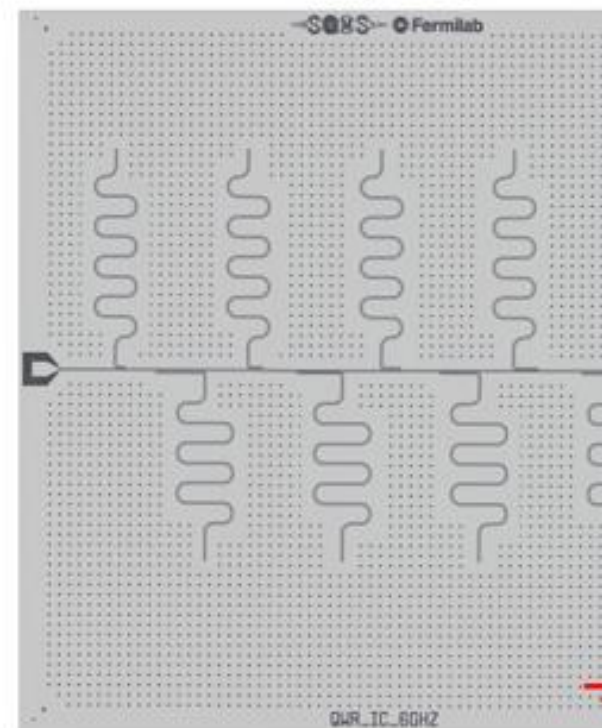
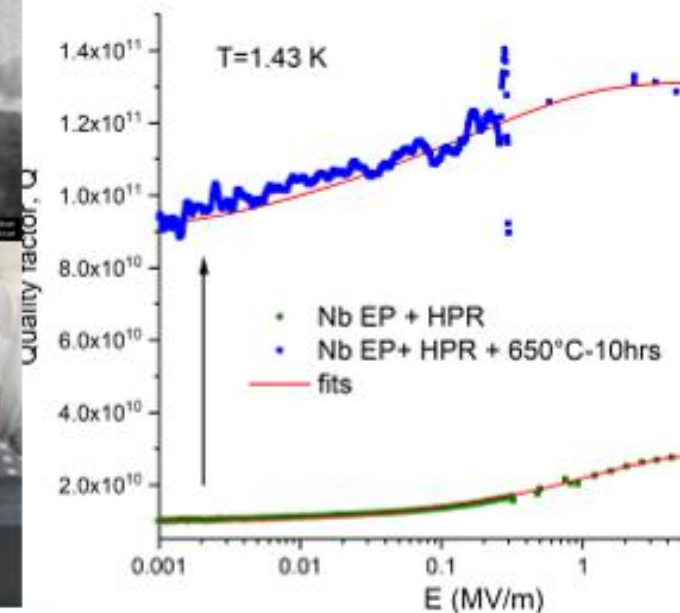




