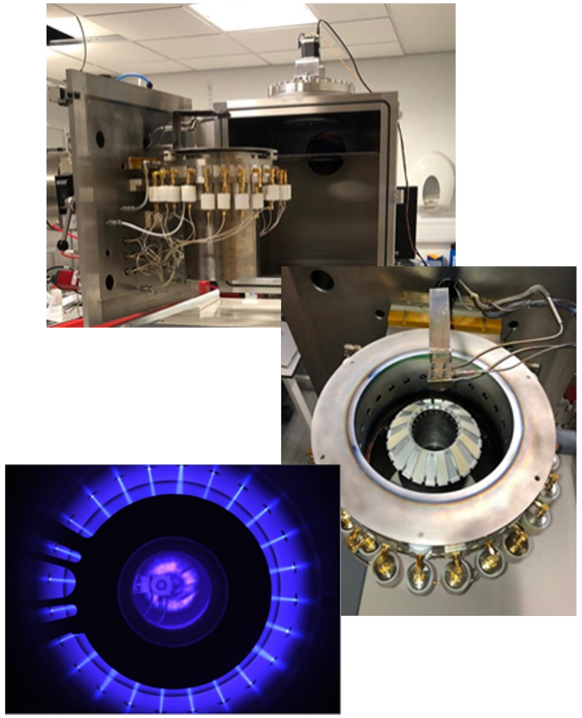
THE UNIVERSITY OF STRATHCLYDE

aSi and SiNx results update University of Strathclyde/Glasgow

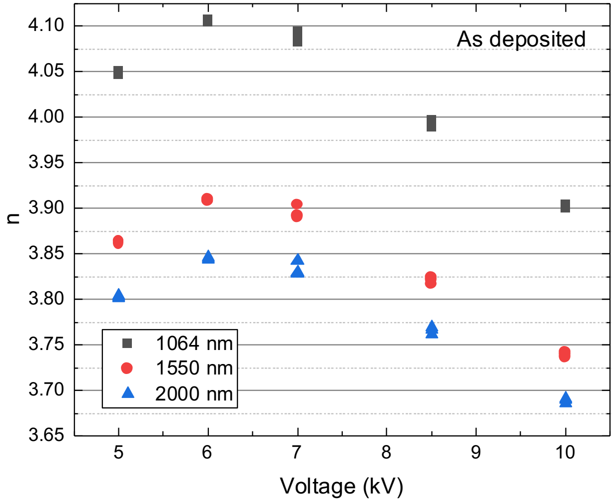
[M. Ben Yaala, G. Wallace, C. Gier, K. Craig, M. Fazio, I. Martin, S. Rowan, J. Hough, S. Reid]

aSi deposited by high energy ECR-IBD

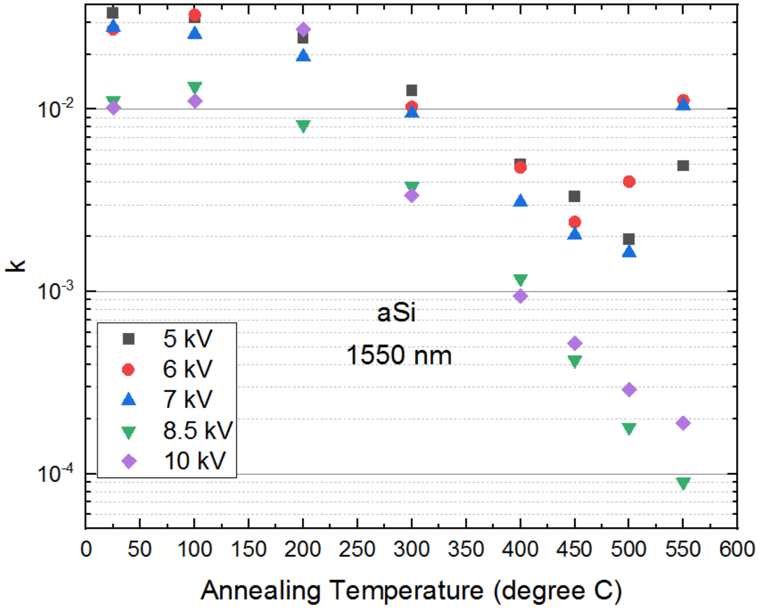
From last update



high-energy 24-beam ECR (microwave) ion beam deposition



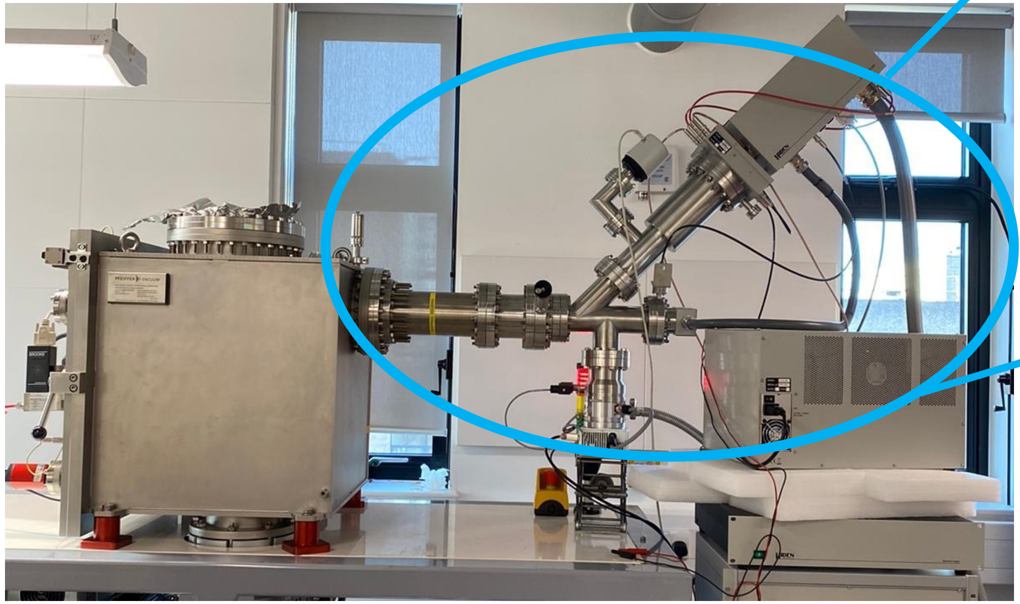
Optimum energy for high density
(densification Vs relaxation?)

