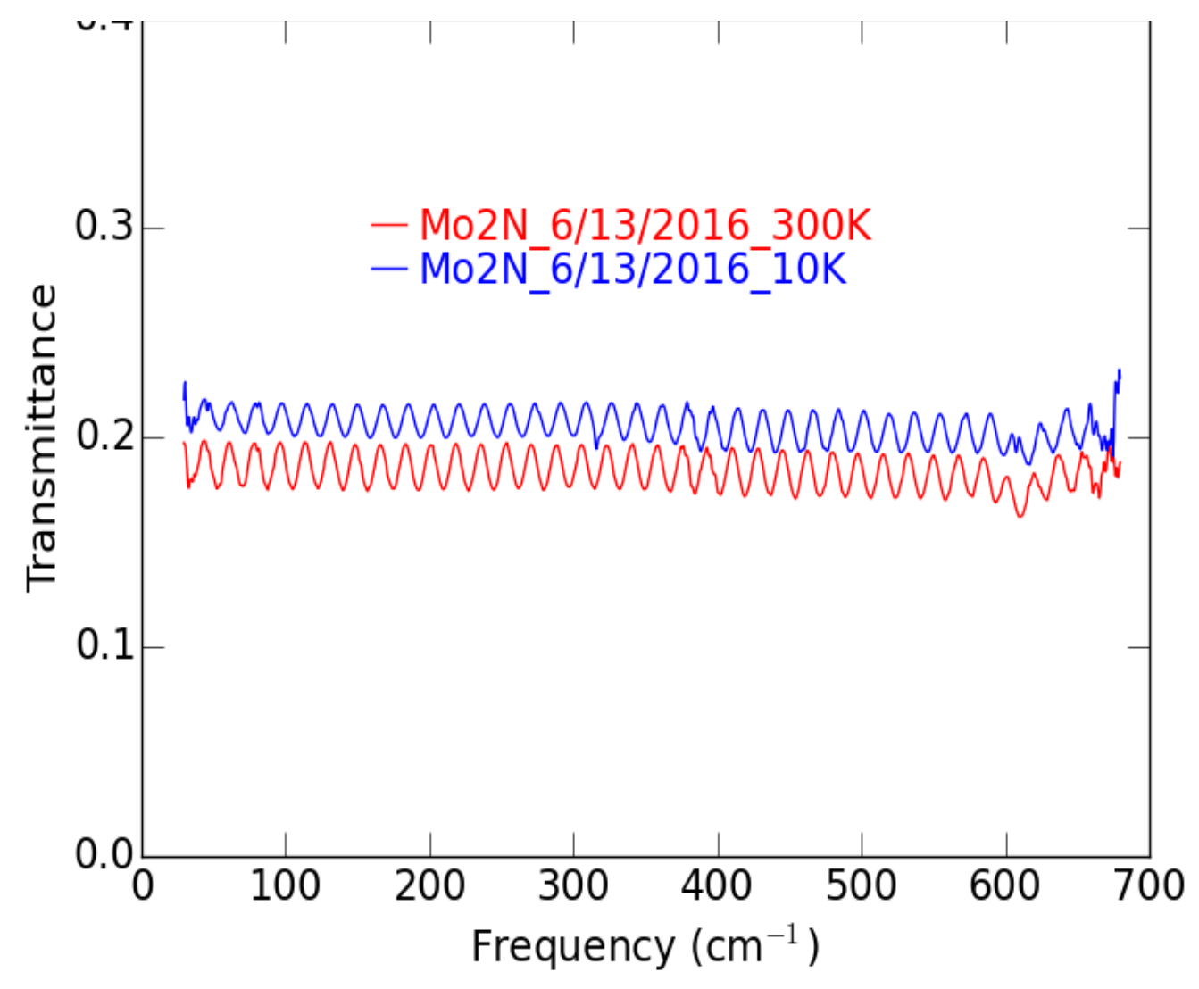
The absorber material chosen for the High-Res Design is NbTiN. This material has a wide range of sheet impedance that can be used to obtain high optical efficiency over the range of bands for this detector. This relaxes requirements on process control. This material is also stable for long periods as shown in a 100 day study.