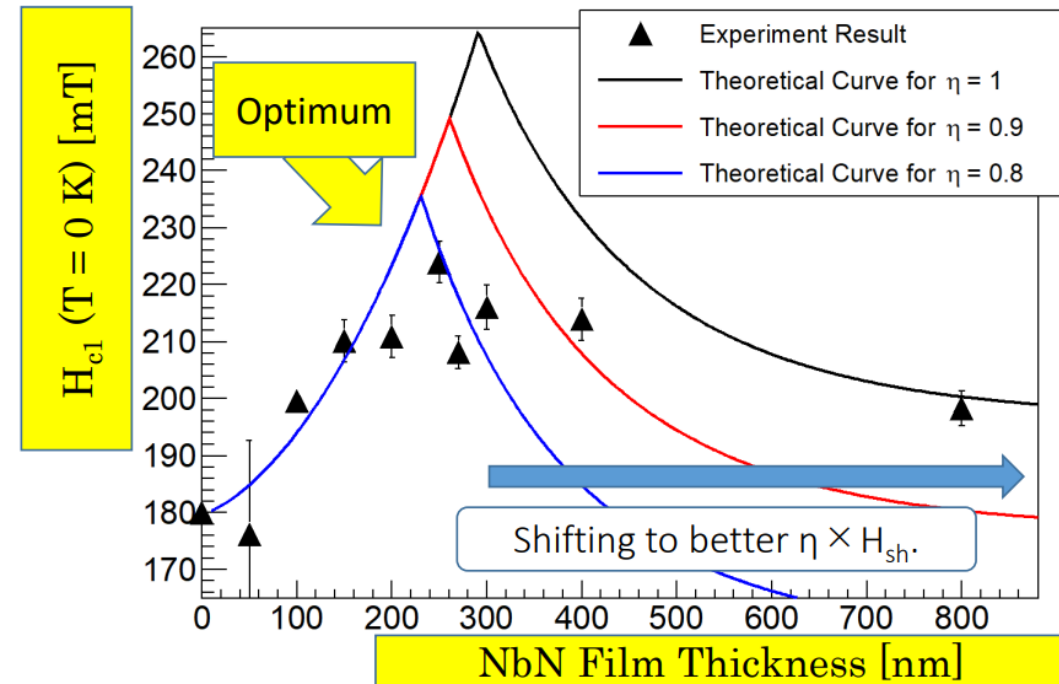
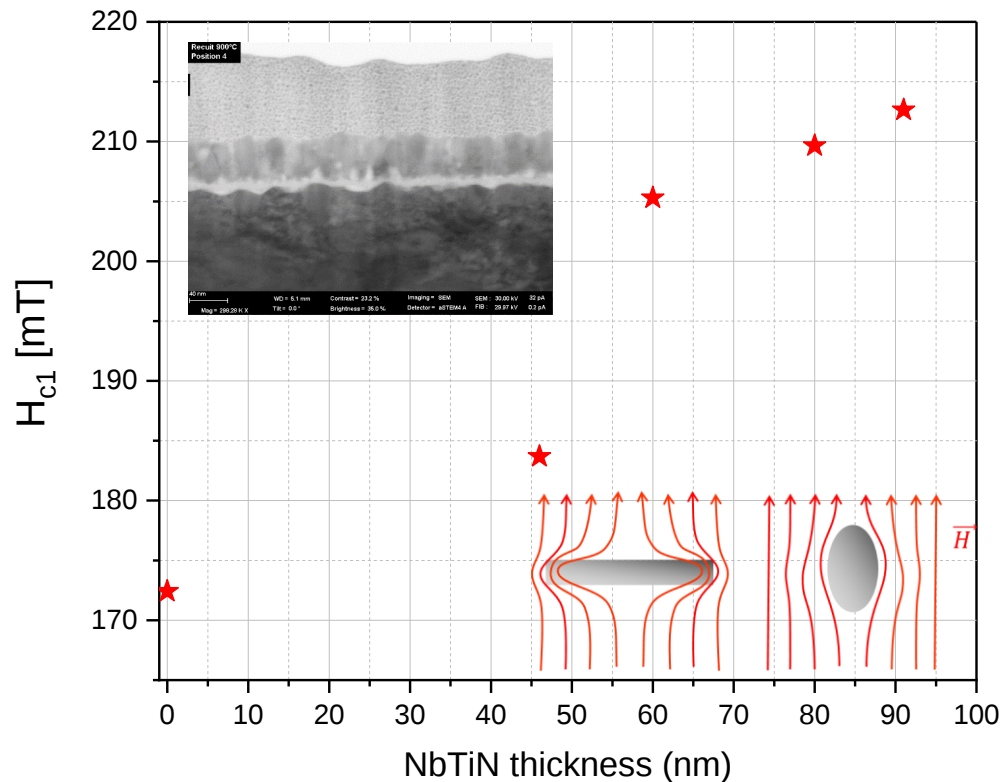
R&D status on SRF cavities

T. Proslie, Y. Kalboussi, I. Curci, T. Dejob, F. Miserque, F. Motschmann, M. Benko, E. Sellin, F. Eozenou, G. Jullien, B. Quentin, P. Sahuquet, L. Maurice...



ALD on SRF cavities and multilayers

- The Niobium ellipsoid was coated and annealed with the optimized NbTiN-AlN bilayer recipe.



T. SAEKI, TFSRF21: Overview of thin-film studies at KEK and Kyoto University, (2021).

- Enhancement of first penetration field demonstrated.
- Thicker layer (~ 200 nm) to determine ξ and the predicted optimal thickness

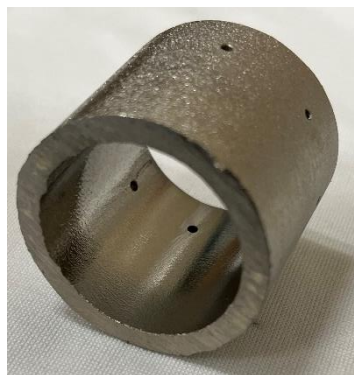
ALD on SRF cavities and multilayers

- Delamination studies.
 - Leak detected and fixed.
 - Upscaling of the samples with tubes and curve plate

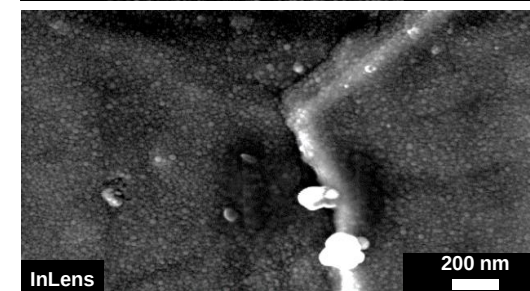
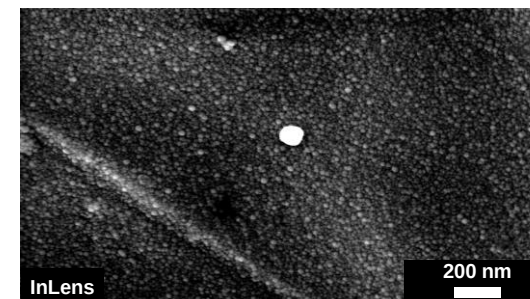
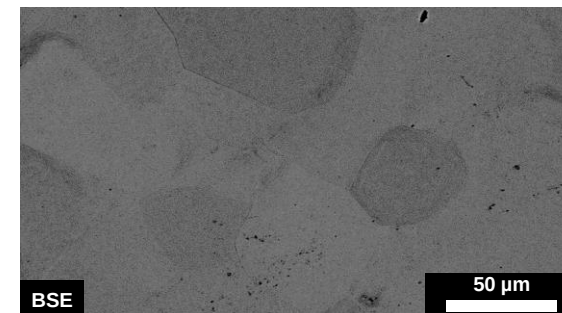
Height : 30 mm
Diameter : 37 mm