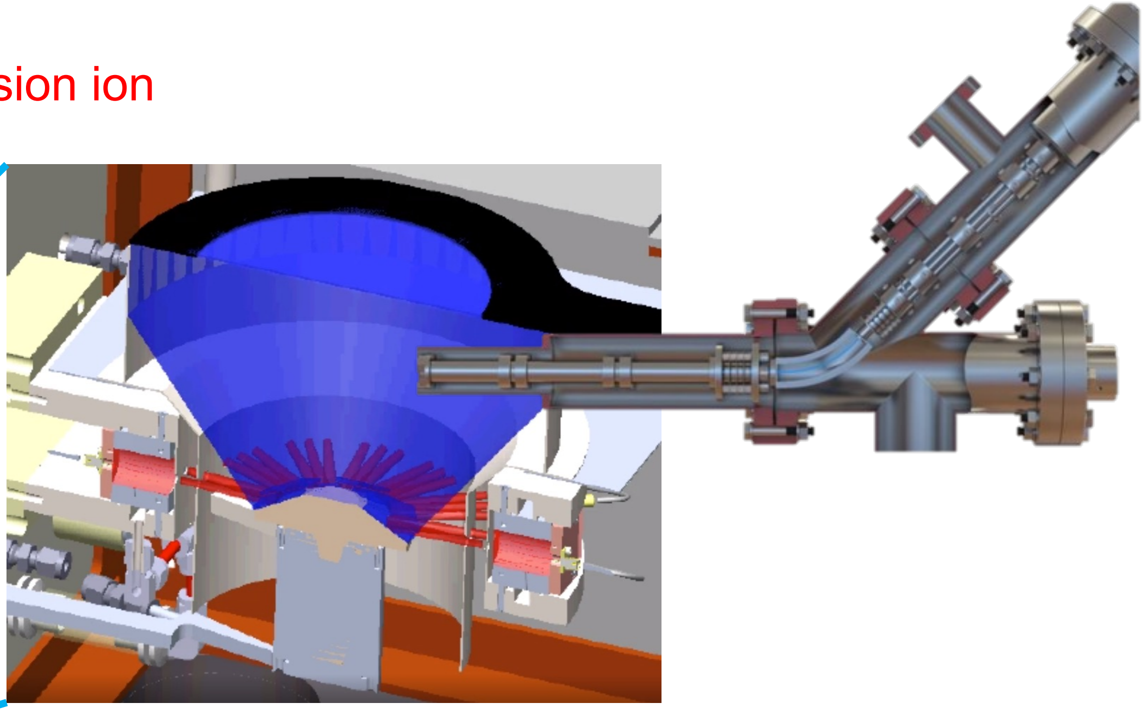


One of the keys for low abs is the high
beam energy (+slow deposition rate?)

aSi deposited by high energy ECR-IBD

Advanced EQP system with combined high transmission ion energy analyser and quadrupole mass spectrometer

