Material Engineering of ALD-deposited Multilayer to improve the superconducting performances of RF cavities under intense Fields

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Introduction
- We are exploring an original approach proposed by A. Gurevich [1] to improve RF cavities through depositing a superconducting multilayer capable of screening efficiently the magnetic field. 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.

ALD protective layer
- First Step: Reduce Niobium native oxides which are deleterious for superconductivity and RF properties and replace it with a thermally stable ALD-deposited diffusion barrier.
- We manage to reduce drastically niobium native oxides after annealing at 650°C-4 hours.

SEY on ALD-deposited films
- Film properties: Multipacting in 1.3 GHz cavity
- We manage to deposit uniformly a thin film of AlN.
- SEY measurements are coherent with multipacting simulation results.
- NiTi thin film decreases the SEY and can help overcome the multipacting barrier.

Bilayer AlN-TiN
- Motivation: NbTiN has good superconducting performance (Tc > 17 K)
- Chemistry: Combination of NbCl4, NH3 and TiCl4/NH3 cycles:
  \( n (TiCl_4 + NH_3) + m (NbCl_4 + NH_3) \)
- We manage to deposit uniformly a thin film of AlN.
- RF test shows a slight improvement of the Q0 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?

Conclusion
- We manage to deposit uniformly a thin film of AlN and reduce drastically niobium native oxides.
- RF test shows a slight improvement of the Q0 under low and medium Fields.
- NiTi 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
- Optimization of NbTiN process to improve the Tc.
- Test the NbTiN-AlN structure on QPR samples.
- Test the NbTiN-AlN structure on RF cavities.

References

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