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Coating studies on 6 GHz seamless cavities

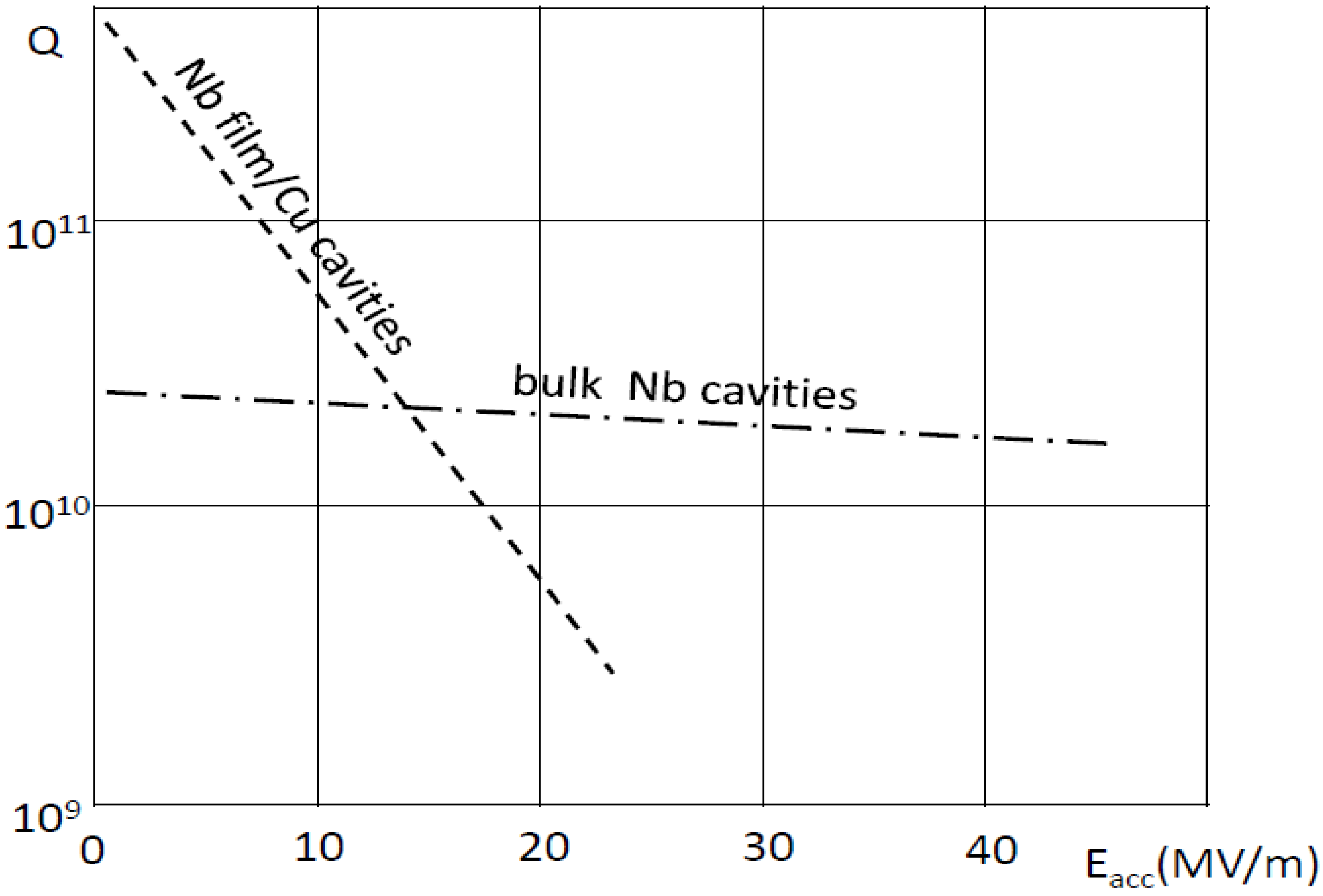
In the framework of CERN-INFN-STFC Agreement N. KE2722/BE/FCC