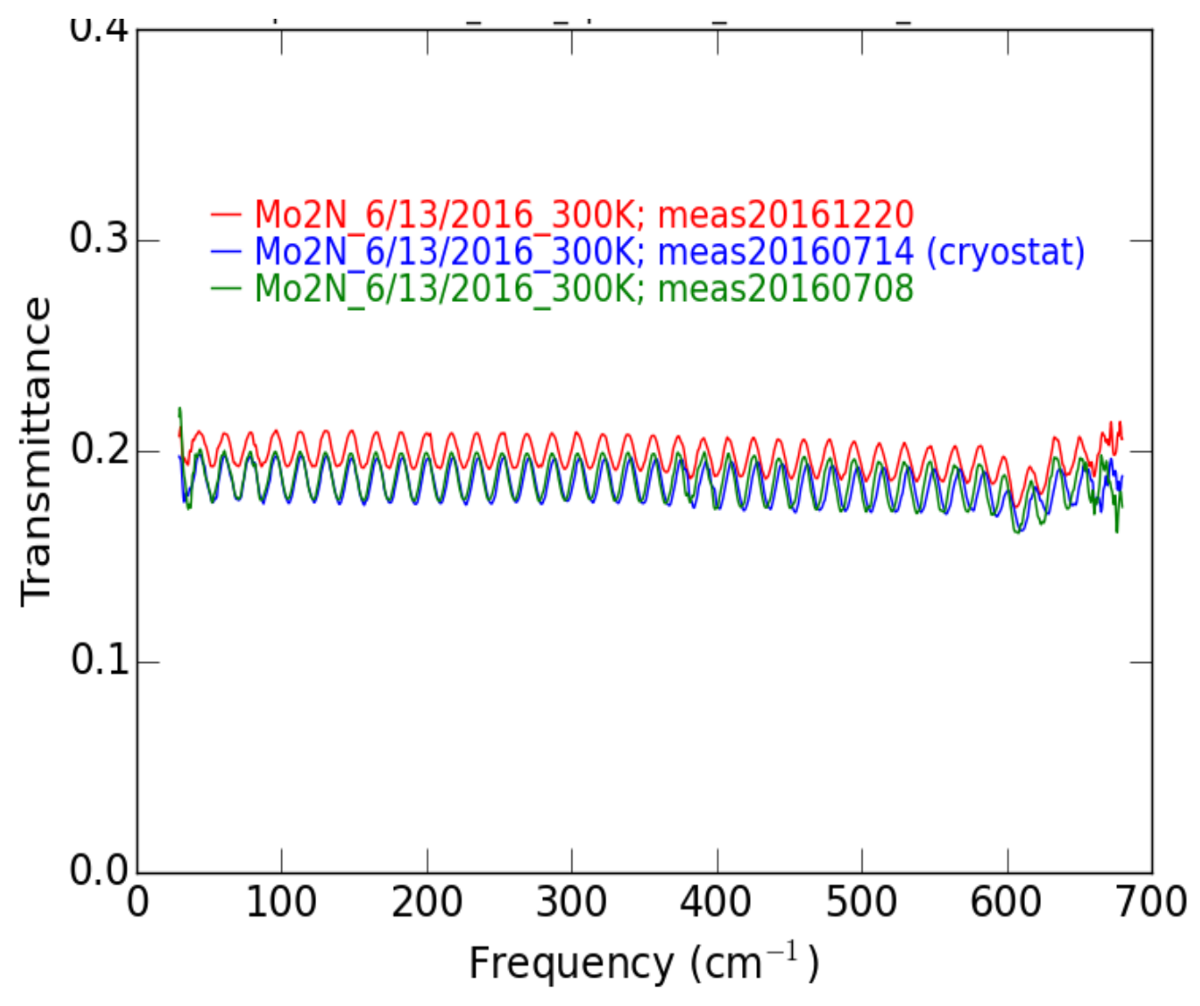




Low-Res Design

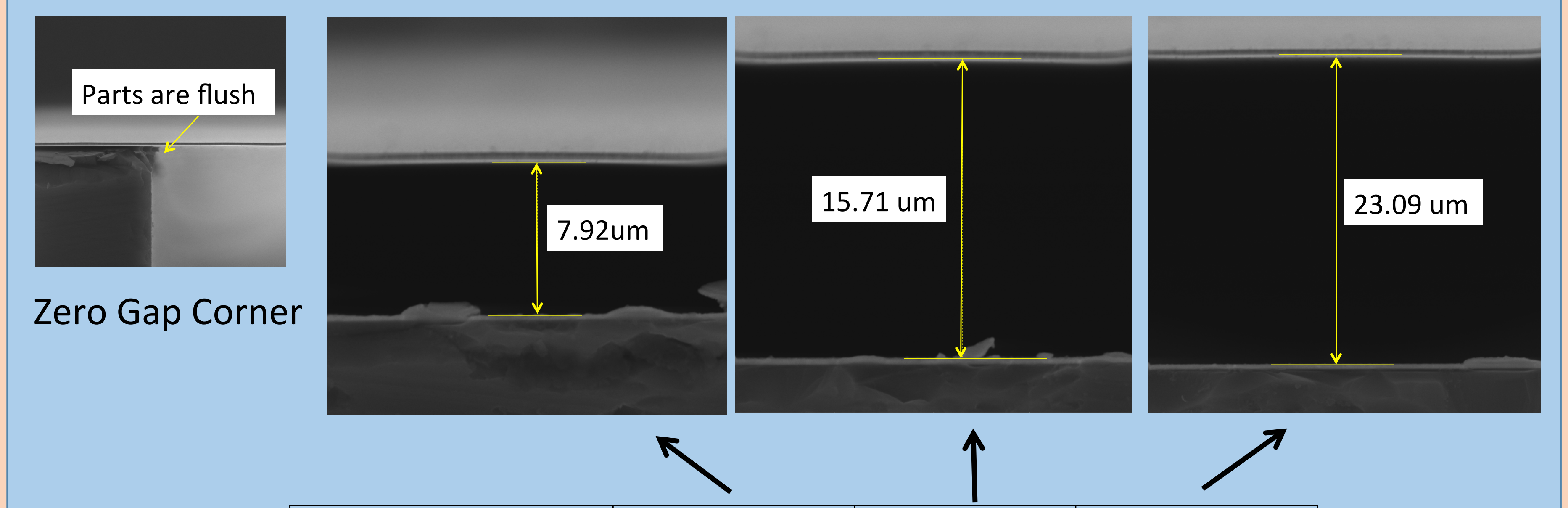
The absorber material chosen for the Low-Res Design is Mo_2N. This material has been proven to be weakly susceptible to aging and can be easily reproduced. Transmittance data over the working bands was obtained using Fourier Transform Spectroscopy at 300K and 10K.





