Coating studies on 6 GHz seamless cavities

In the framework of CERN-INFN-STFC Agreement N. KE2722/BE/FCC

FCC Week 2018, Amsterdam, 12th April 2018
Outline

• Q-slope problem and LNL approach
• Deposition Set Up
• Process Parameters
• Results
Q-slope problem
LNL Approach

• High temperature

• Thick films
Thick film motivation

Q-slope is related to local enhancement of the thermal boundary resistance at the Nb/Cu interface, due to poor thermal contact between film and substrate.

Theoretical model from Vaglio and Palmieri

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Thick films increase grain dimensions and RRR

Grain dimension $\approx 1\mu m$

RRR $> 60$

EBSD Micrograph of cavity #4, courtesy of Reza Valizadeh (STFC)
High Temperature Deposition Motivation

- **Thorton SZ Diagram**

- **CERN (550 °C)**
  C. Benvenuti et al., Physica B 197 (1994) 72-83

- **LNL Alpi Linac (300-500 °C)**
  Stark et al., Proceedings of SRF1997

- **Hie-Isolde (650 °C)**
  Sublet et al., Proceedings of SRF2013
6 GHz cavity coating protocol
(2 weeks per cavity)

- Spinning
- Mechanical Grinding
- Degreasing
- EP + SUBU
- 7 h PVD process
- 48 h Baking 600 °C
- Cleanroom Vacuum Assembling
- HP Rinsing
- Cleanroom RF Assembly
- 4,2 K RF Test
- 1,8 K RF Test
Deposition Set Up

- 6 GHz cavity
- Nb Post Magnetron Target
- IR Lamp
- Quartz sample
- Thermocouple
Process parameters

- Temperature = **550 °C**  *(baking 600 °C)*
- Base pressure < **2 • 10^{-9} mbar**  *(room T)*
- Ar Pressure = from **7 • 10^{-3} to 5 • 10^{-2} mbar**
- Current = **1 A (0,017 A/cm²)*
- Magnetic Field = **830 Gauss**
- Deposition Rate = **2,5 - 3 nm/s**

*Bending of the flange at 650 °C*
Deposition parameters optimization

- Pressure

- Multilayer
Pressure

- Test on kapton foil
- Bending as a function of a pressure

![Graph showing tensile and compressive stress vs. pressure](chart.png)

300 °C

7 \( \cdot \) 10\(^{-3}\) mbar

9 \( \cdot \) 10\(^{-3}\) mbar

2 \( \cdot \) 10\(^{-2}\) mbar

5 \( \cdot \) 10\(^{-2}\) mbar
Pressure

- Test on kapton foil
- Bending as a function of a pressure

7 \cdot 10^{-3} \text{ mbar} \\
9 \cdot 10^{-3} \text{ mbar} \\
2 \cdot 10^{-2} \text{ mbar} \\
5 \cdot 10^{-2} \text{ mbar}

300 °C
Multilayer

**Deposition Rate**: 3 nm/s

**Total Thickness (on the cell)**: 70 µm

**Single Layer Thickness**: 100, 300, 400, 500 nm

**Time**: 9 - 10 h

**DC ON**: 70 %

**DC OFF**: 30 %
Pressure

5 • 10^{-2} mbar

7 • 10^{-3} mbar

Zero stress pressure helps to increase accelerating gradient
Multilayer

One shot deposition

Multilayer Deposition

Multilayer process helps to increase accelerating gradient

Effect of the Multilayer procedure

$6 \text{ GHz } @ 1.8 \text{ K}$

$6 \text{ GHz } @ 4.2 \text{ K}$
Results interpretation

- Sputtering pressure and multilayer deposition reduce film stress
- Film stress reduction reduces film peeling and voids dimension at the interface
- How to explain low reproducibility?
Cavity surface after spinning
After Mechanical Finishing

With mechanical grinding some areas of the cell are difficult to access
Surface defects after chemistry
Thick films help on Q-slope problem?
Q-slope remains in many cavities...
...but not in all ones!
Conclusions and future actions

• We explored the thick films deposition on Nb/Cu cavities

• Strong Q-slope mitigation on 3 cavities

• The technique is very promising but not mature

• Improvements on cavity preparation process is mandatory

• Film characterization from STFC
8th International Workshop on
Thin Films and New Ideas for Pushing the Limits of RF Superconductivity

October 8-10, 2018
Legnaro National Laboratories INFN
Legnaro (Padua) - Italy