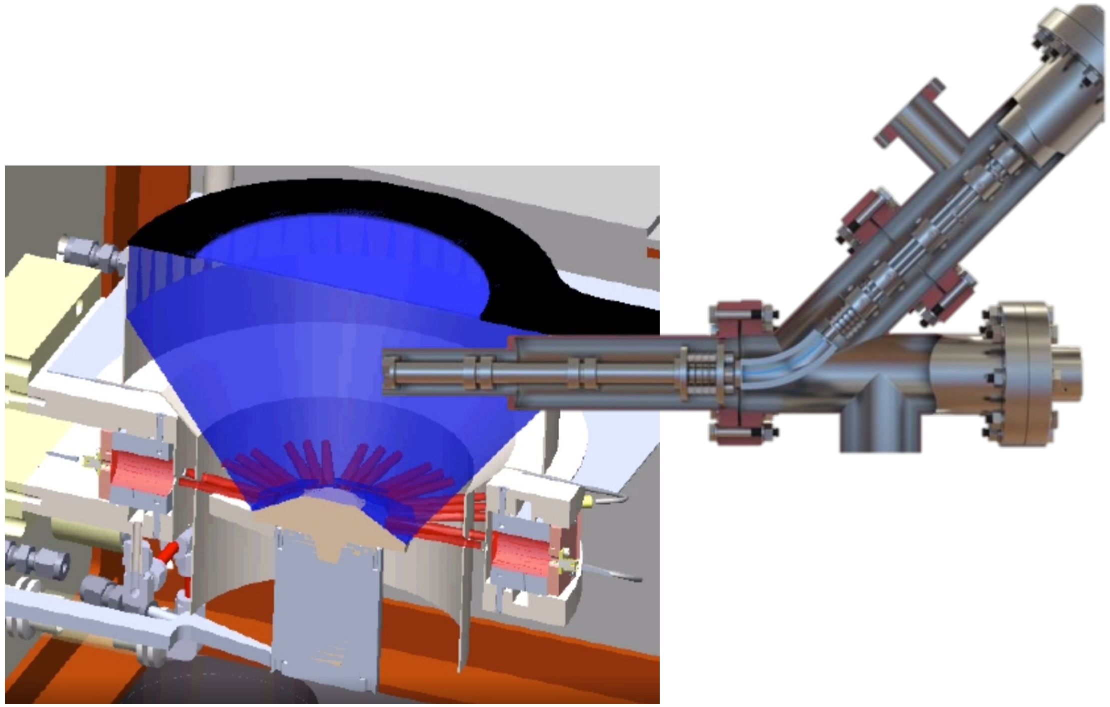


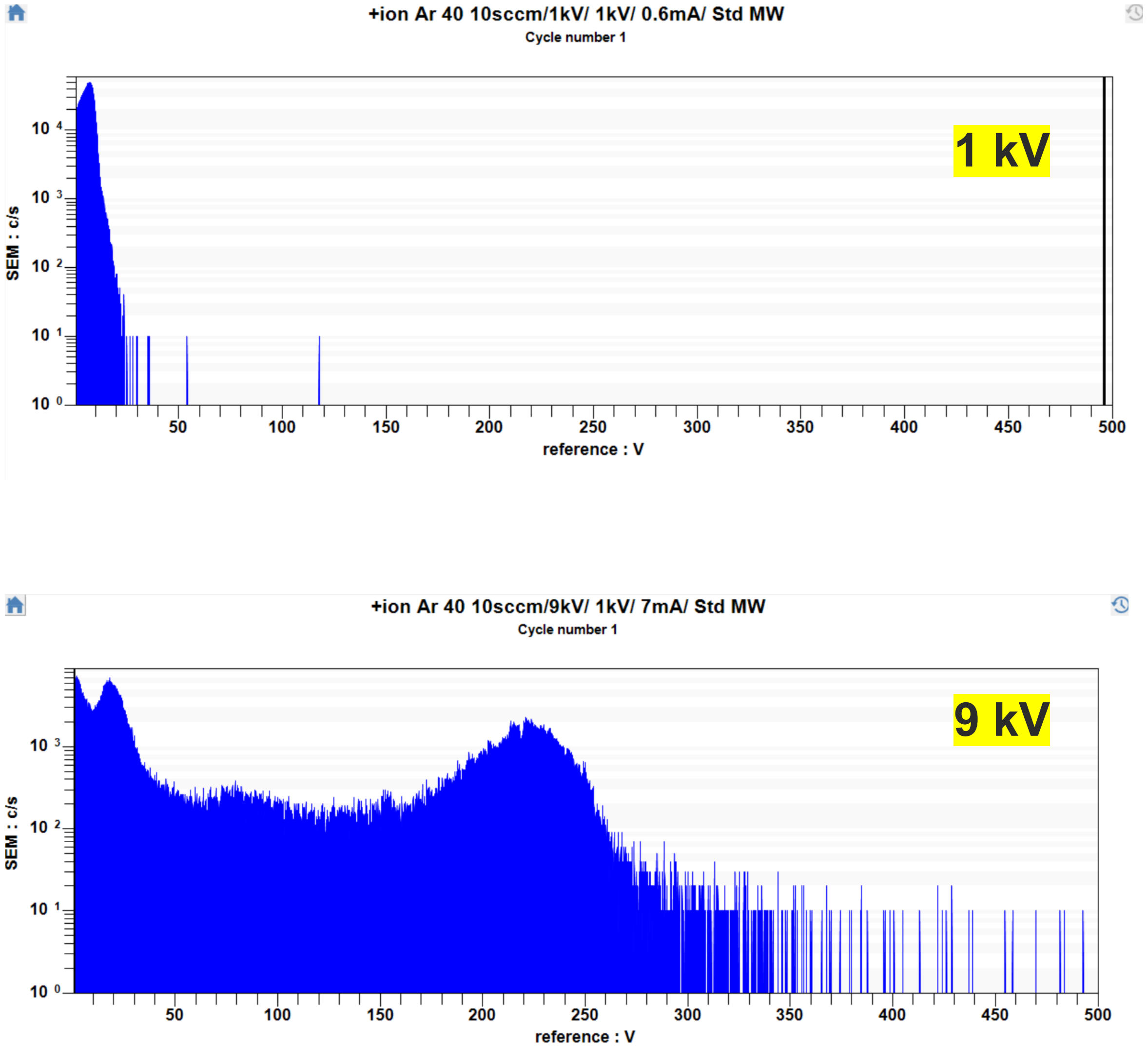


- Direct analysis of plasma ion mass and energy
- For characterising the deposition plume in the ECR systems

=> Correlate plume dynamics (energies, species, charge states) to optical constants of aSi single layers

aSi deposited by high energy ECR-IBD

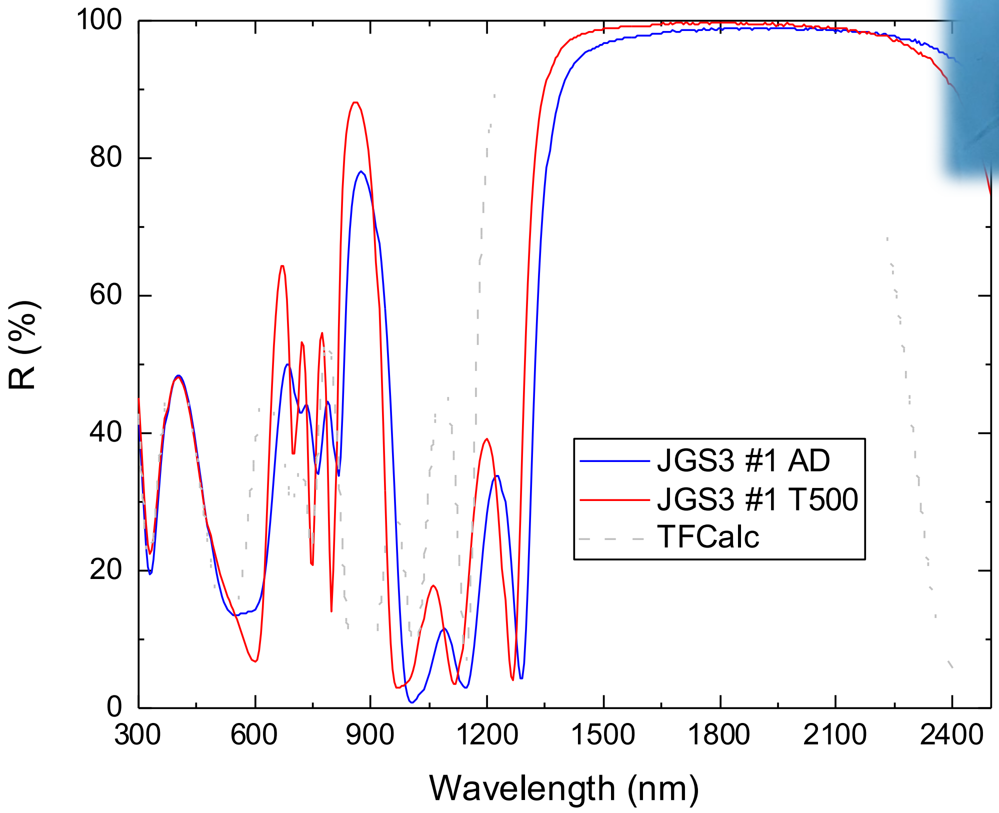




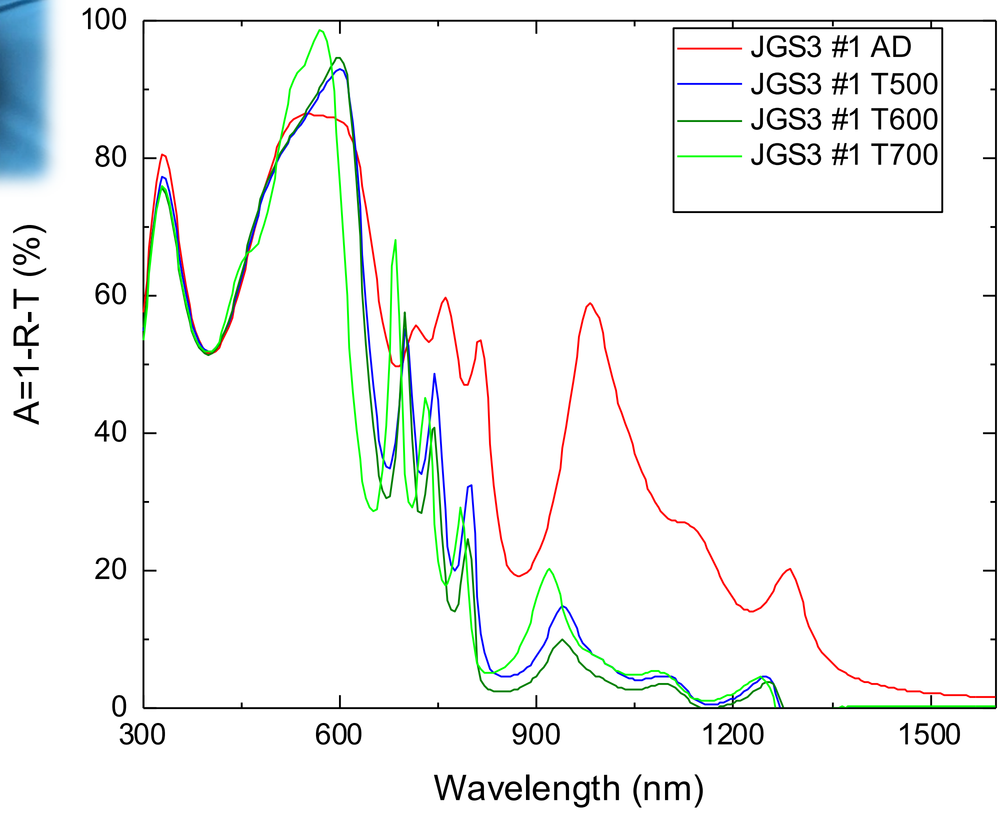
Energy distribution of Ar ions in the sputtering plume

From single layers to HR mirrors

$(HL)^4=(a\text{-}Si/SiO_2)^4$



Annealing for lower absorption



- First HR test successful. ***High R for only 4 bilayers.***
- Maximum *R* not centred around 1550 nm: Thickness error caused by the quartz microbalance inaccuracy for sputtering => ***BBOM will be installed for next HR coatings***

aSi study: what's next?

