ALD-deposited Multilayer to improve the superconducting performances of RF cavities

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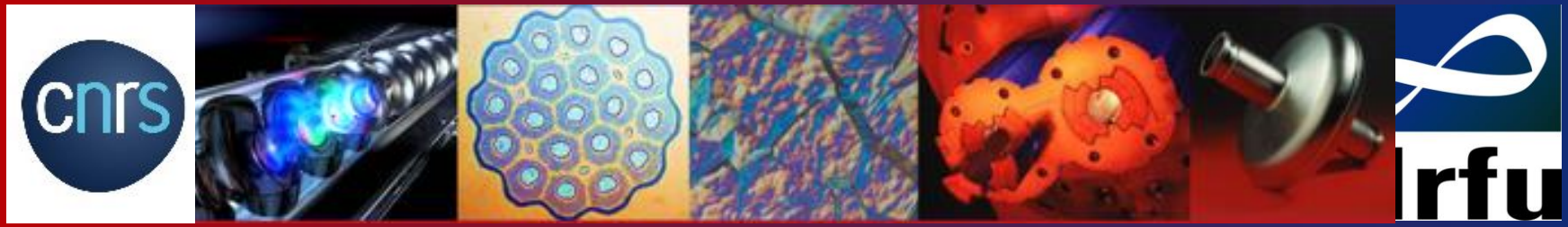
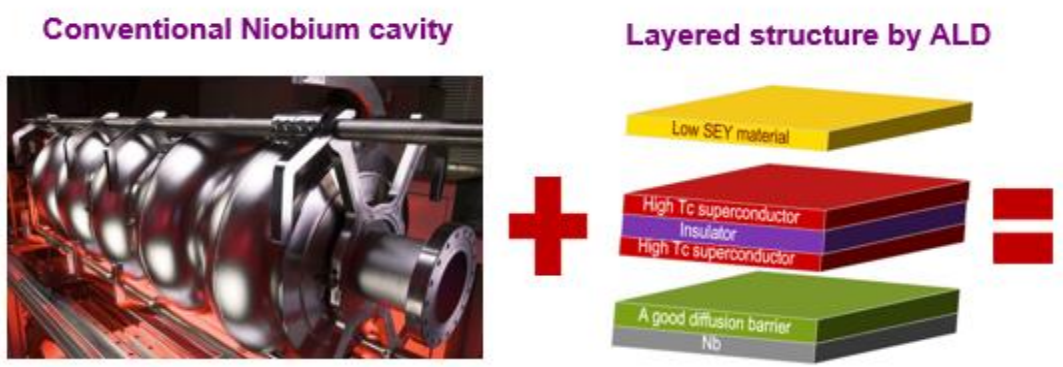
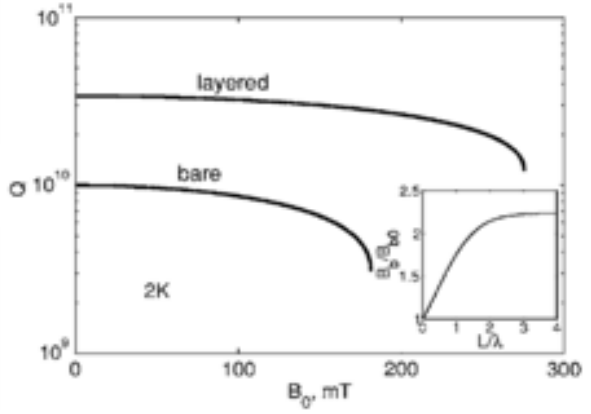
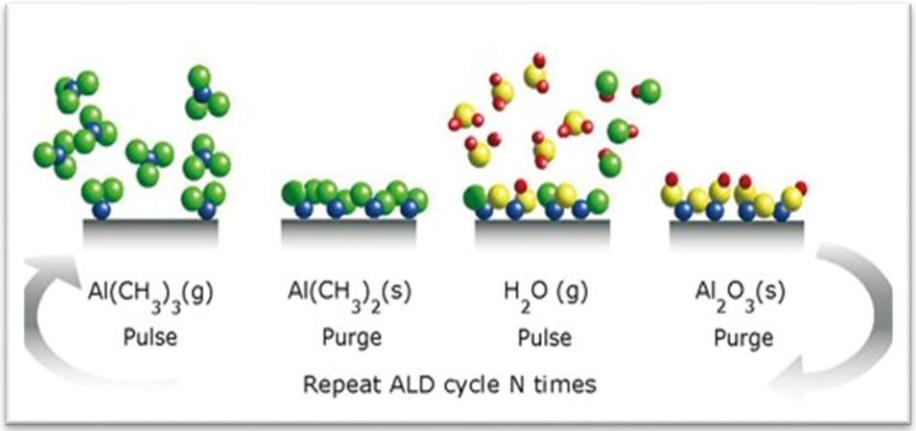


INTRODUCTION





- An original approach proposed by A. Gurevich [1] to improve RF cavities through depositing a superconducting multilayer capable of screening efficiently the magnetic field.
- To optimize this concept, we need as well a thermally stable diffusion barrier as a base and a low SEY material on the outer layer in order to limit multipacting inside the cavities.