Annealed at 900°C



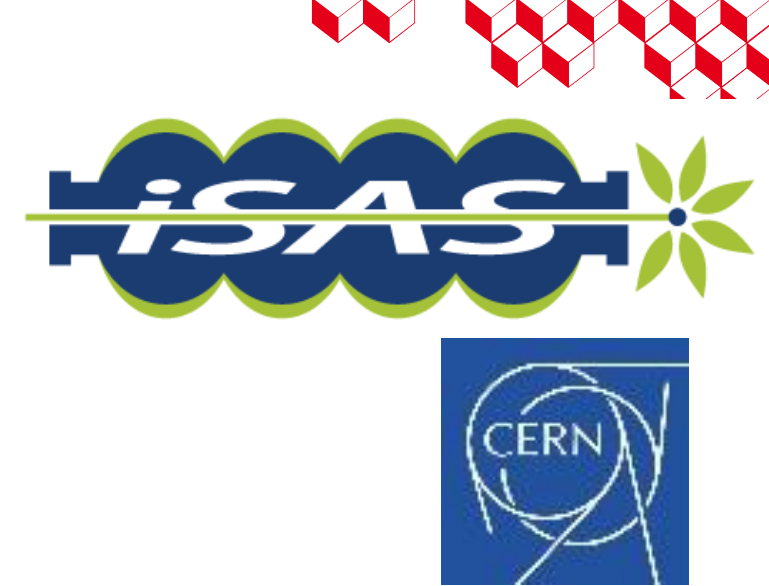
55 by 22 mm



- Presence of film confirmed by XRD, EDS, MEB
- No delamination observed

- $T_c \sim 14.5 - 15 \text{ K}$ (42 nm)
- New multilayer diffusion barrier.

ISAS – CERN collaboration



ISAS - WP3: Nb₃Sn on Cu films for 4.2K cavity operation

INFN, CEA, HZB, UKRI

Task 3.4: Adaptative layers – M1-M40

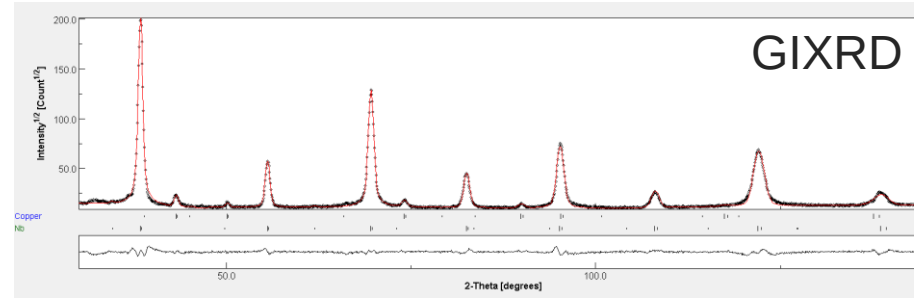
- *Develop adaptative layers by atomic layer deposition on Cu that are stable up to 650 °C.*
- *Compare performance Nb₃Sn on Cu with and without adaptive layers on planar samples and QPR.*

CERN Collaboration:

- *Develop insulating diffusion barrier layers for Nb thin film deposition: thermal stability of Cu surface and film, thermo-current suppression.*

Al₂O₃/Cu – Nb deposition

Baseline coating recipe:
 1.2kW avg
 100Hz, 200us HiPIMS pulses
 -75V bias voltage
 150C
 2.5.10⁻³ mbar Kr



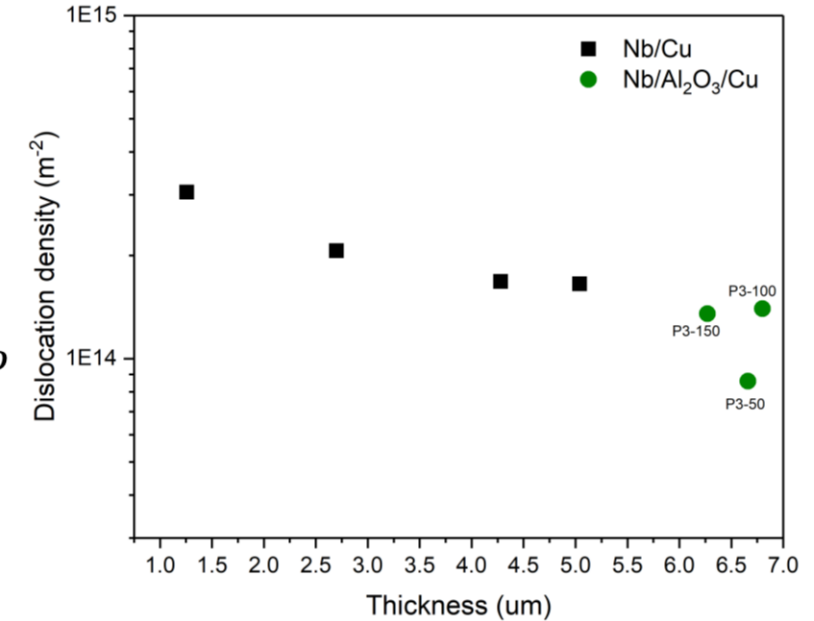
crystallite size, D
 microstrain, ε
 lattice parameter, a



