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Anti-reflection Coatings to Improve the Optical Quantum Efficiency of MKID Arrays

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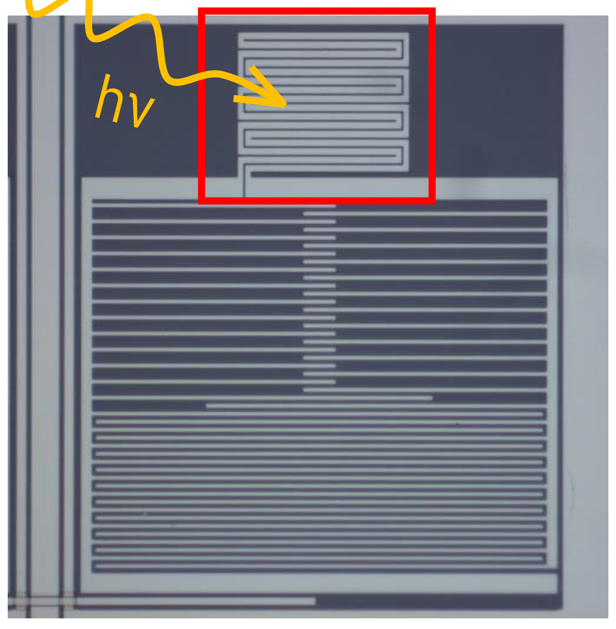
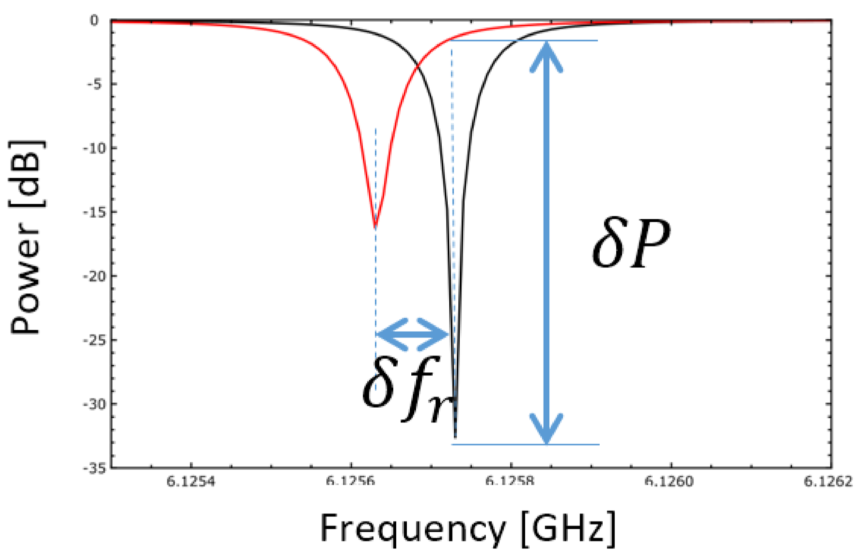
MOTIVATION

The **kinetic inductance effect** causes incident photons to change the surface impedance of a superconductor

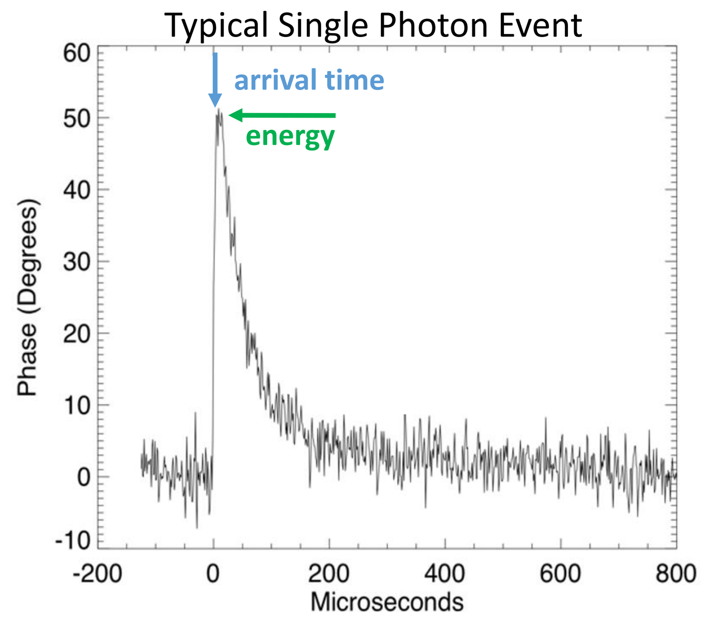
Response of a Patterned Superconducting MKID Resonator