FCC Week 2018, Amsterdam, 12th April 2018

Outline

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

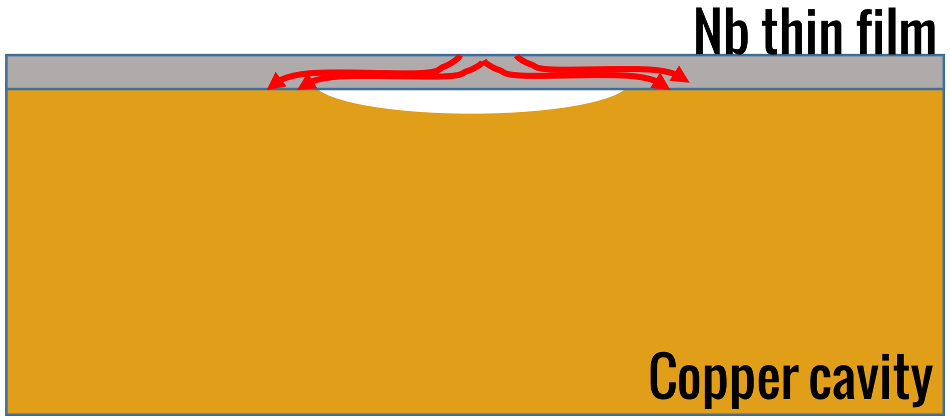
Q-slope problem



LNL Approach

- High temperature
- Thick films

Thick film motivation

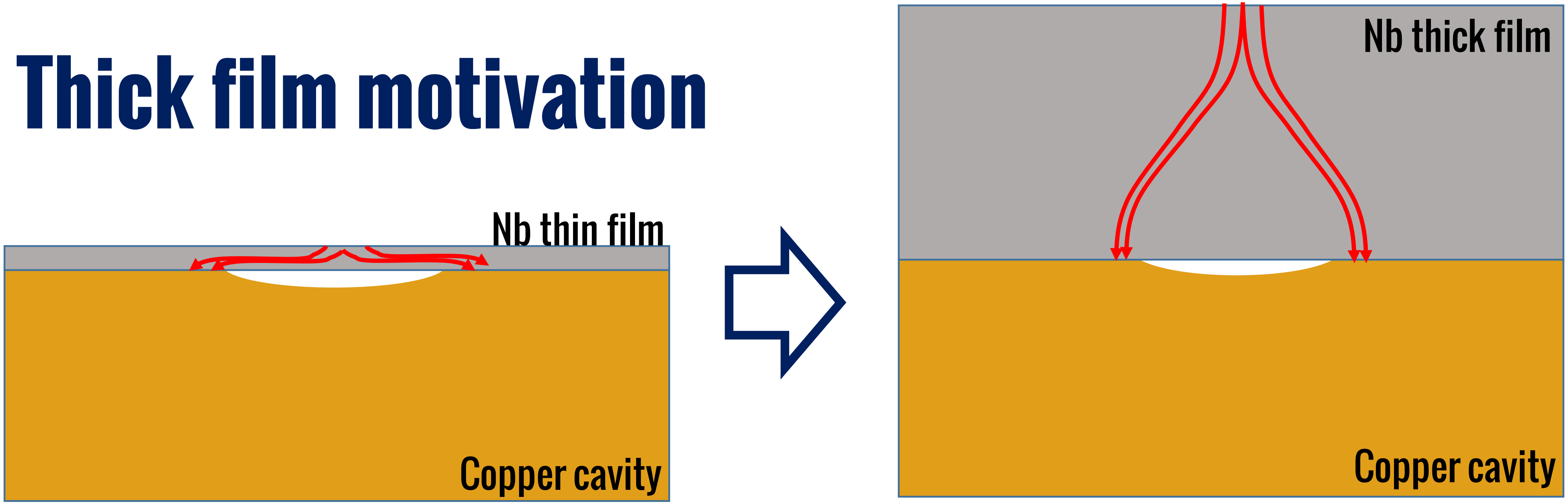


Q-slope is related to local enhancement of the **thermal boundary resistance at the Nb/Cu interface**, due to poor thermal contact between film and substrate