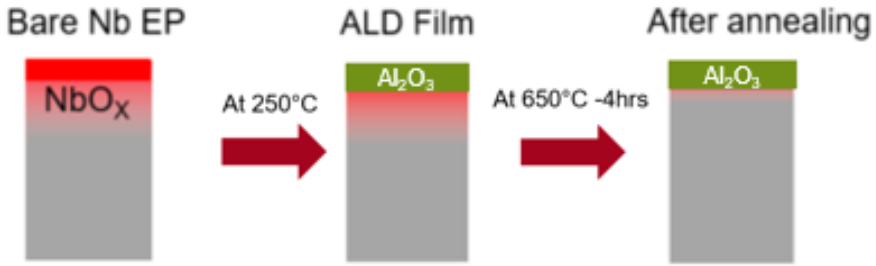


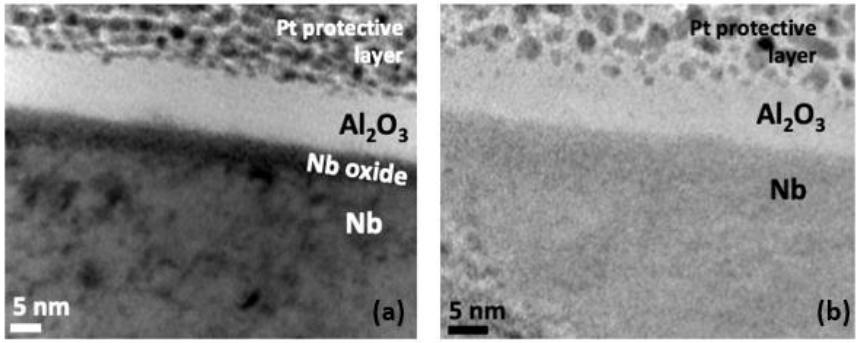
- The multilayer is a stack of nanometric films of high Tc superconductors and insulators.
- To synthesize this structure, we use atomic layer deposition ALD as a deposition technique as it well known to provide high quality Nano-films over large surfaces with complex shapes such as RF cavities.

[1] A.Gurevich,Enhancement of RF breakdown field of SC by multilayer coating.Appl. Phys.Lett, 2006.

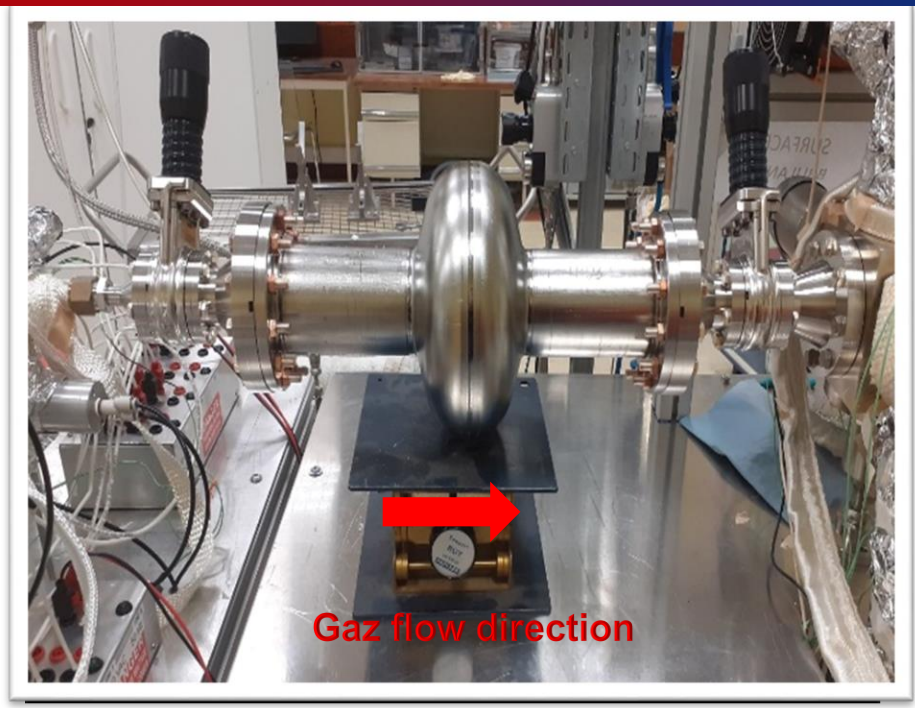
ALD PROTECTIVE LAYER

- First Step: Reduce Niobium native oxydes which are deleterious for superconductivity and replace it with a thermally stable ALD-deposited diffusion barrier.