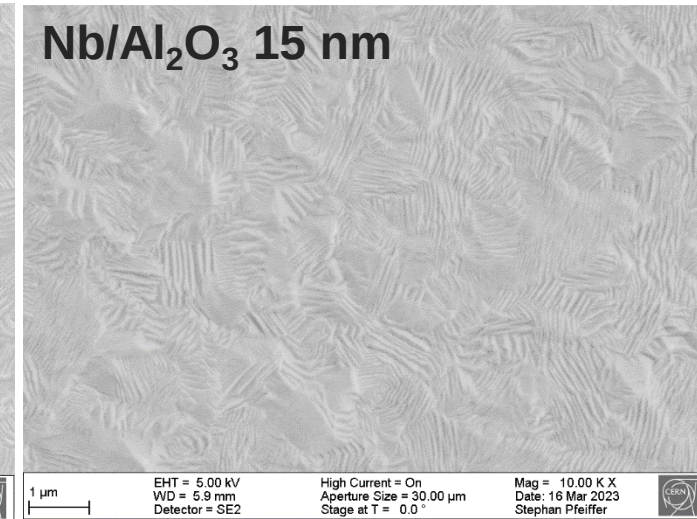
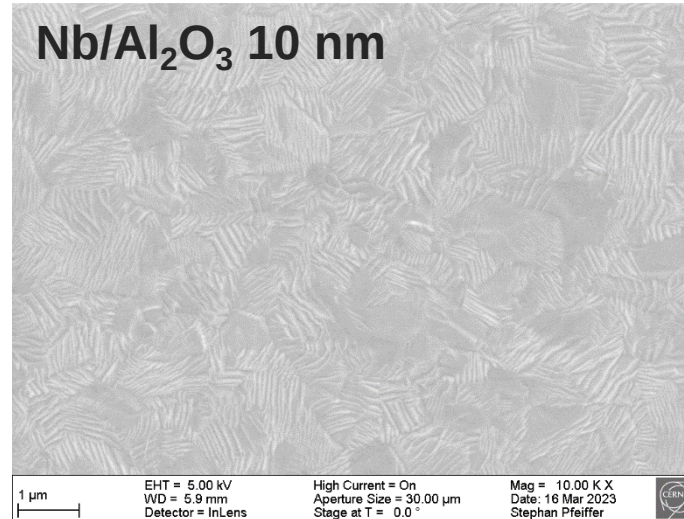
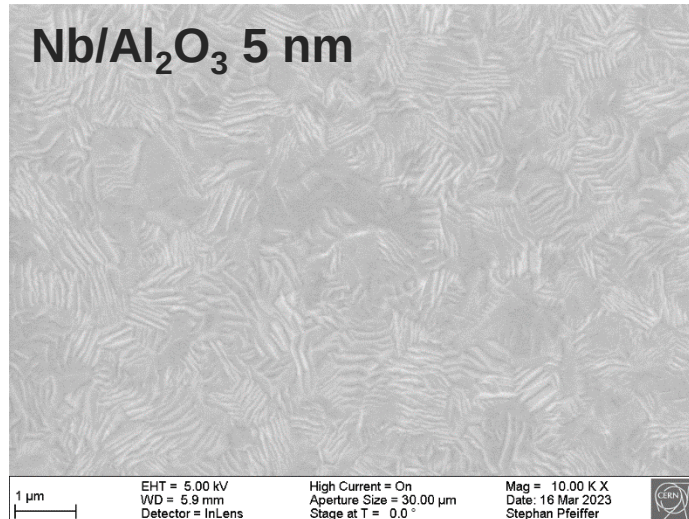
Dislocation density, ρ_D

$$\rho_D = 2\sqrt{3} \frac{\langle \varepsilon^2 \rangle^{1/2}}{D \times b}$$

C. Pereira, S. Leith, G. Rosaz, S. Pfeiffer

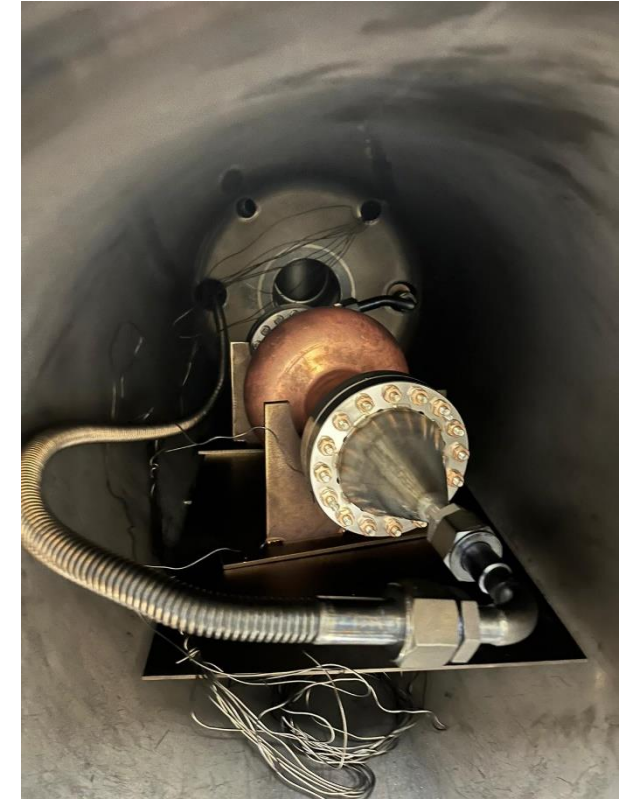


- Nb/Cu and Nb/Al₂O₃/Cu do not show any difference from XRD.
- The lower dislocation density can be explained by the thicker layer.