1/ Establish a correlation between optical properties (mainly absorption) and sputtered species energies/ process parameters

2/Optimise single layer absorption/deposition process/annealing

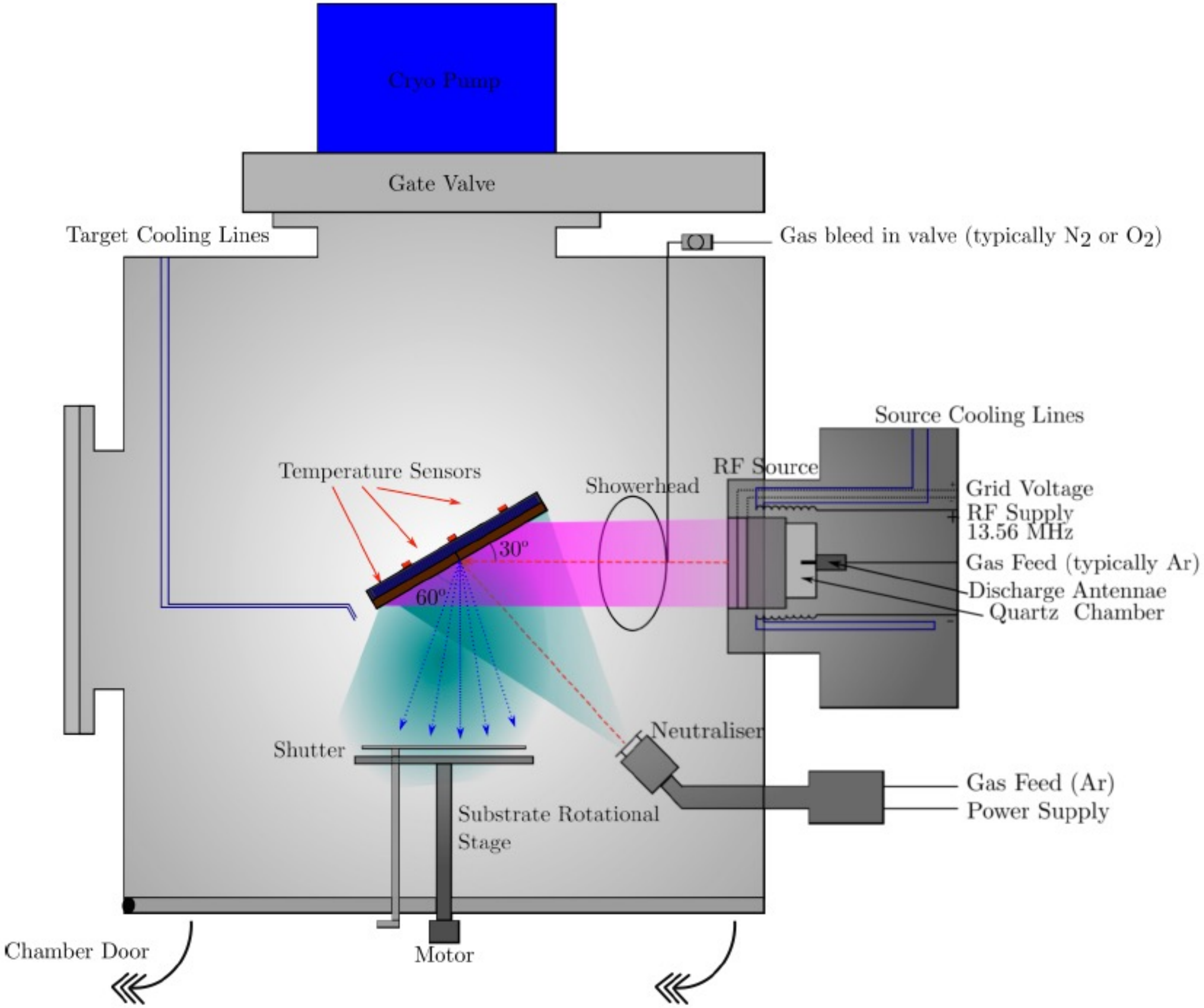
3/ Decrease the absorption by introducing hydrogen for reducing the dangling bonds defects

- Either during the process (atomic H dissociated by the ion beam)
- Or annealing under H_2 atmosphere