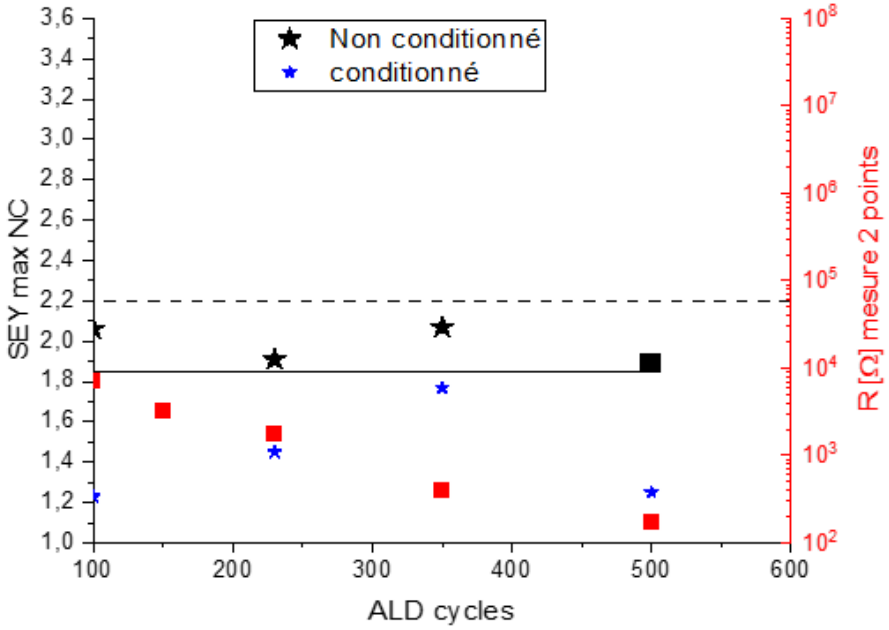


Transmission Electron Microscopy bright-field images (JANNuS-SCALP facility @ IJCLab) of 10 nm thick Al_2O_3 films deposited on niobium : (a) as-deposited ; (b) after annealing at 650°C, 4 hrs.

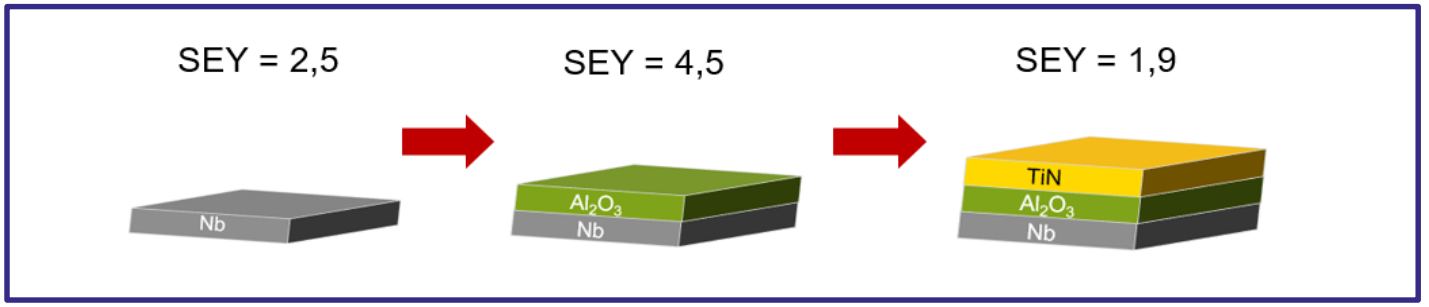


- We manage to deposit uniformly a thin film of alumina.
- RF test shows a slight improvement of the Q_0 at low field that increases with the accelerating gradient.
- Strong Multipacting barrier found at 18 MV/m that cannot be processed.
- Why and how to mitigate this effect?