$\text{Al}_2\text{O}_3/\text{Cu}$ – Nb deposition

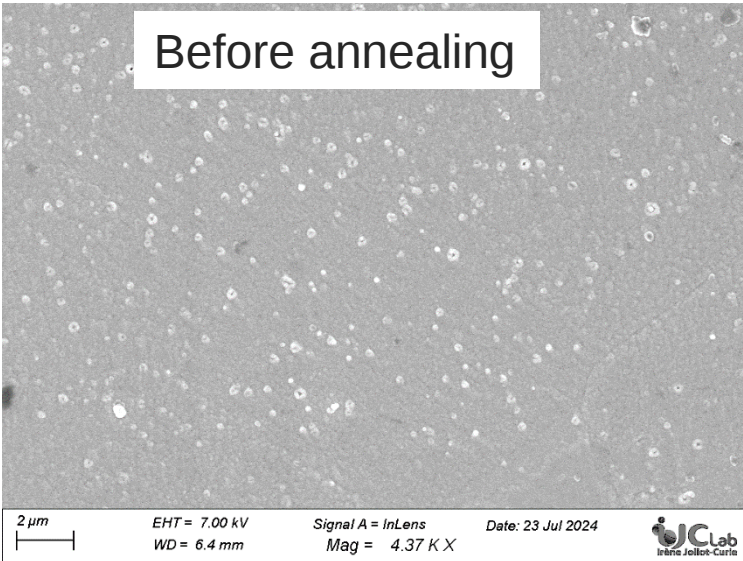
- No difference observed by XPS before or after HPR of 5, 10 or 15 nm thick Al_2O_3 layers on Cu.
- Stable up to at least 250°C. Try higher post annealing temperature in High Vacuum.
- Very similar superconducting properties as measured by Tunneling spectroscopy.
- Coating of a 1,3 GHz cavity EP from CERN with 15 nm of Al_2O_3 . Send back to CERN for HPR and Nb deposition.
- Coating Nb with higher deposition temperature (150°C to 250°C or higher) increase the grain size and potentially improve RF performances.