4/ HR mirrors fabrication based on previous steps

New furnace (UoS) for annealing under up to 100% H_2 atmosphere up to 1000C

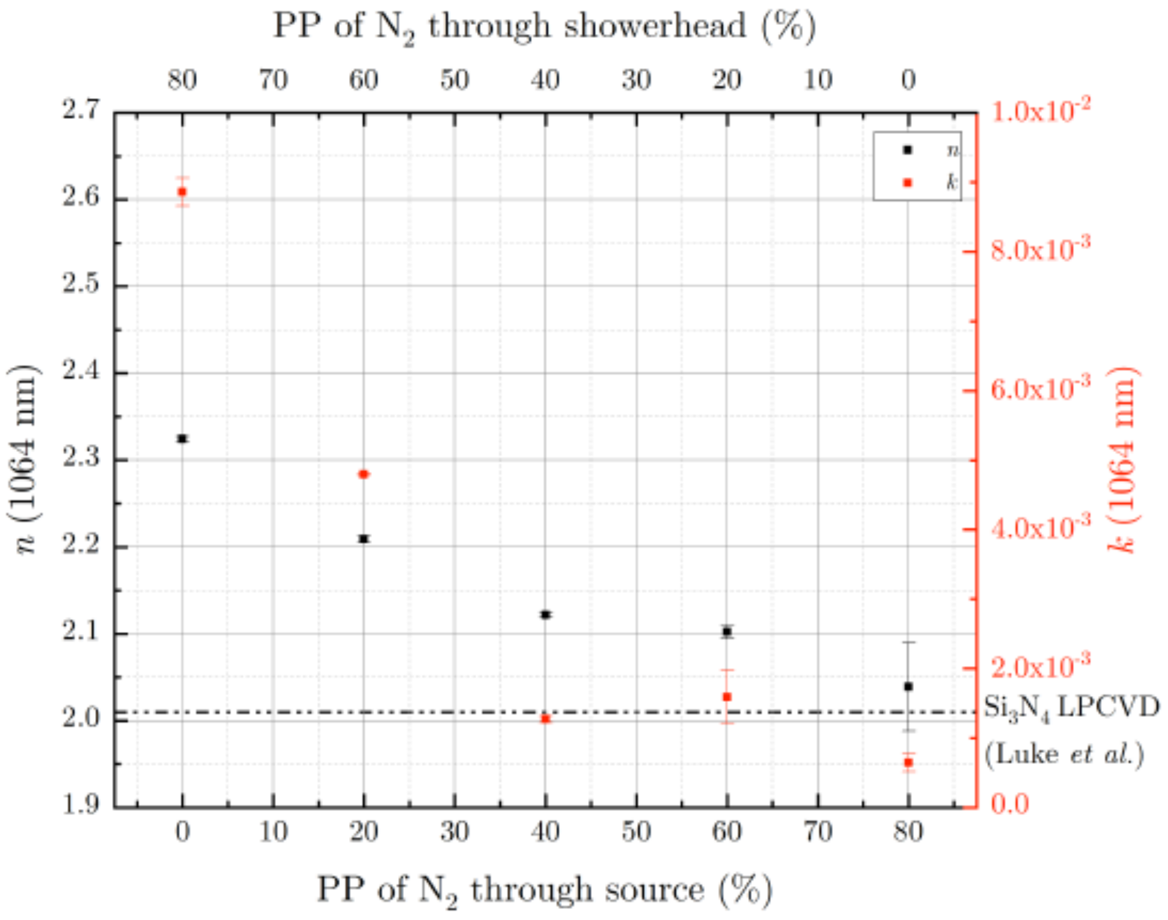
SiNx deposited by RF-IBD



Parameters varied for this study:

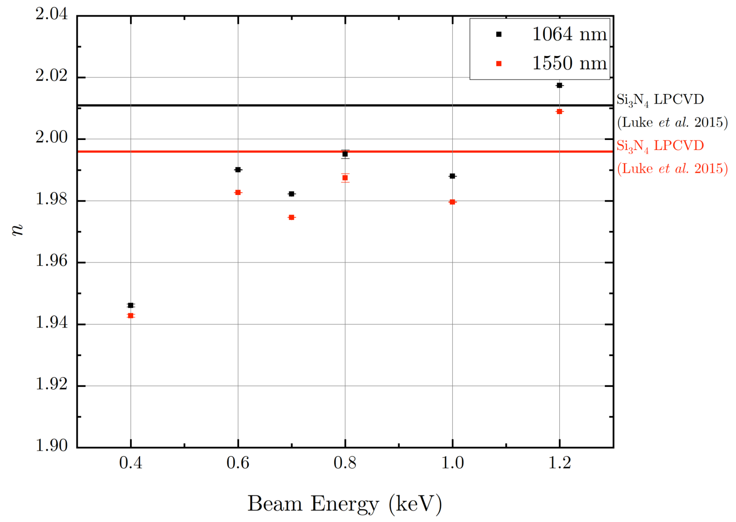
- ion beam energy
- ion beam current
- N_2 sputtering gas pressure (source)
- N_2 reactive gas pressure (showerhead)

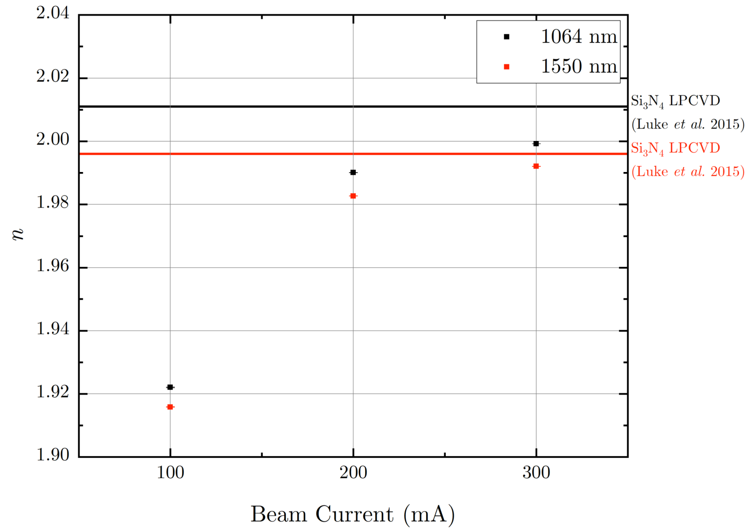
Stoichiometric SiNx (Si_3N_4)

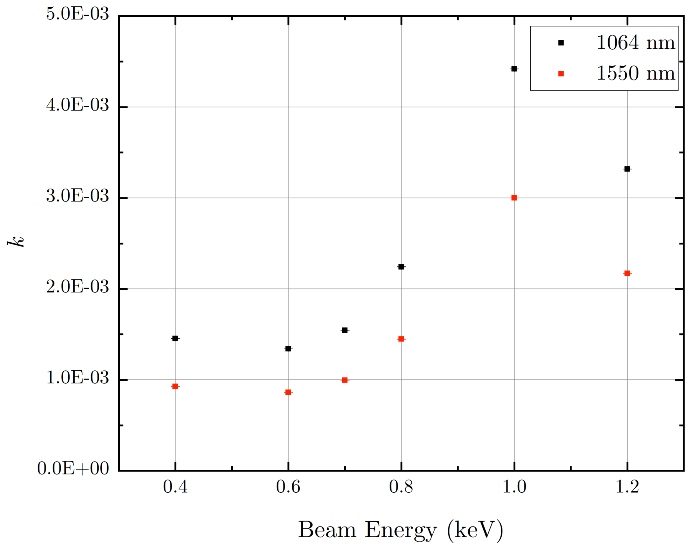


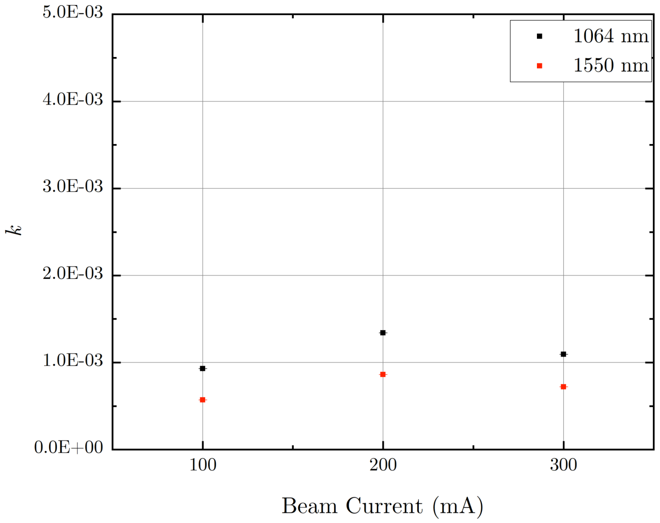
- By increasing the concentration of N_2 through the ion source, the refractive index is closer to that of Si_3N_4 in addition to attaining a lower extinction coefficient
- Energy required to dissociate molecular N_2 into reactive N to react with Si and create Si_3N_4