GAP VERIFICATION WITH SEM

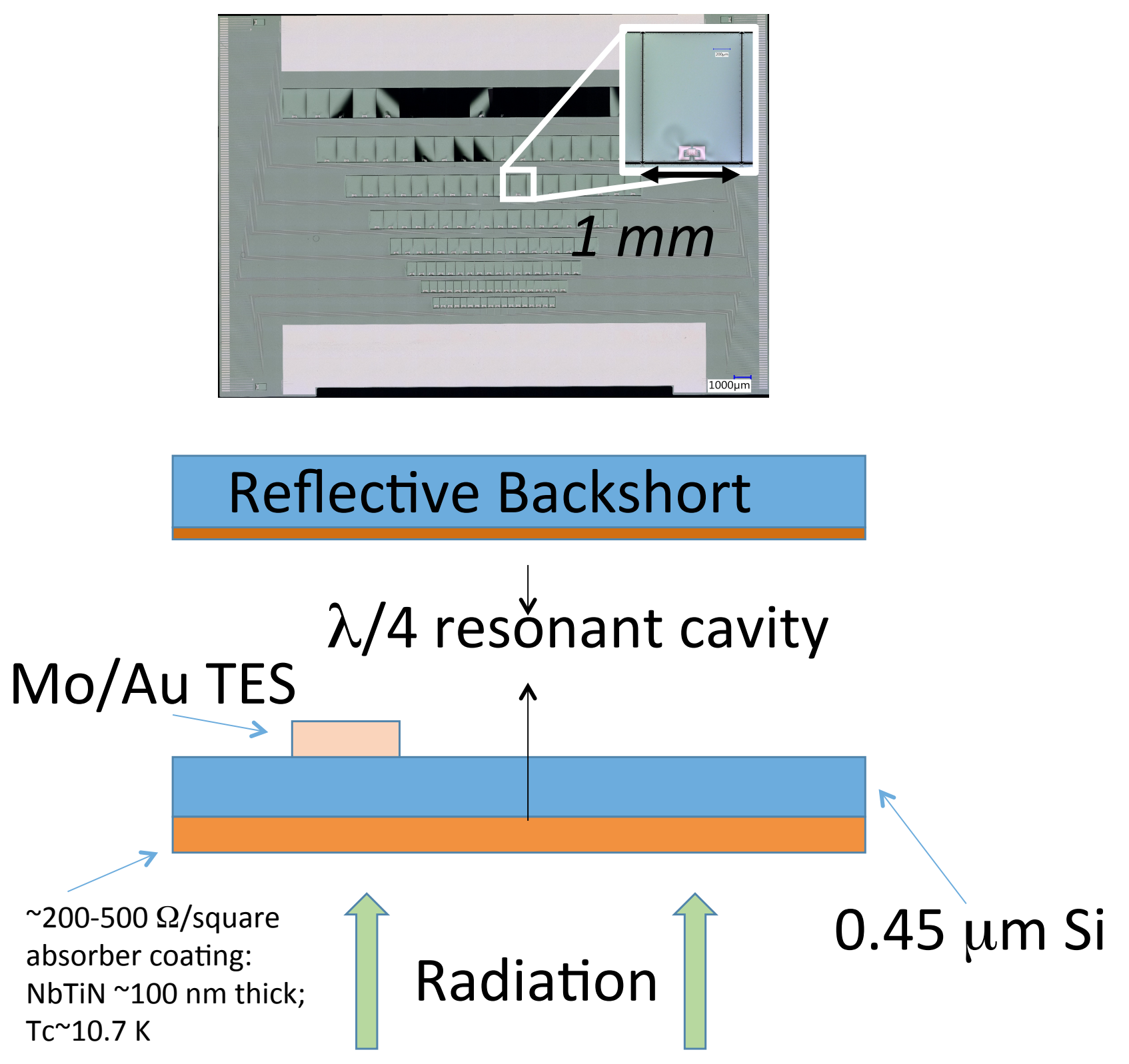
Cross-sectional images and measurements taken with 1 degree of tilt on a TESCAN VEGA-3 SEM with the sample mounted vertically.