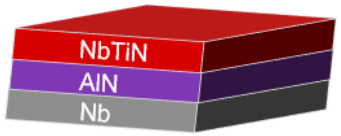
SEY ON ALD-DEPOSITED FILMS



Picture of the new ALD system under construction

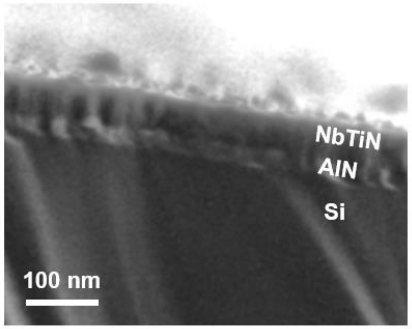


BILAYER ALN-NBTIN

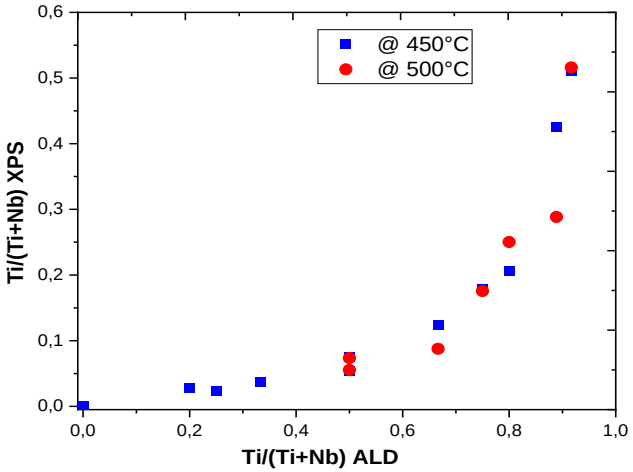


- Motivation: NbTiN has good superconducting performance (T_c = 17 K).
- Chemistry: Combination of $NbCl_5$/ NH_3 and $TiCl_4$/NH_3 cycles:

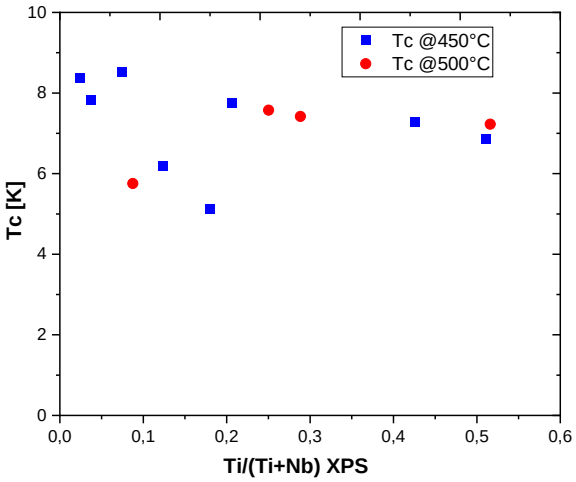
$$n\,(TiCl_4 + NH_3) + m\,(NbCl_5 + NH_3)$$