Ion source: parameters optimisation

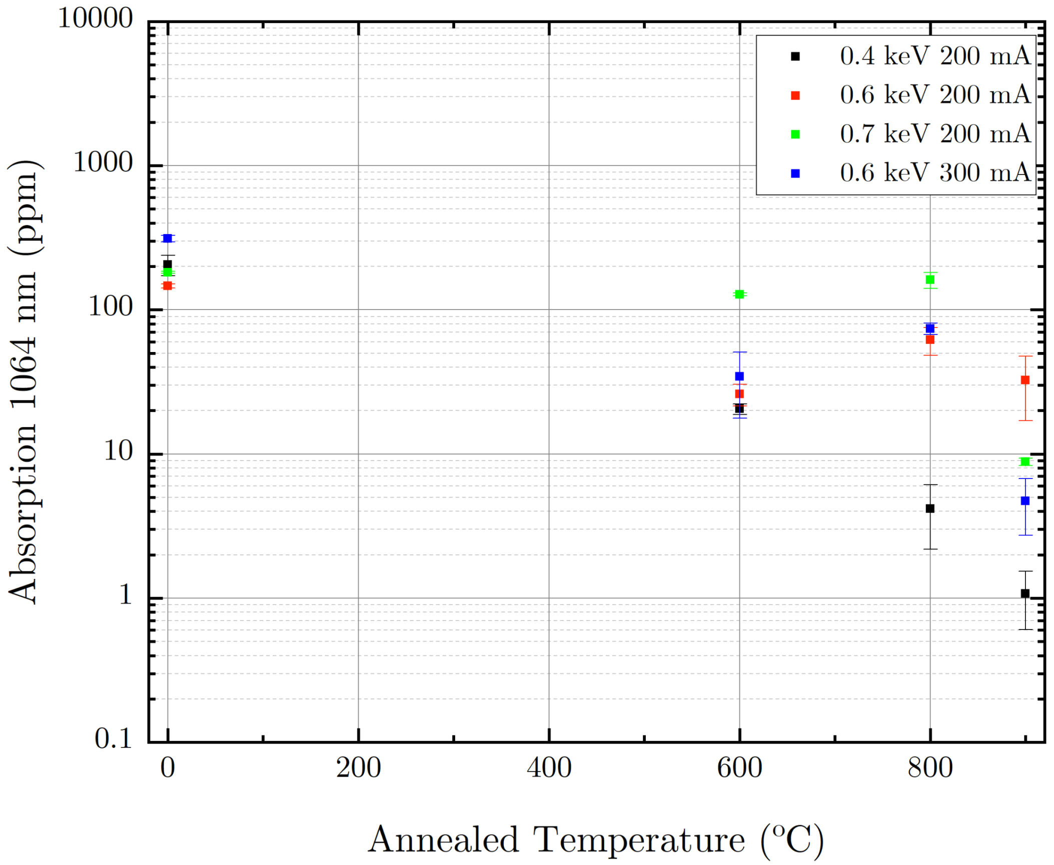


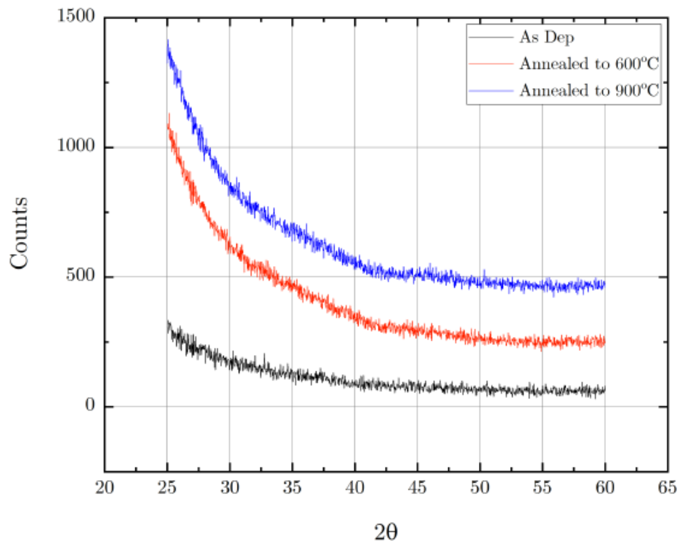




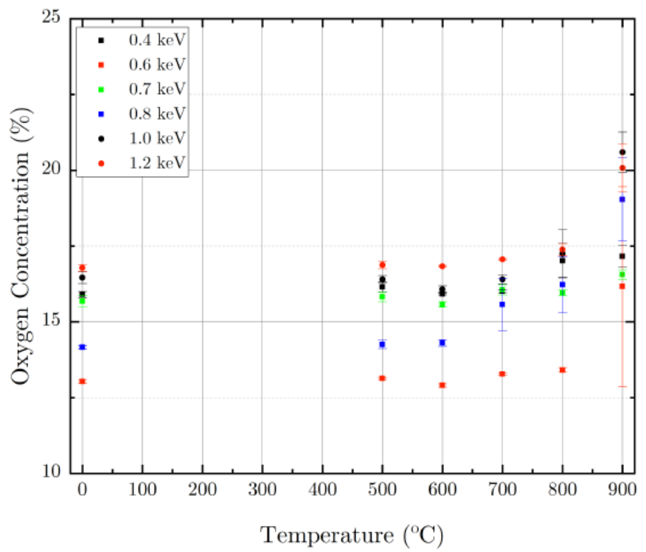


Annealing of SiNx coatings





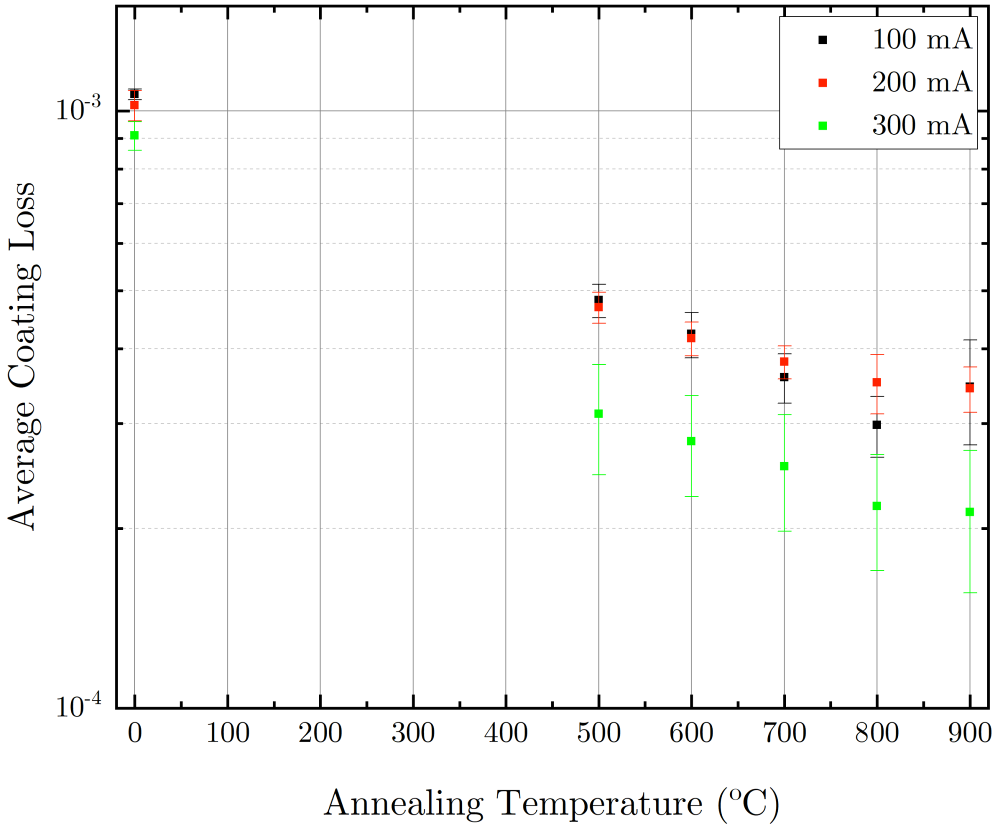
Amorphous up to 900º C

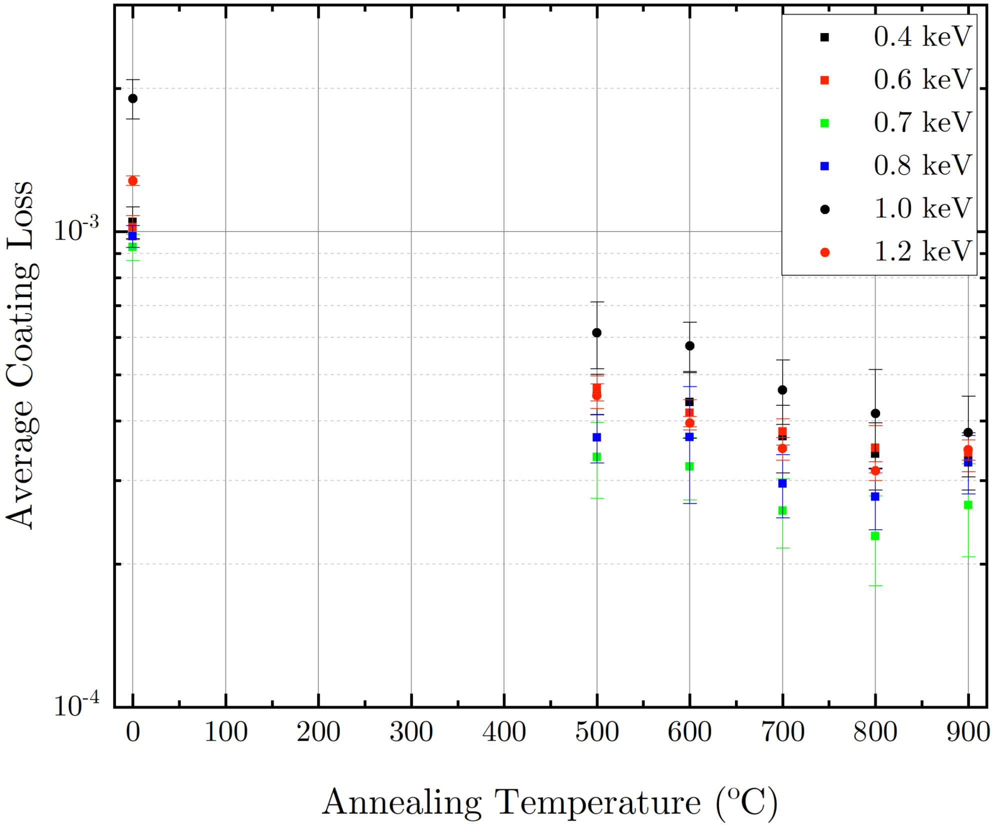


Oxygen concentration increase with annealing

- SiNx: low absorption properties when the process beam parameters are taken into consideration (0.4kV/ 200mA optimum)
- Absorption is related to O_2 variation during the annealing process