	A GAP	B GAP	C GAP
Design Value	7.5	15	22.5
Measured Value	7.92	15.71	23.09

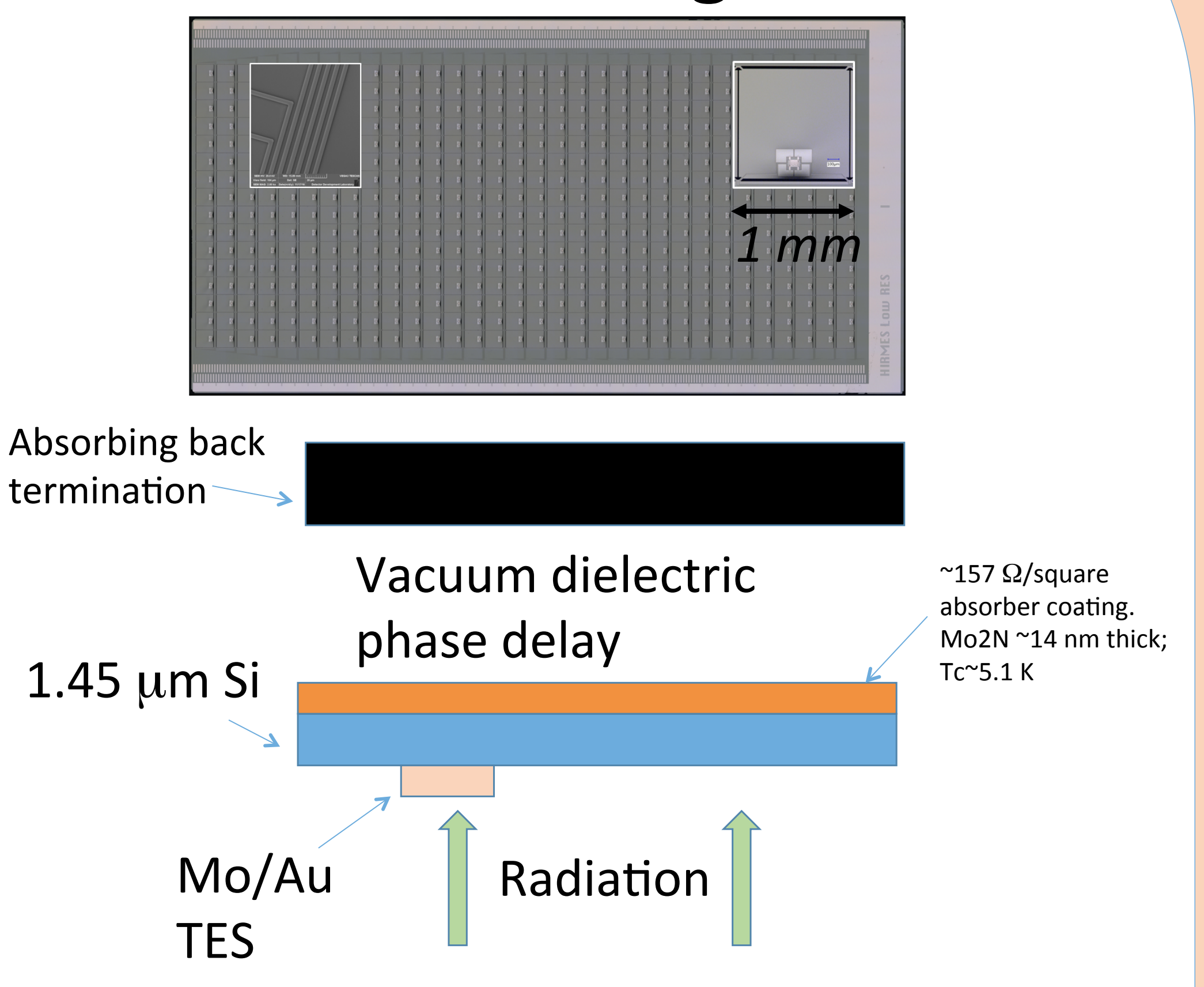
OPTICAL COUPLING DESIGN

High-Res Design