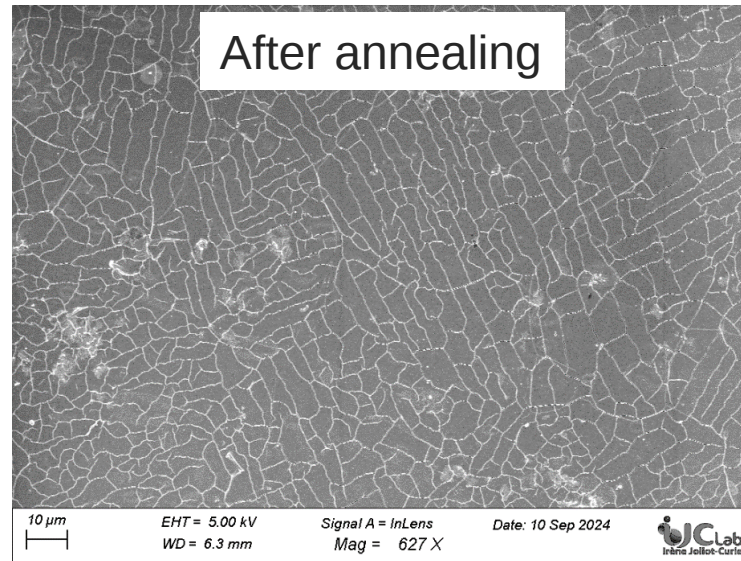
ZrO₂ (50 nm) /Cu



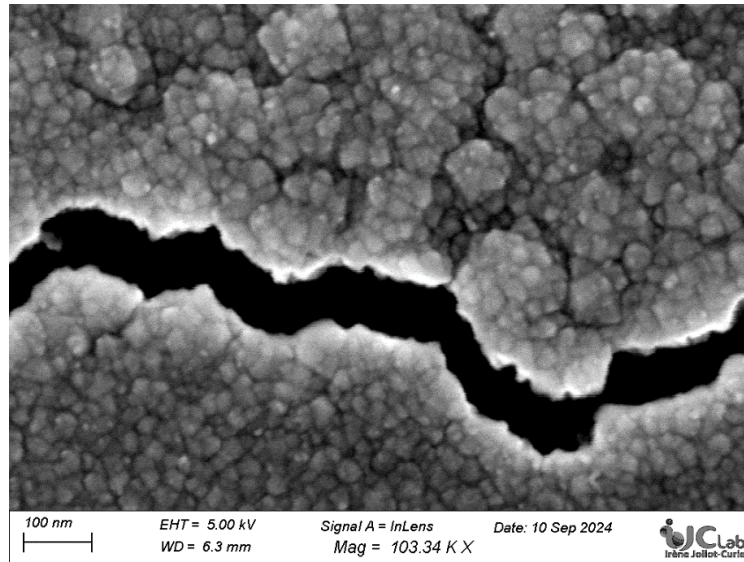
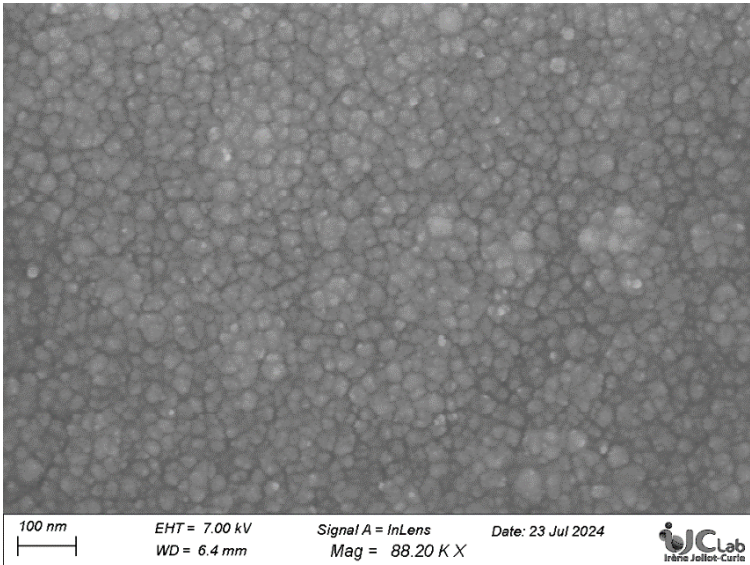
Before annealing



After annealing

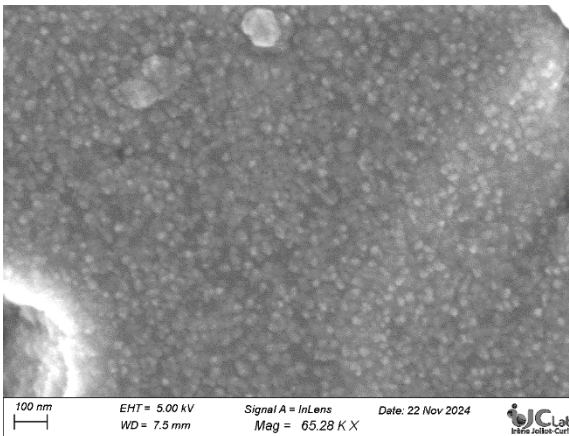
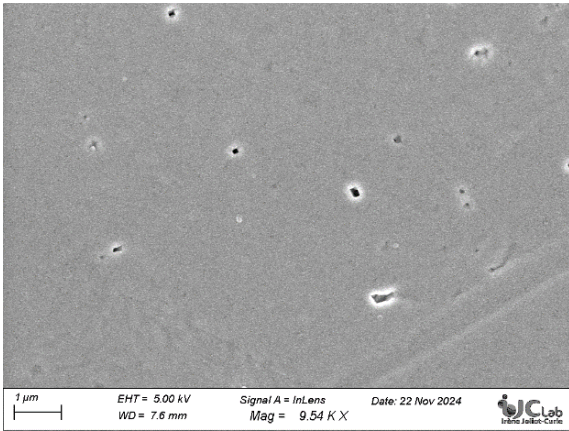


- Cu: EP from CERN
- Annealing : 700°C – 2hrs
- Homogeneous 50 nm ZrO₂ films
- ZrO₂ cristalline (cubic) as grown with grains ~ 20 nm.
- Clear cracks after Annealing in High Vacuum (10^{-6} mbar) at 700°C for 2 hrs (Ramp of 6°C/min).
- Attempt to do thinner film....more elastic?
- Also seen on YSZ (22 nm).

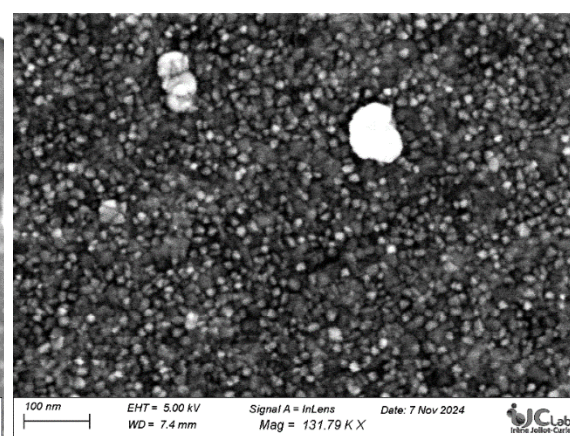
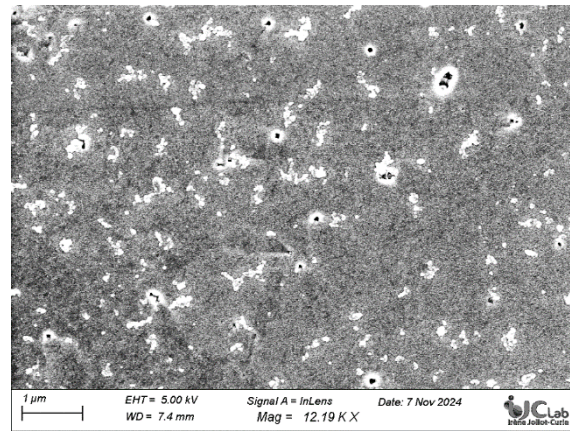