Theoretical model from Vaglio and Palmieri

V. Palmieri and R. Vaglio, *Supercond. Sci. Technol.*, vol. 29, no. 1, p. 015004, Jan. 2016

Thick film motivation



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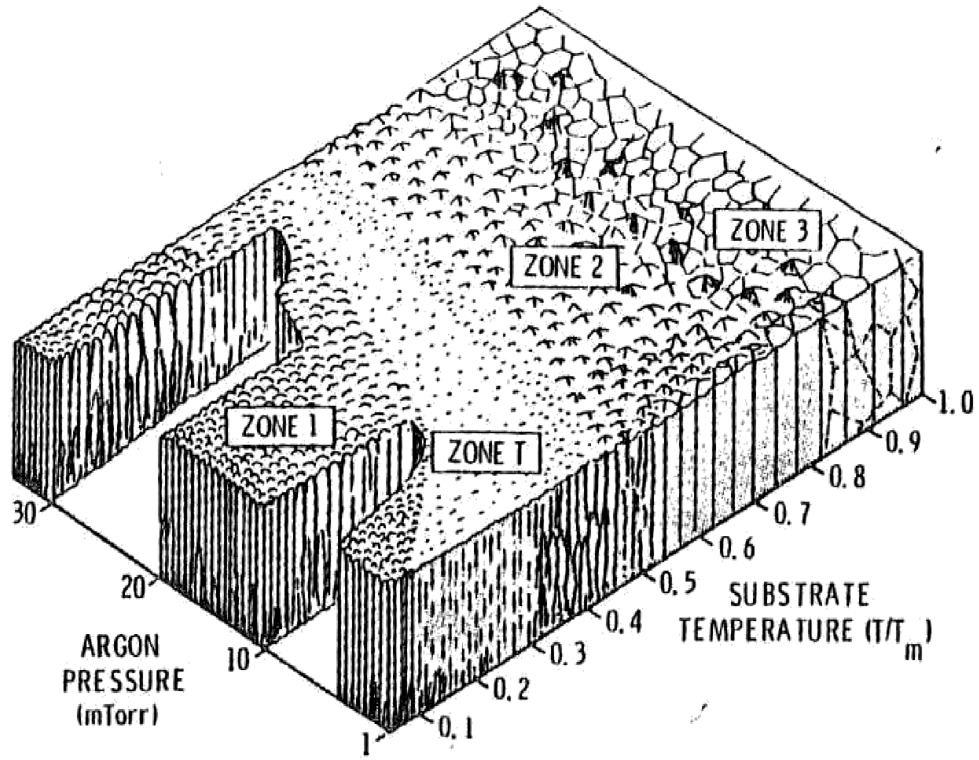
Thick films increase grain dimensions and RRR

Grain dimension ≈1μm

EBSD Micrograph of cavity #4, courtesy of Reza Valizadeh (STFC)