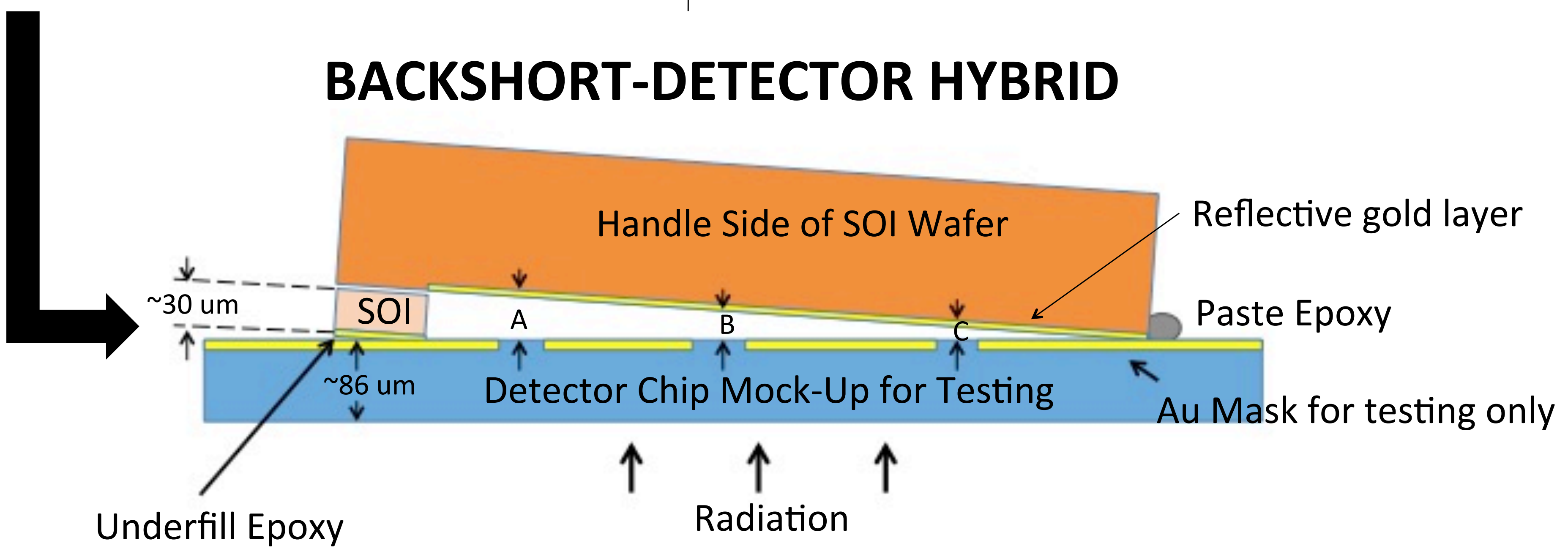
Each ROW in the High-Res Design targets a different waveband – thus a wedged backshort is required to achieve high optical coupling at each wave band.