ZrO₂ (20 nm) /Cu

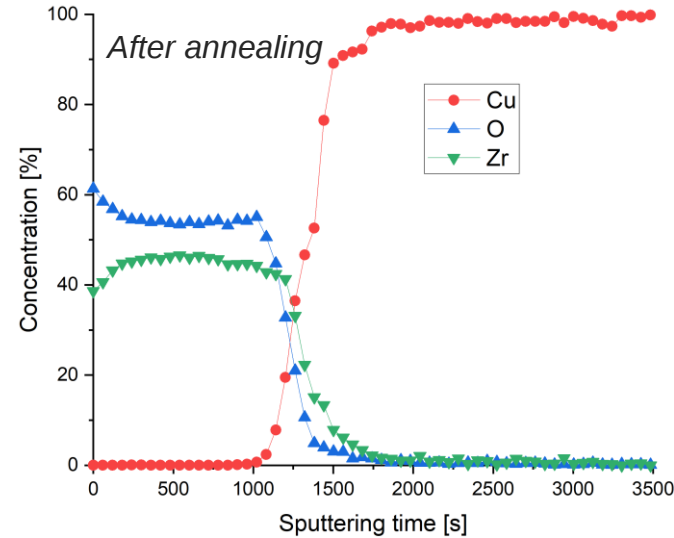
Before annealing



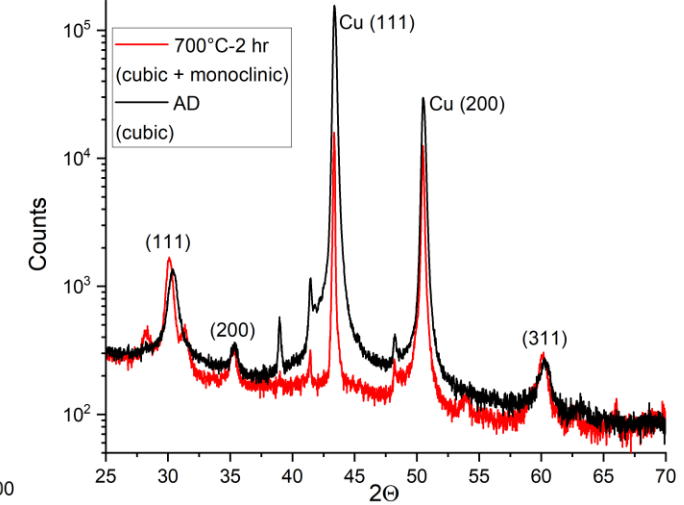
After annealing



XPS



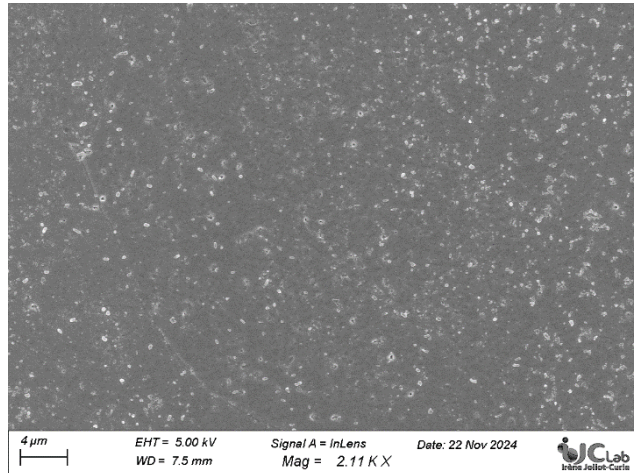
XRD



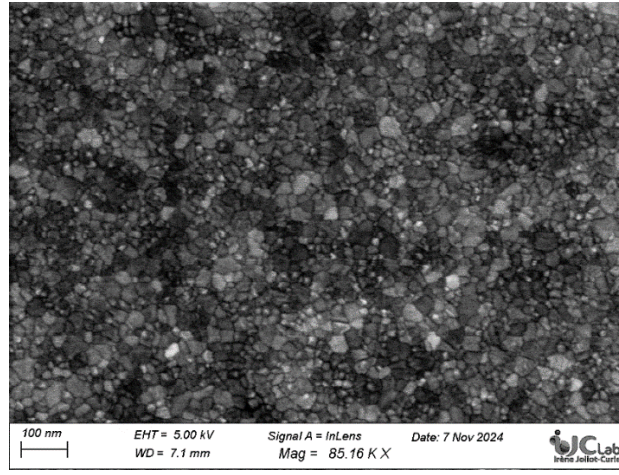
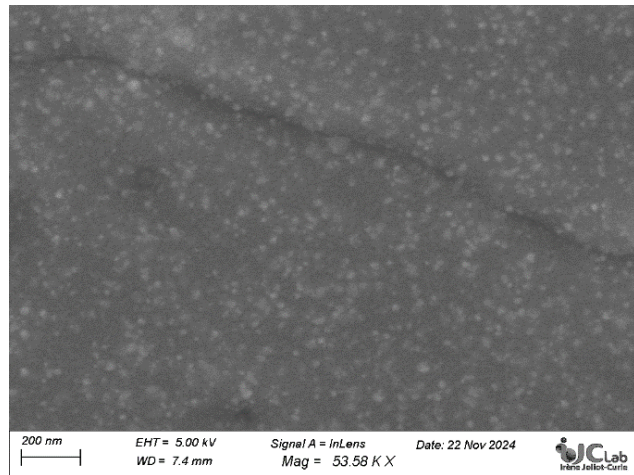
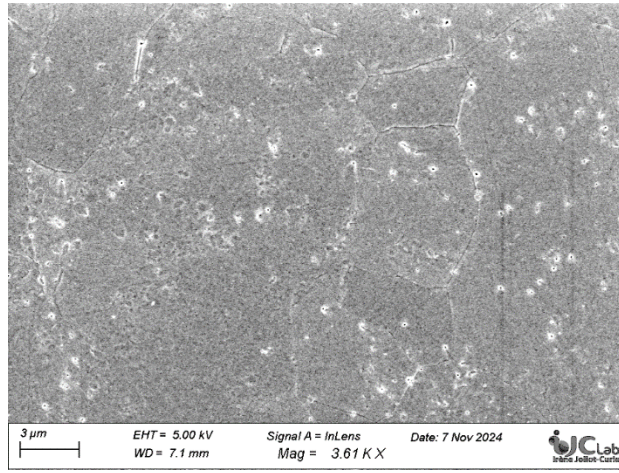
- Crystalline ZrO₂ grains 5-10 nm as grown or after annealing.
- No cracks for ZrO₂ films ≤ 20 nm on Cu.
- Cubic as deposited and mixture tetragonal after annealing.
- No copper diffusion after 700°C-2hrs.
- ZrO₂/Metallic Cu interface.
- Verified for 10 nm ZrO₂ films.

ZrO₂ (20 nm)/Al₂O₃ (5 nm)/Cu

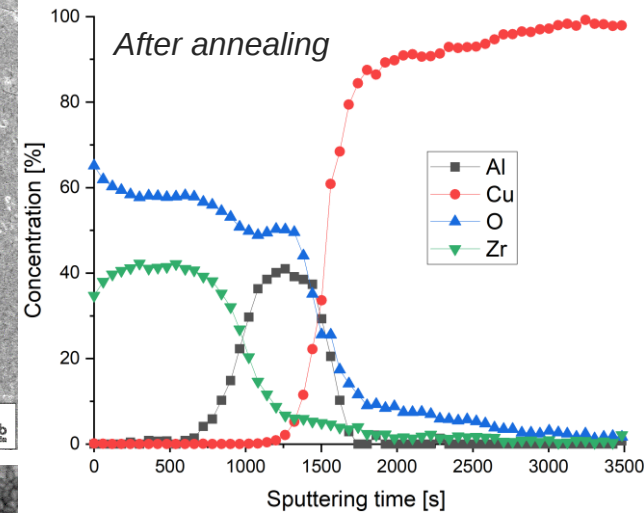
Before annealing



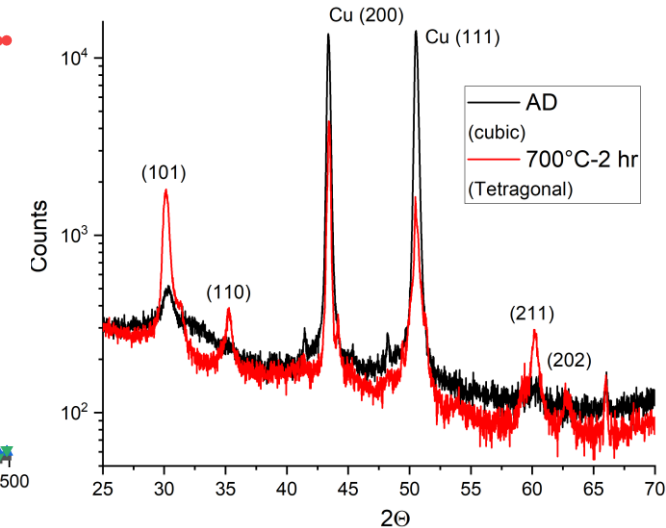
After annealing



XPS



XRD



- No cracks
- Much less holes.
- Clear crystallites (~10-30 nm) bigger than just 20 nm of ZrO₂.
- Cubic + much weaker monoclinic phase.
- No copper diffusion after 700°C-2hrs.
- ZrO₂/Metallic Cu interface.
- Bilayer structure stable - maybe interdiffusion Al₂O₃-ZrO₂

ZrO₂ – Al₂O₃/Cu – Nb₃Sn (or Nb) deposition

- Crystalline layers stable up to 700°C in high vacuum on Cu.
 - No Cu diffusion through the insulating ALD films.
 - Other deposition of alloys ZrAlO_x with various thicknesses.
 - Test Nb₃Sn or Nb deposition. More EP Cu sample coming from CERN. Awaiting samples from INFN and STFC.
 - Test mechanical stability of Nb₃Sn/ALD layer/Cu (tuning).
- } ISAS ✓