RRR > 60

High Temperature Deposition Motivation

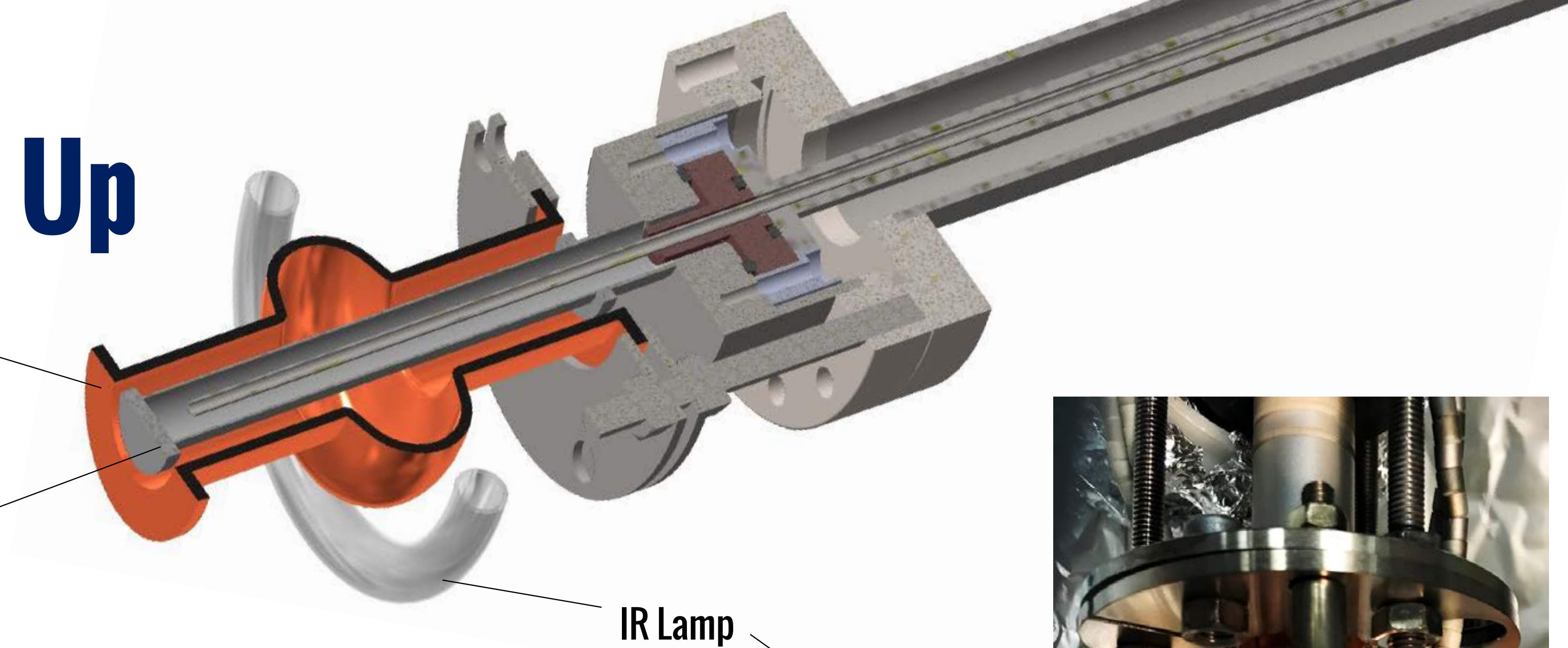


- **Thorton SZ Diagram**
  J.A. Thornton and D.W. Hoffman, Thin Solid Films, vol. 171, no. 1, pp. 5-31, 1989
- **CERN (550 °C)**
  C. Benvenuti et al., *Physica B 197 (1994) 72-83*
- **LNL Alpi Linac (300-500 °C)**
  Stark et al., Proceedings of SRF1997
- **Hie-Isolde (650 °C)**
  Sublet et al., Proceedings of SRF2013

6 GHz cavity coating protocol (2 weeks per cavity)

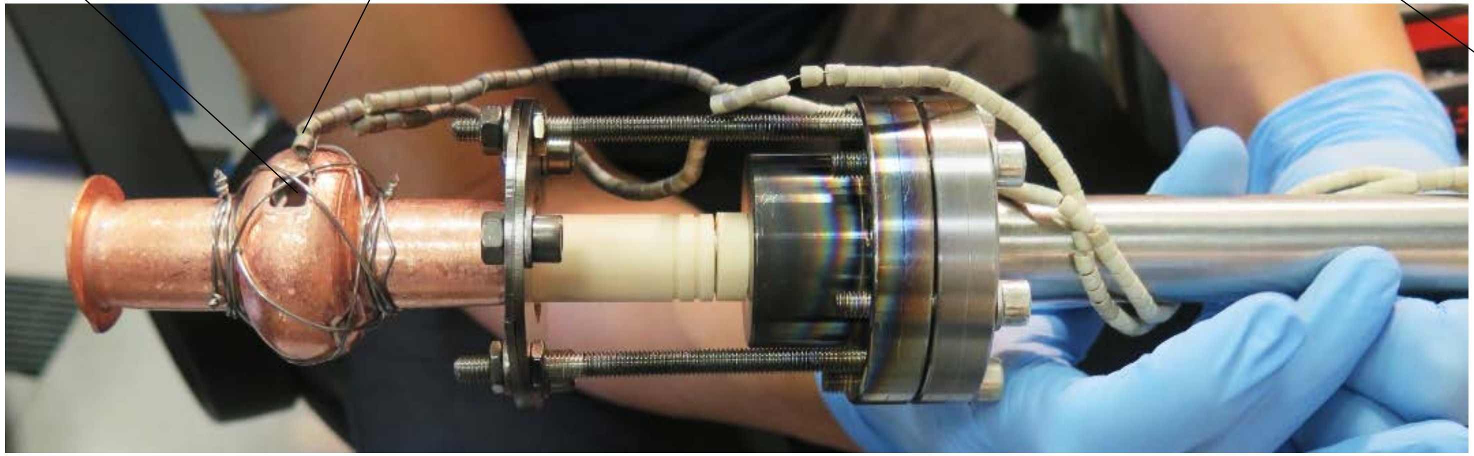
1. Spinning
2. Mechanical Grinding
3. Degreasing
4. EP + SUBU
5. HP Rinsing
6. Cleanroom Vacuum Assembling
7. 48 h Baking 600 °C
8. 7 h PVD process
9. HP Rinsing
10. Cleanroom RF Assembly
11. 4,2 K RF Test
12. 1,8 K RF Test