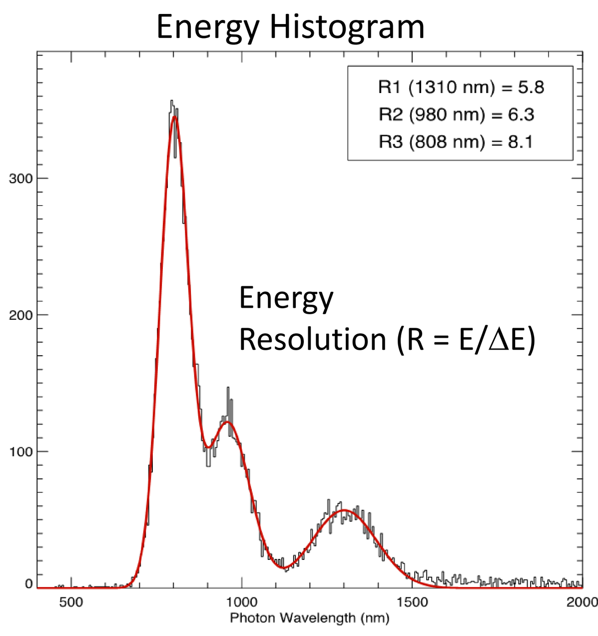




Inductor (high current density) is the sensitive element of the MKID pixel

Monitor the change of its resonant frequency in response to a photon event

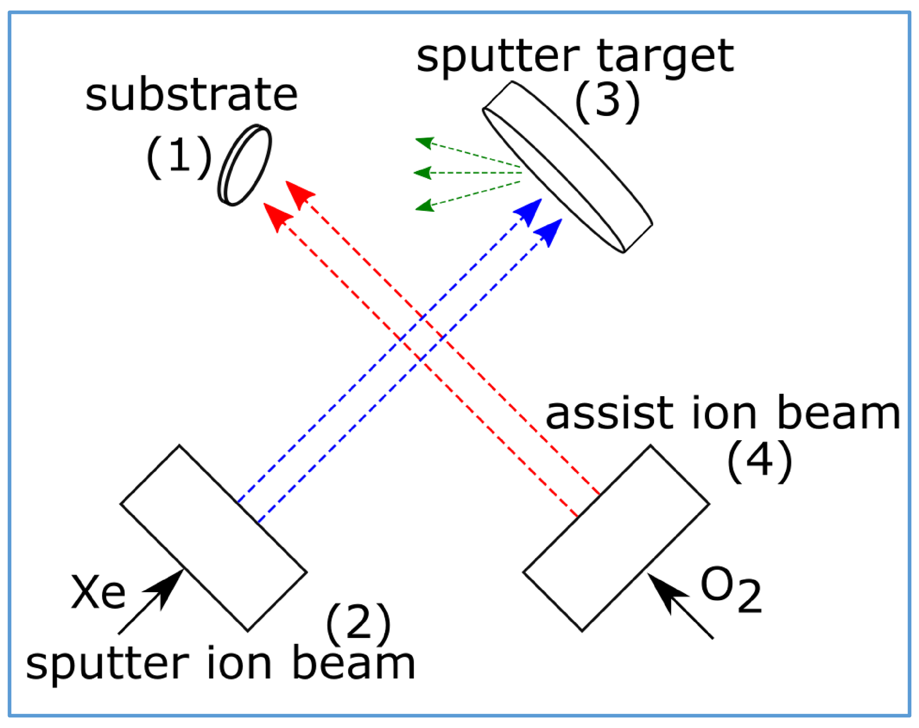




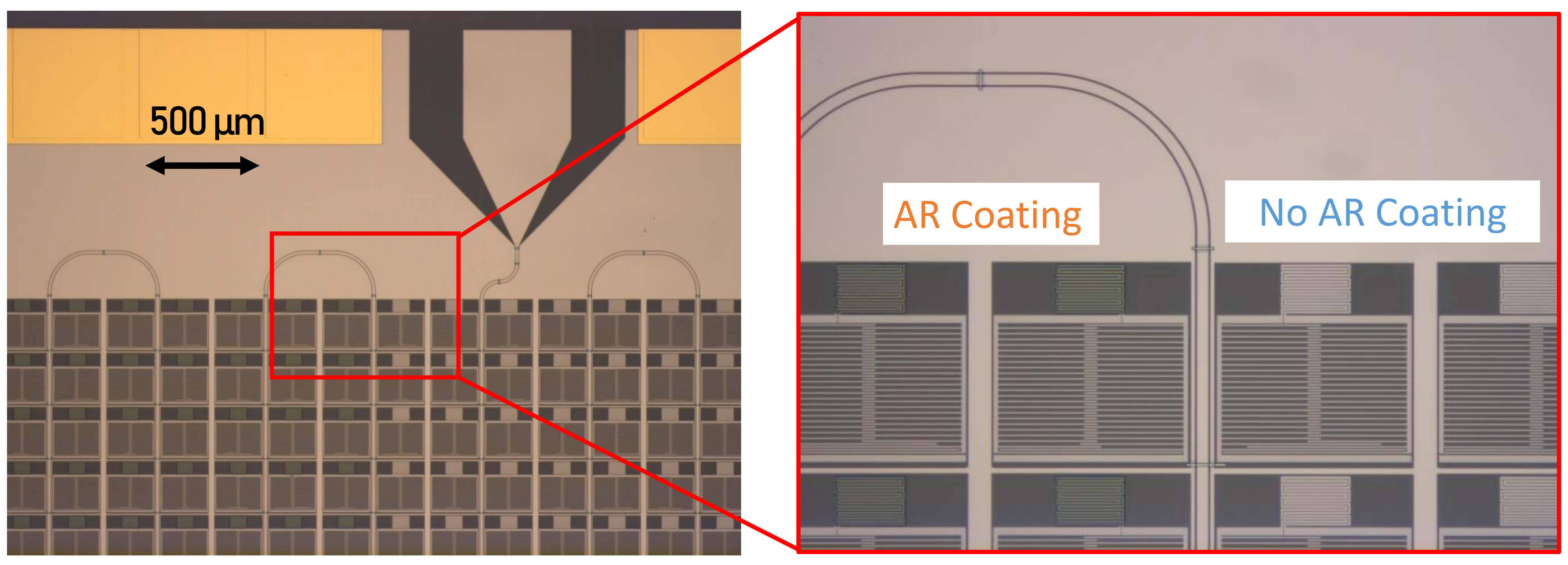
The main goal of the anti-reflective (AR) layer is **to maximize the absorption of photons in the inductor** by lowering its reflectance. This is done by creating destructive interferences for the reflected light and constructive interferences for the transmitted light.