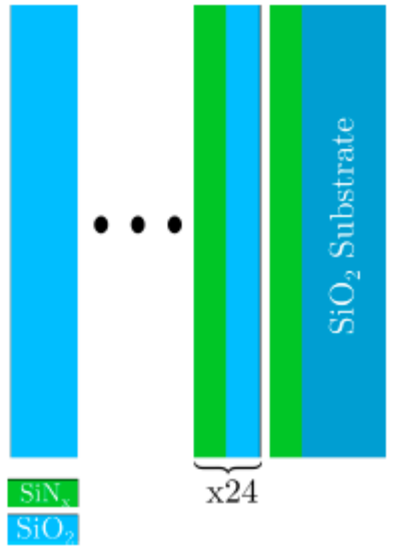
Coating mechanical loss

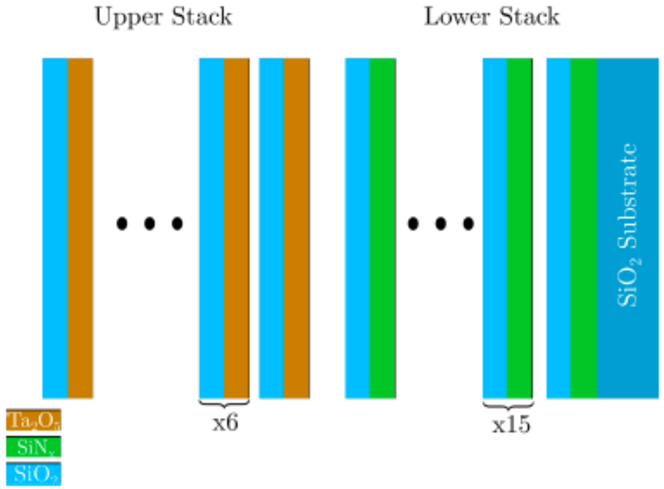


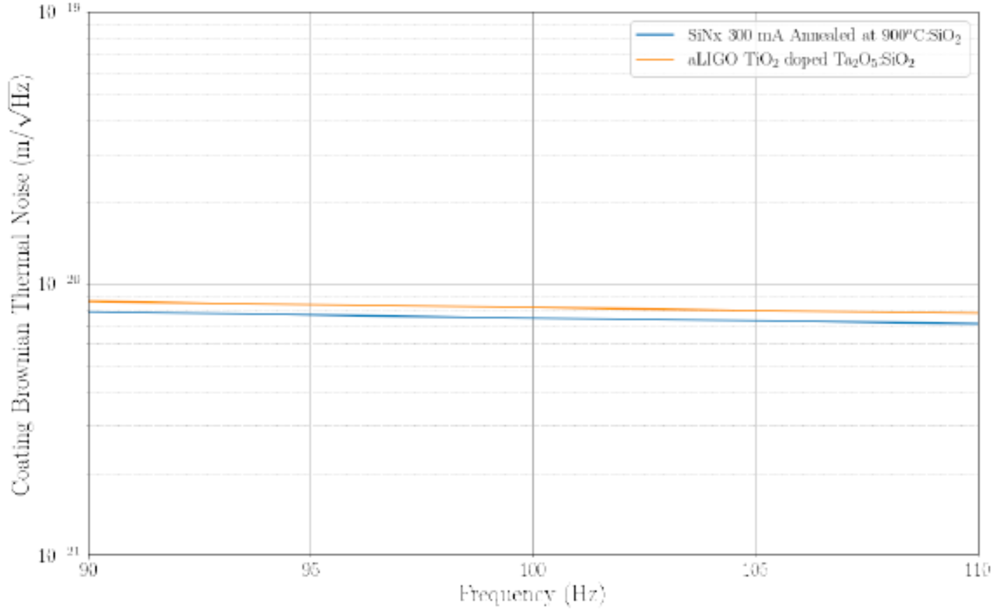


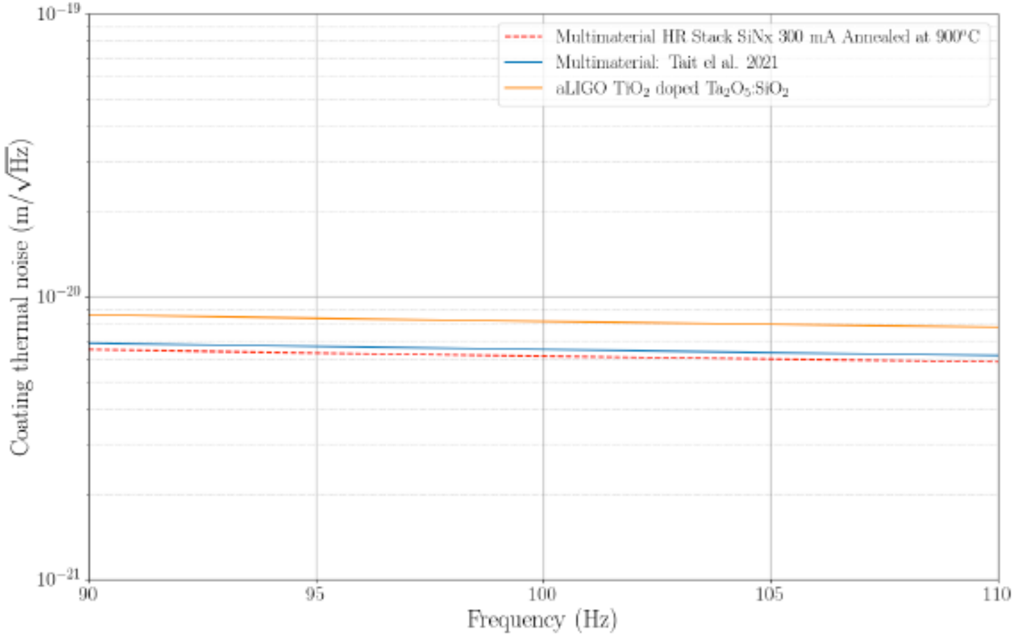
GeNS measurements conducted by Dr Gabriele Vajente at the California Institute of Technology

Thermal Noise Modelling

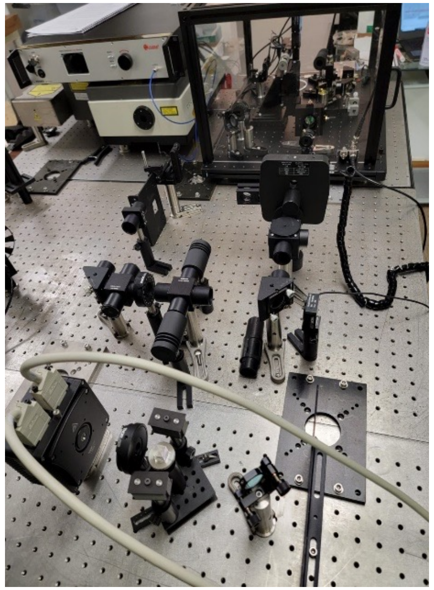






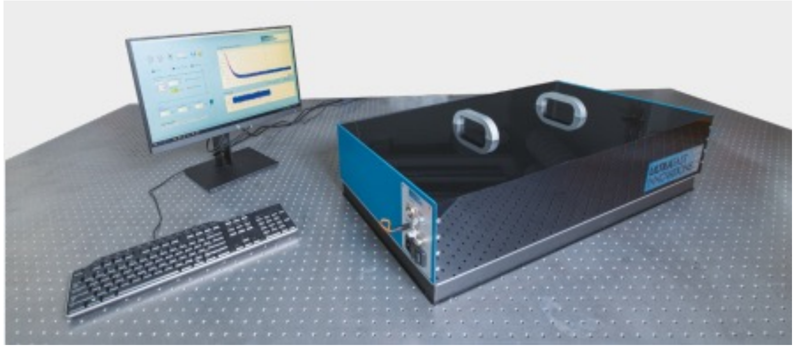


Further updates from UoS



Photothermal Common-Path Interferometer
@ 800 nm, 1064nm, 1550 nm
Absorption losses as low as 0.1 ppm

Cavity-Ringdown (CRD) Loss Meter and Reflectometer:
optical losses down to 5 ppm



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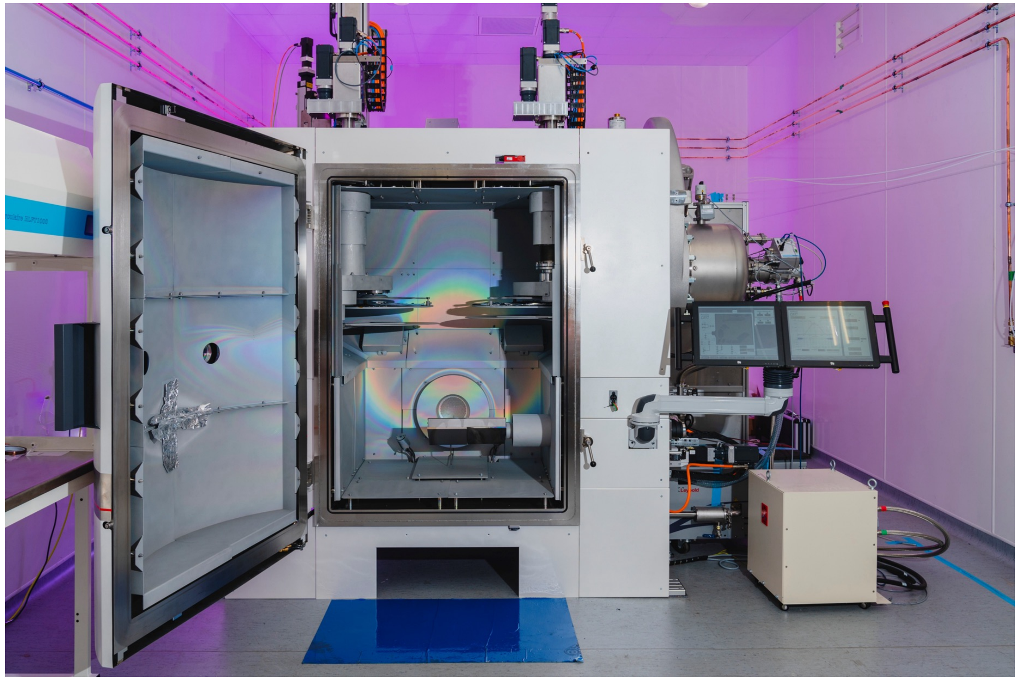

Cutting Edge Coatings system

- <1% uniformity in 62 cm diameter without masks
- One main ion source and (coming next) one assist source
- Two substrate holders
- Process is monitored by BBOM
- 2 IR heaters
- Base pressure ~ 10^{-8} mbar
- 4 targets (20 cm x 25 cm) – metallic
- Mixed materials achieved easily by horizontal translation of target stage
- Optical designs by Optilayer, process allows for on-the-fly redesigning

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Thank you for your attention

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