Deposition Set Up



Quartz sample

Thermocouple



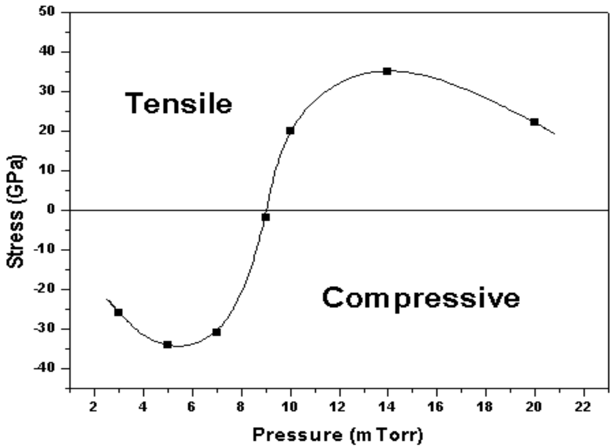
Process parameters

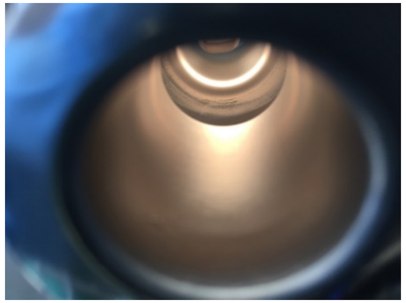
- Temperature = **550 °C** *(baking 600 °C)*
- Base pressure < **2 • 10^{-9} mbar** *(room T)*
- Ar Pressure = **from 7 • 10^{-3} to 5 • 10^{-2} mbar**
- Current = **1 A** (0,017 A/cm^2)
- Magnetic Field = **830 Gauss**
- Deposition Rate = **2,5 - 3 nm/s**