FABRICATION PROCESS

Ion Beam Assisted Sputter Deposition (Veeco Nexus IBD-O)



The substrate (1) is tilted and rotating. The "depo" ion beam source (2) is focused on the sputter target (3). Sputtering of the Si or Ta particles is done using a Xe ion-beam. The "assist" ion beam source (4) oxidizes the film.



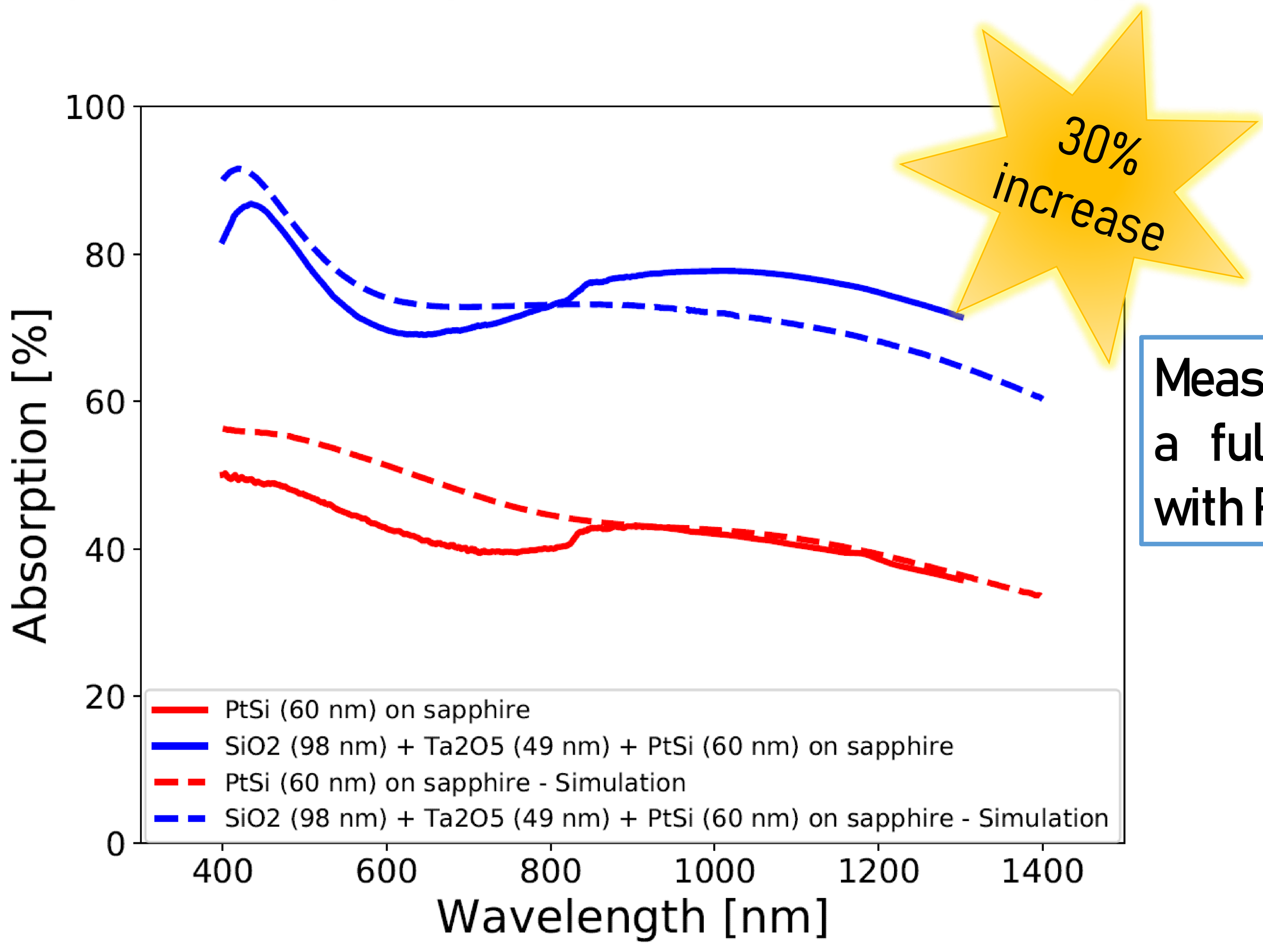
*Optical coating is the last step of the array fabrication process