Low-Res Design



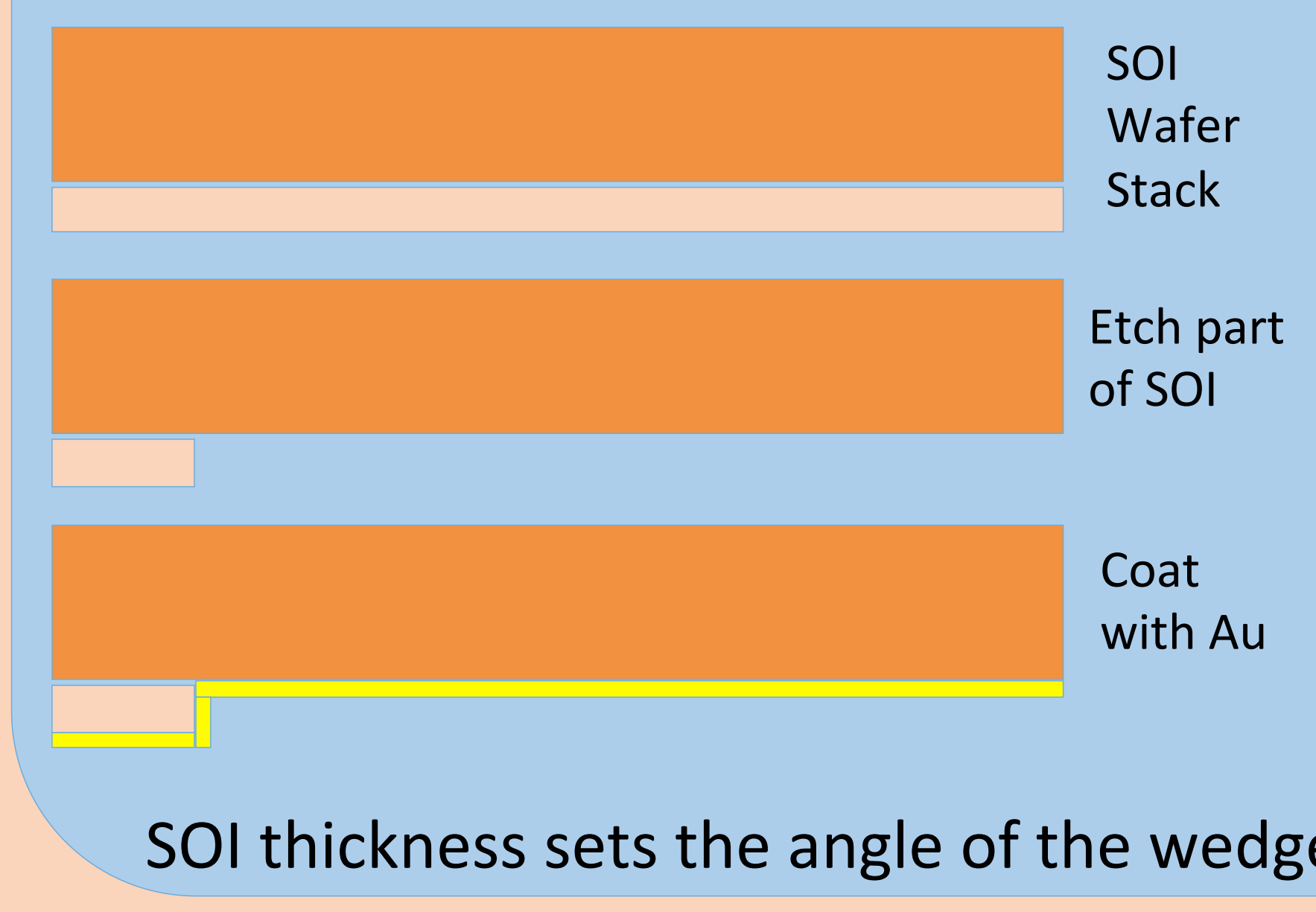
The Low-Res Design is uniform, so the coupling design is straight forward.