Bending of the flange at 650 °C

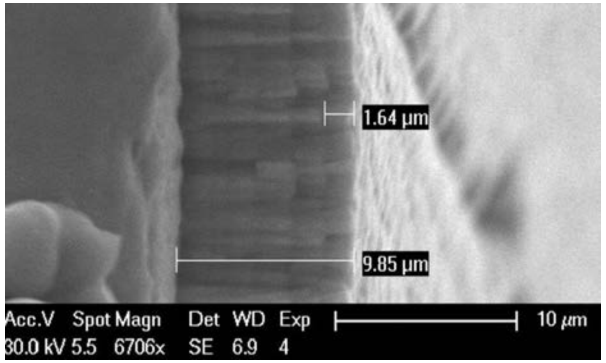
Deposition parameters optimization

- Pressure



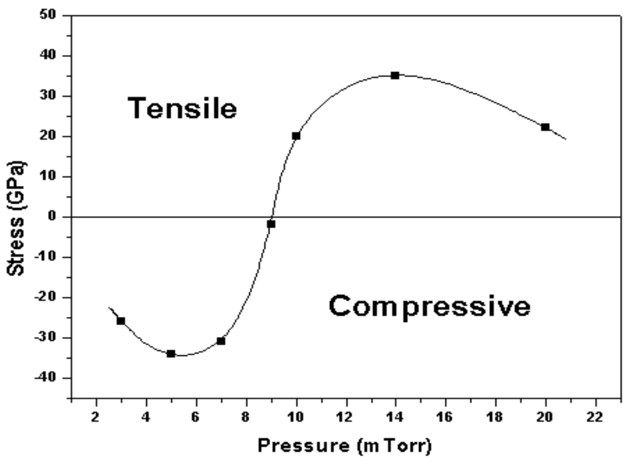


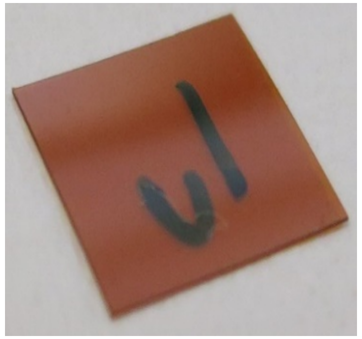
- Multilayer



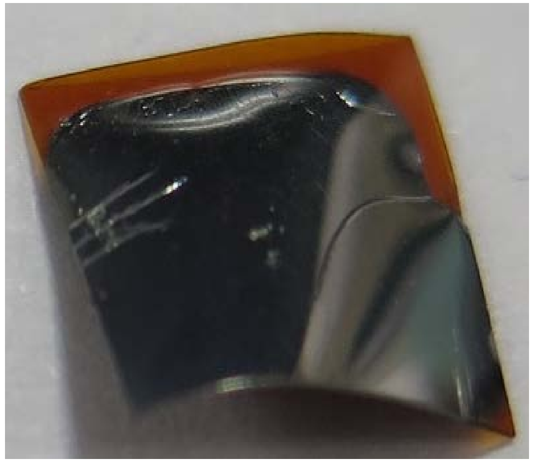
Pressure

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

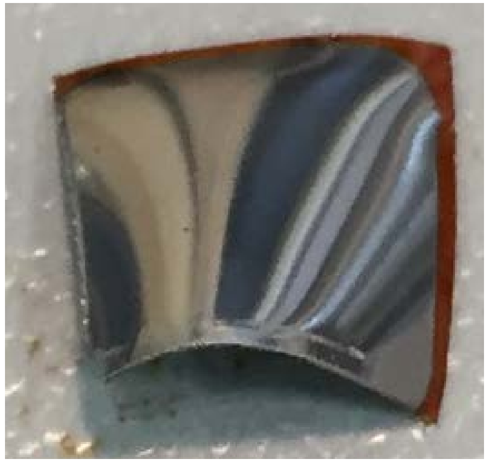




300 °C

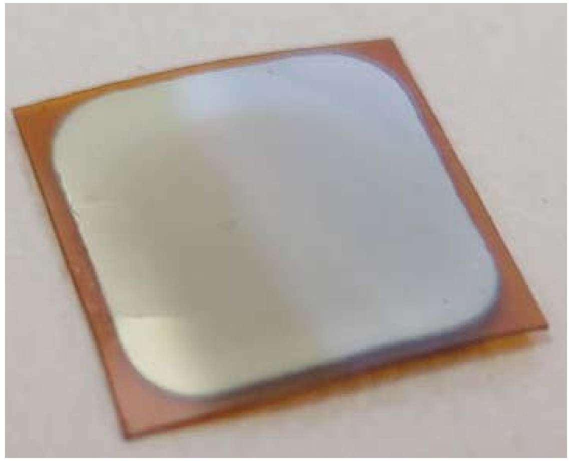


$7 \cdot 10^{-3}$ mbar



$9 \cdot 10^{-3}$ mbar