RESULTS

Analysis Methods:

→ Determine optical constants (n & k) of the metal with ellipsometry
→ Simulate films using TFCalc software
→ Optimize SiO_2 and Ta_2O_5 thicknesses to maximize absorption in the 400-1400 nm range
→ Measure the absorption of the finished AR coating with a spectrometer

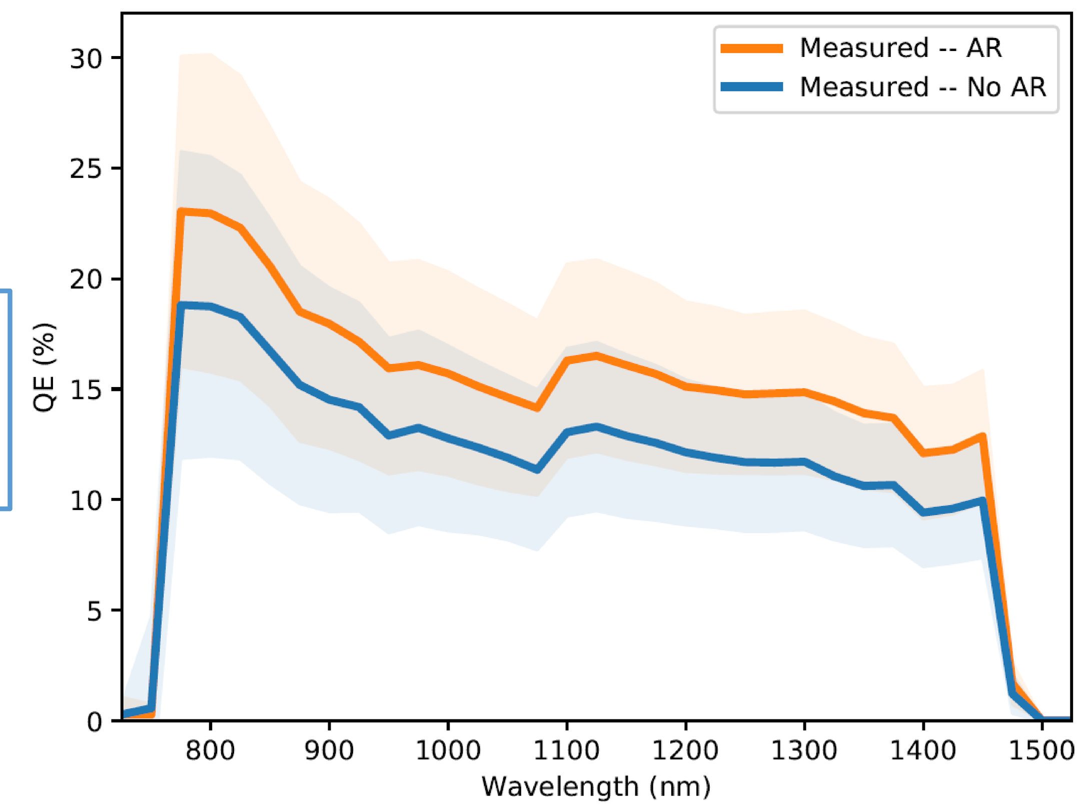
Optimized film thickness was found to be **98 nm of SiO_2** and **49 nm of Ta_2O_5** deposited on top of a platinum silicide (PtSi) film + sapphire