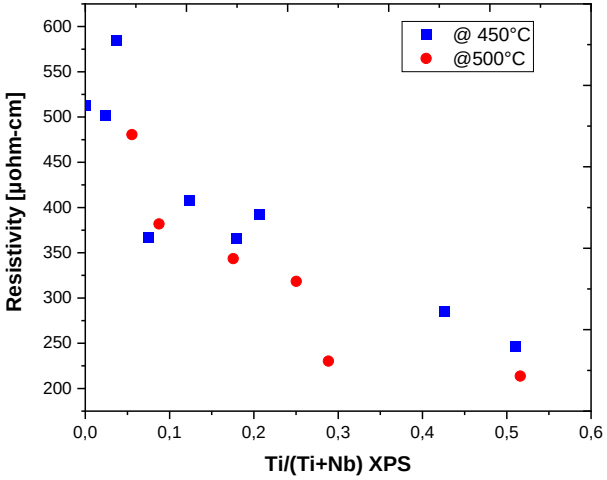
NbTiN Chemical composition



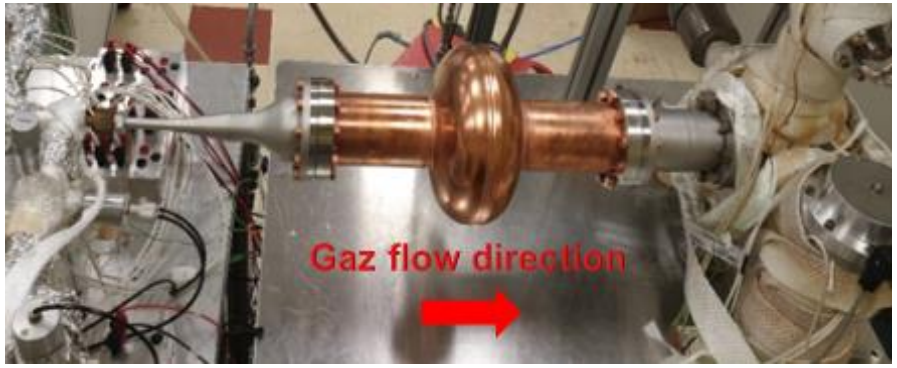
Critical temperature

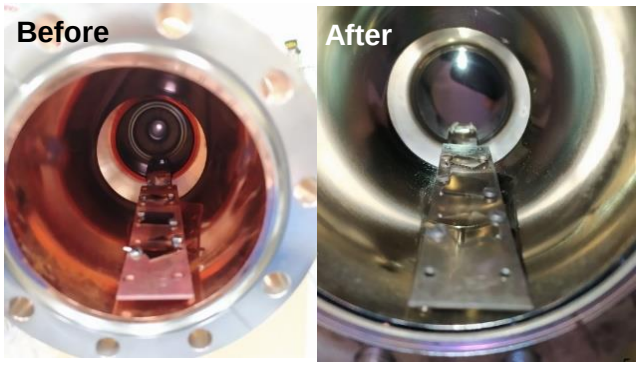


Resistivity

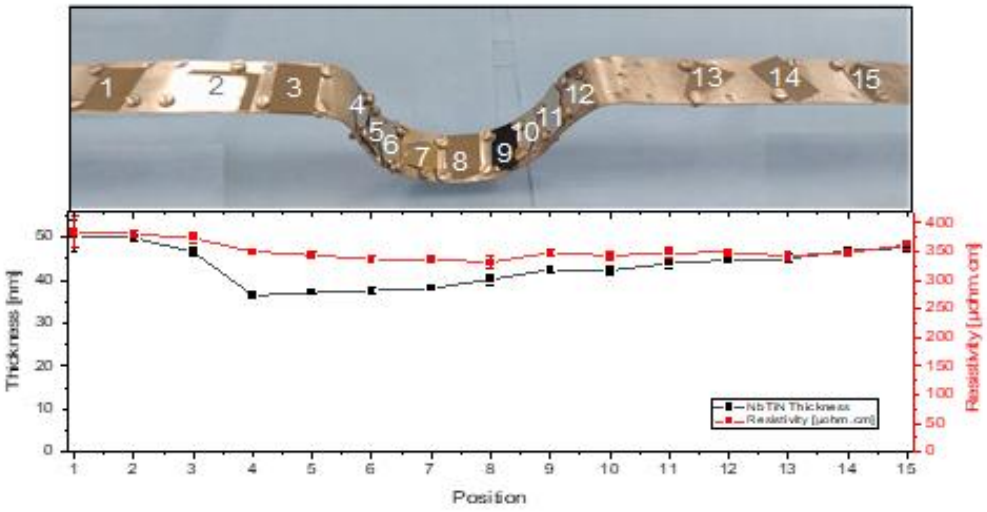


ALN-NBTIN ON COPPER 1,3 GHZ CAVITY

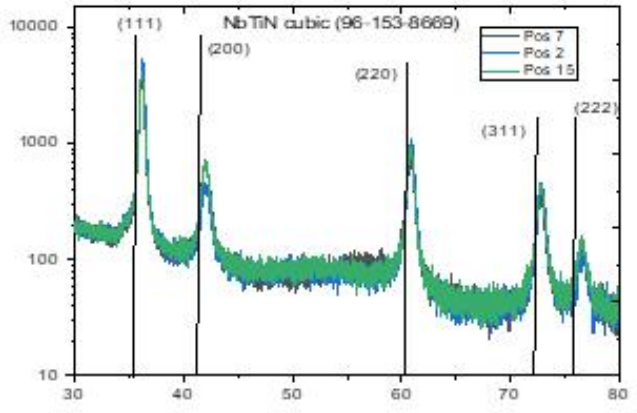




Test 2 : purge 20s



GIXRD diffraction patterns on different samples



CONCLUSION

- ✓ We manage to deposit uniformly a thin film of Alumina and reduce drastically niobium native oxides.
- ✓ RF test shows a slight improvement of the Q_0 under low and medium Fields.
- ✓ TiN film is promising to reduce multipacting inside RF cavities.
- ✓ Growth of superconducting NbTiN by ALD with homogeneous composition and thickness control over large surface areas.

Future Goals will be:

- ❖ Optimization of NbTiN process to improve superconducting properties.
- ❖ Test the NbTiN-AlN structure on Niobium RF cavities.

Thank you for your attention …