BACKSHORT-DETECTOR HYBRID

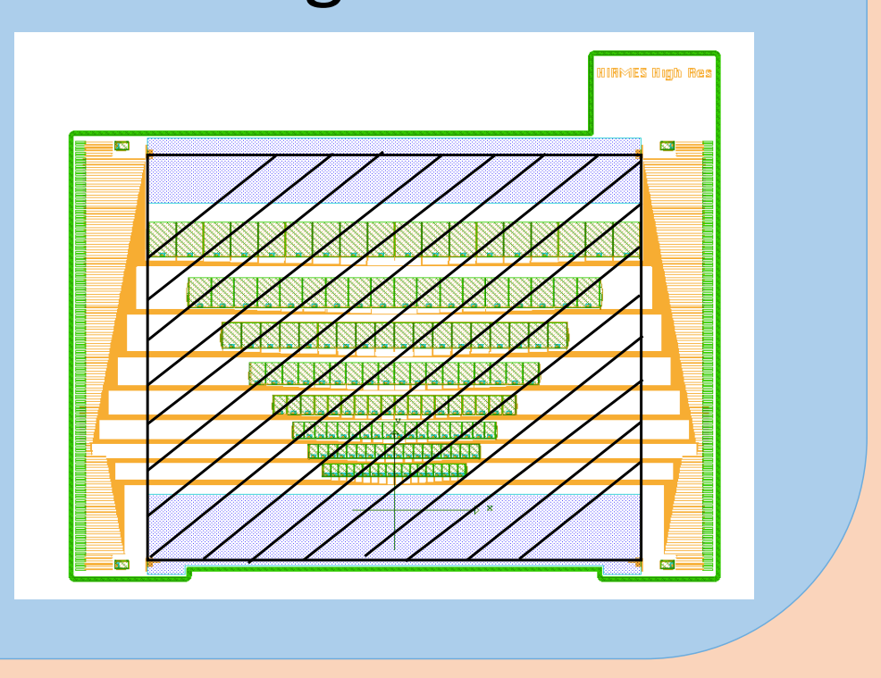


- Developed a process for fabricating and hybridizing a reflective back short that enables a two-fold increase of the optical efficiency with minimal fabrication complexity.
- The mock up shown allowed for assembling and testing parts to verify the gaps required at positions labeled A, B and C.

SIMPLE FAB AND HYBRID ASSEMBLY



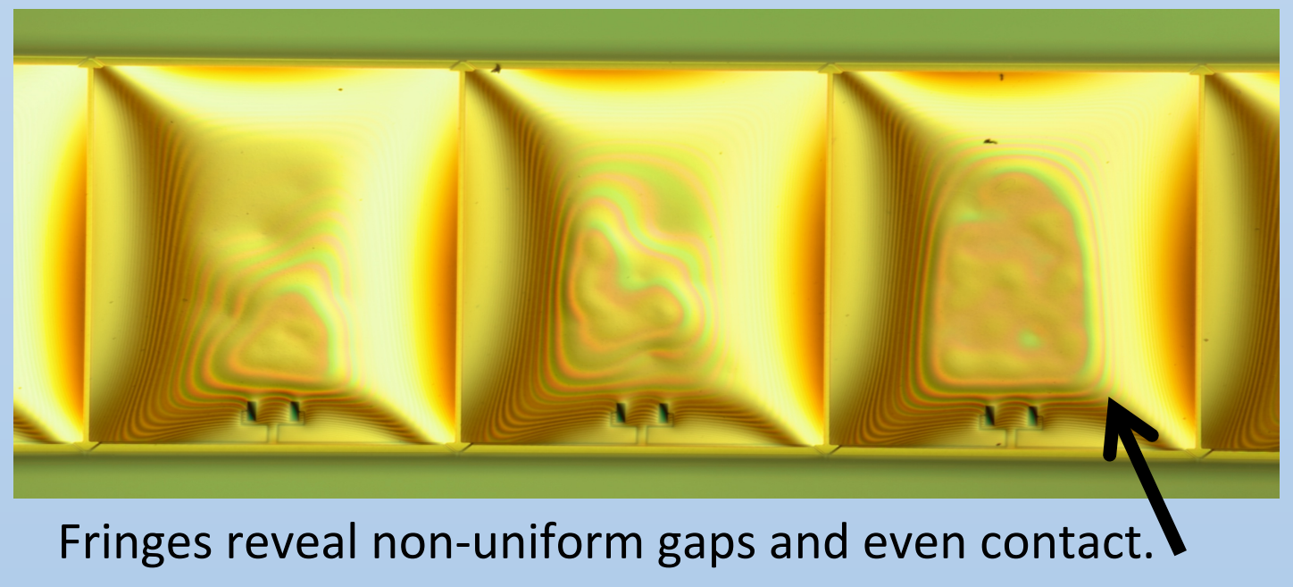
The backshort (hatched area below) is placed on the detector using a Finetech Fineplacer pico-ma, which allows for alignment and force control. Epoxies are placed with a single hair brush while force is applied.