Measurement made on a full sapphire wafer with PtSi + AR coating

SiO_2 /Ta_2O_5 AR Coating on a Patterned MKID Array

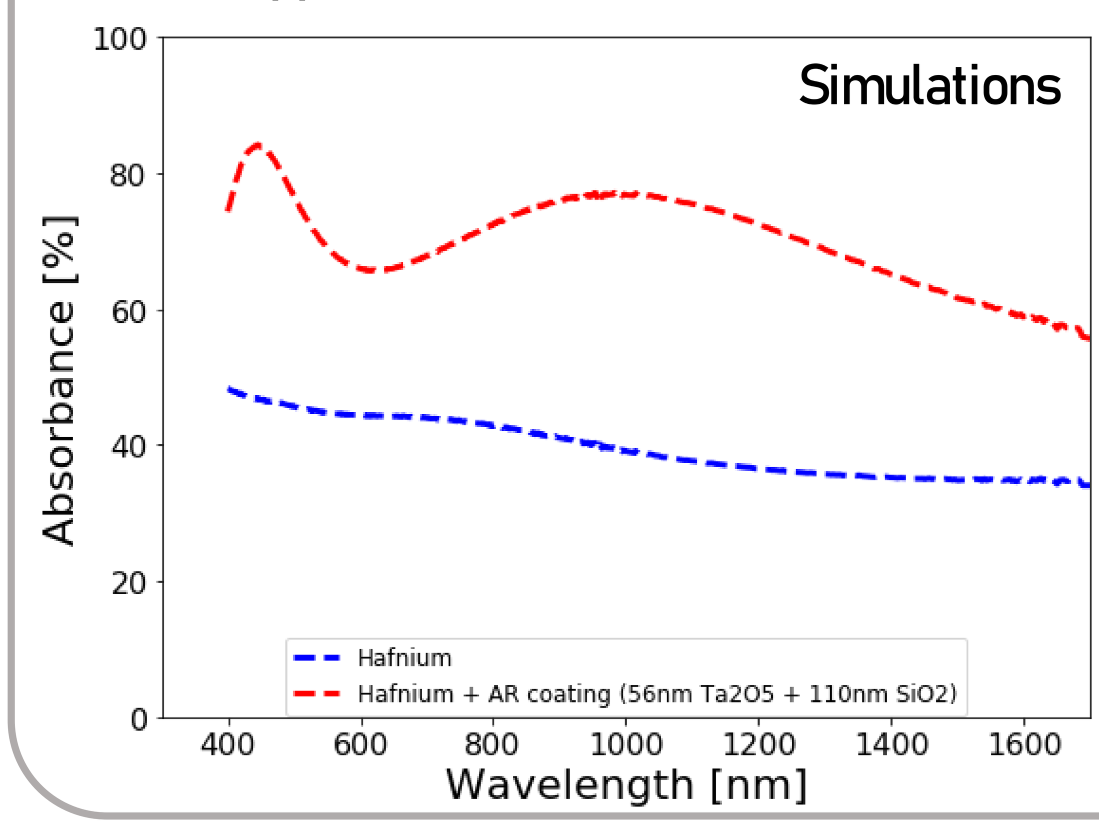
Only half of the MKID array has been coated with the AR layer for direct comparison



The Quantum Efficiency (QE) measurement is lower than our expectations
→ indicates extra loss in the system, possibly due to bad microlens alignment

MKID Arrays using Hafnium (Hf) Thin Films

Optimized film thickness was found to be **110 nm of SiO_2** and **56 nm of Ta_2O_5** on a Hf film + sapphire



A 30% increase in the absorbance is expected in the instrument bandwidth

CONCLUSIONS

→ A bi-layer of SiO_2/Ta_2O_5 (98 nm and 49 nm, respectively) deposited on top of the photosensitive PtSi inductor of the MKID increases the QE by roughly 30% in the instrument bandwidth
→ The same performance should be achievable with Hf based MKIDs
→ High QE, 20, 000 pixel arrays to be fabricated soon

18th International Workshop on Low Temperature Detectors

July 21st – 26th 2019, Milano