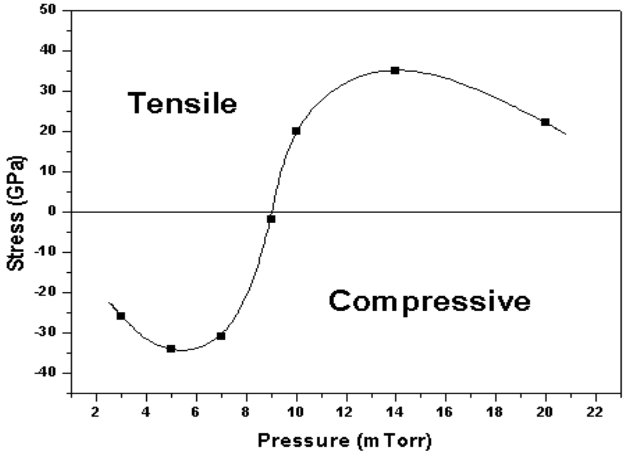
$2 \cdot 10^{-2}$ mbar

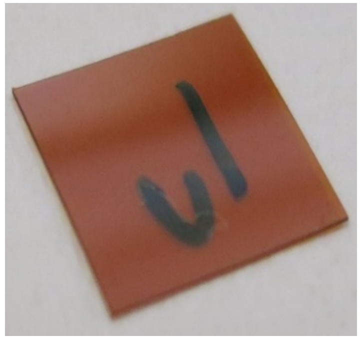


$5 \cdot 10^{-2}$ mbar

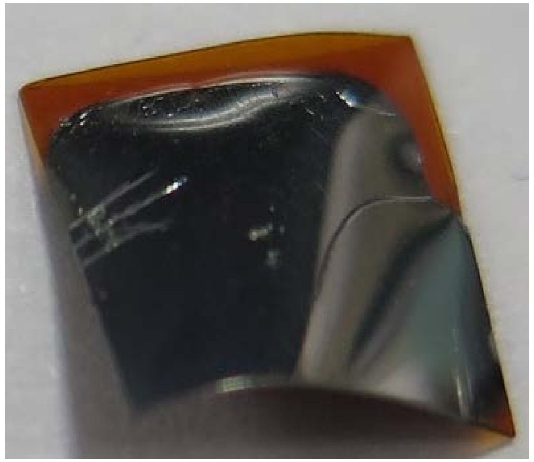
Pressure

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

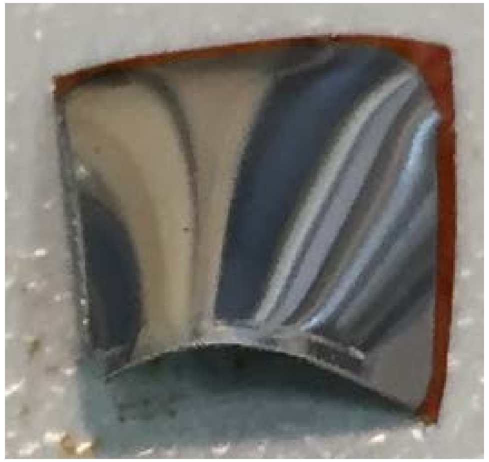




300 °C



$7 \cdot 10^{-3}$ mbar



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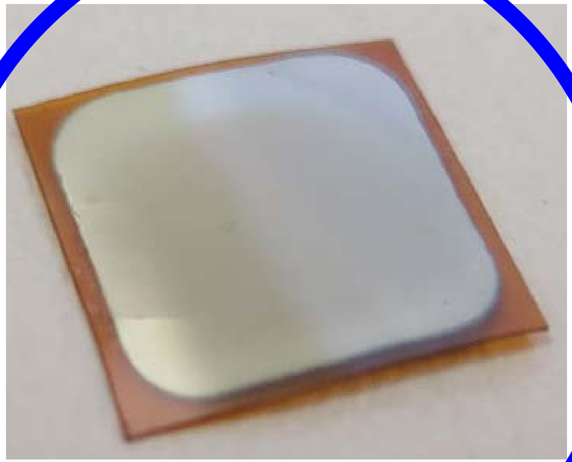
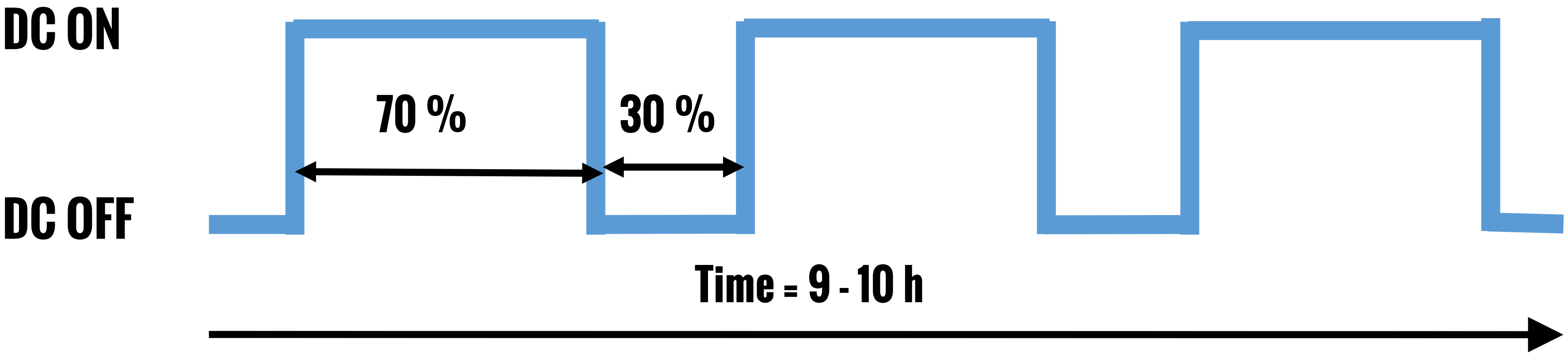
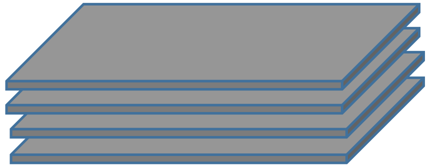