SOI thickness sets the angle of the wedged backshort.

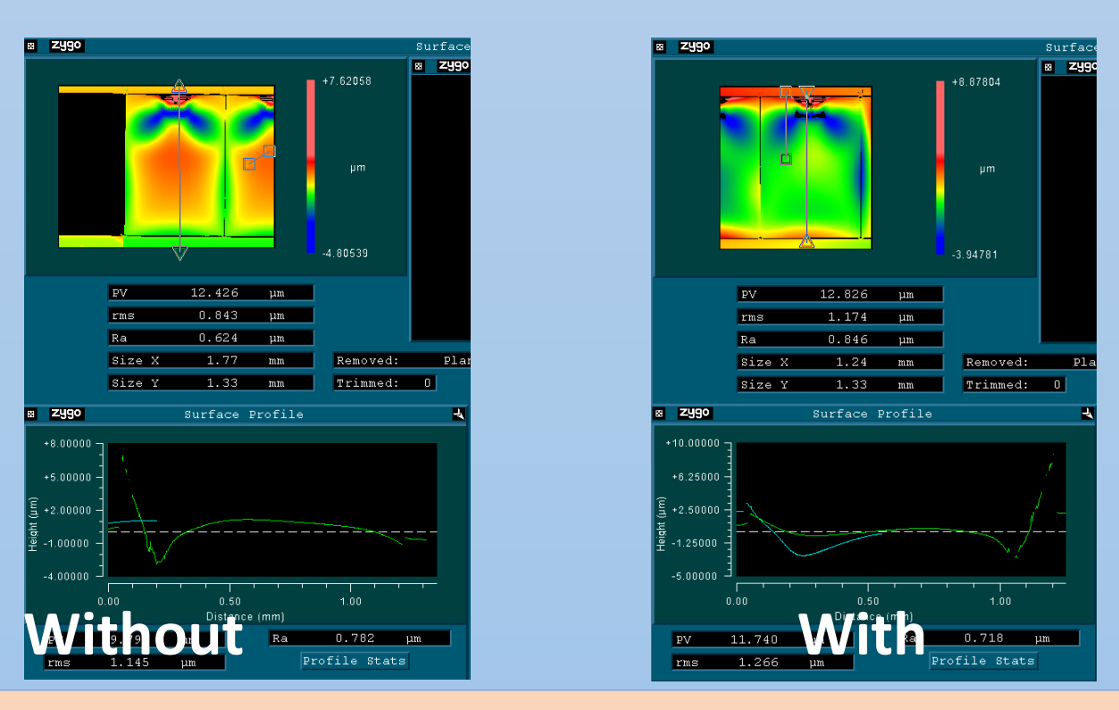
FUTURE CHALLENGES

- The shortest gaps can result in the membrane getting stuck against the reflective backshort. We believe this is likely due to static forces and are actively pursuing surface treatments to minimize this effect.



Fringes reveal non-uniform gaps and even contact.

- The bowing of membranes with and without absorber, as seen at right from Zygo interferometer measurement, is not expected to be the root cause as low curvature is seen.



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