$5 \cdot 10^{-2}$ mbar

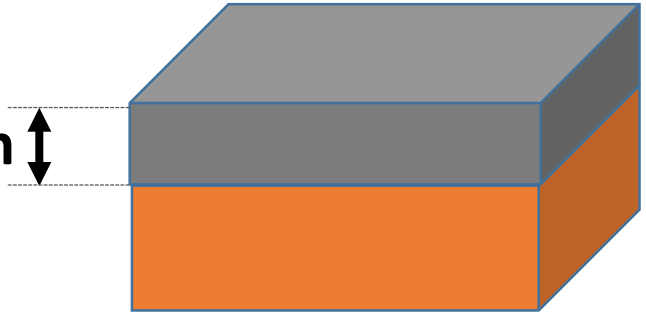
Multilayer





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

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



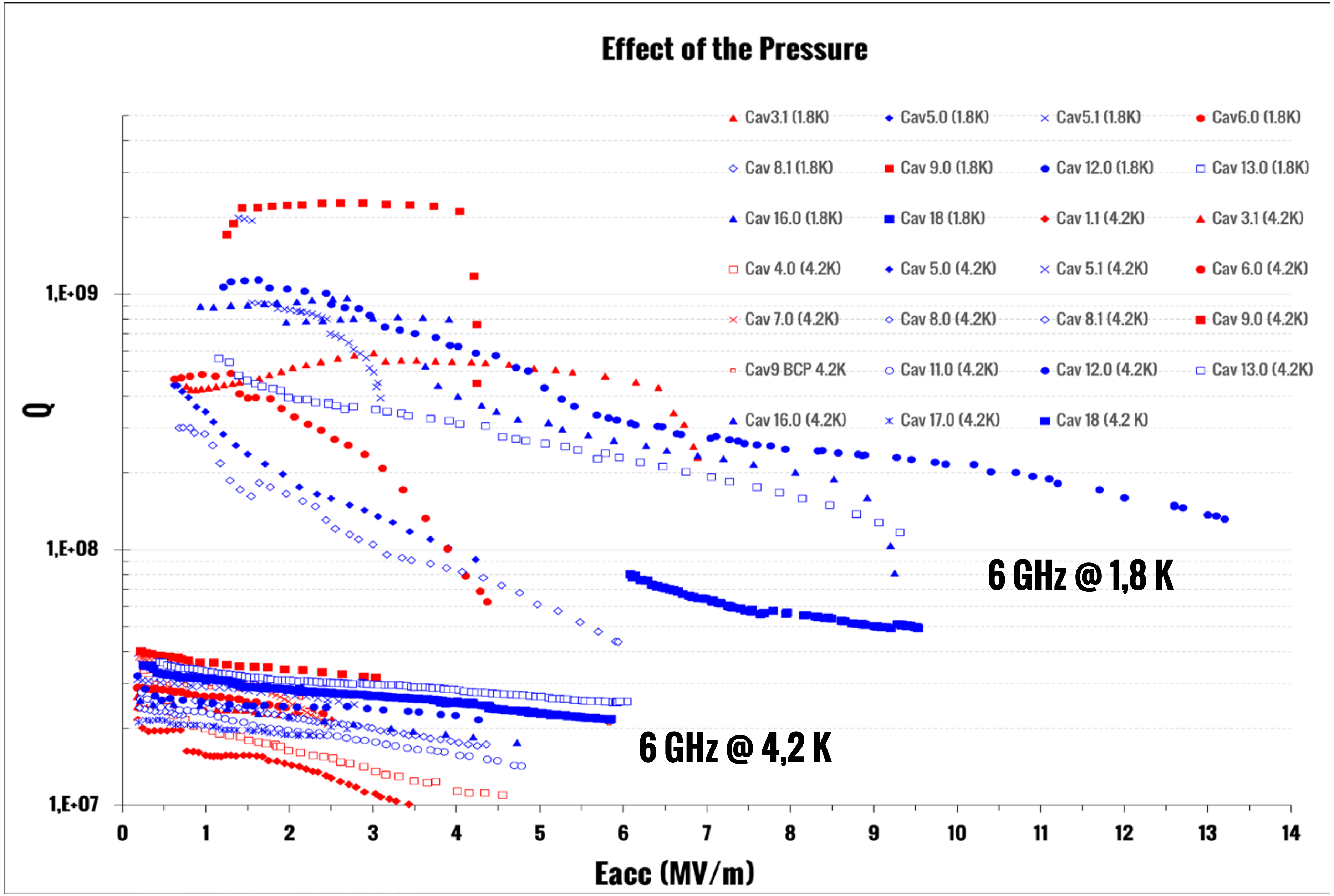
Deposition Rate = **3 nm/s**

Pressure

$5 \bullet 10^{-2}$ mbar

$7 \bullet 10^{-3}$ mbar

Zero stress pressure helps to increase accelerating gradient

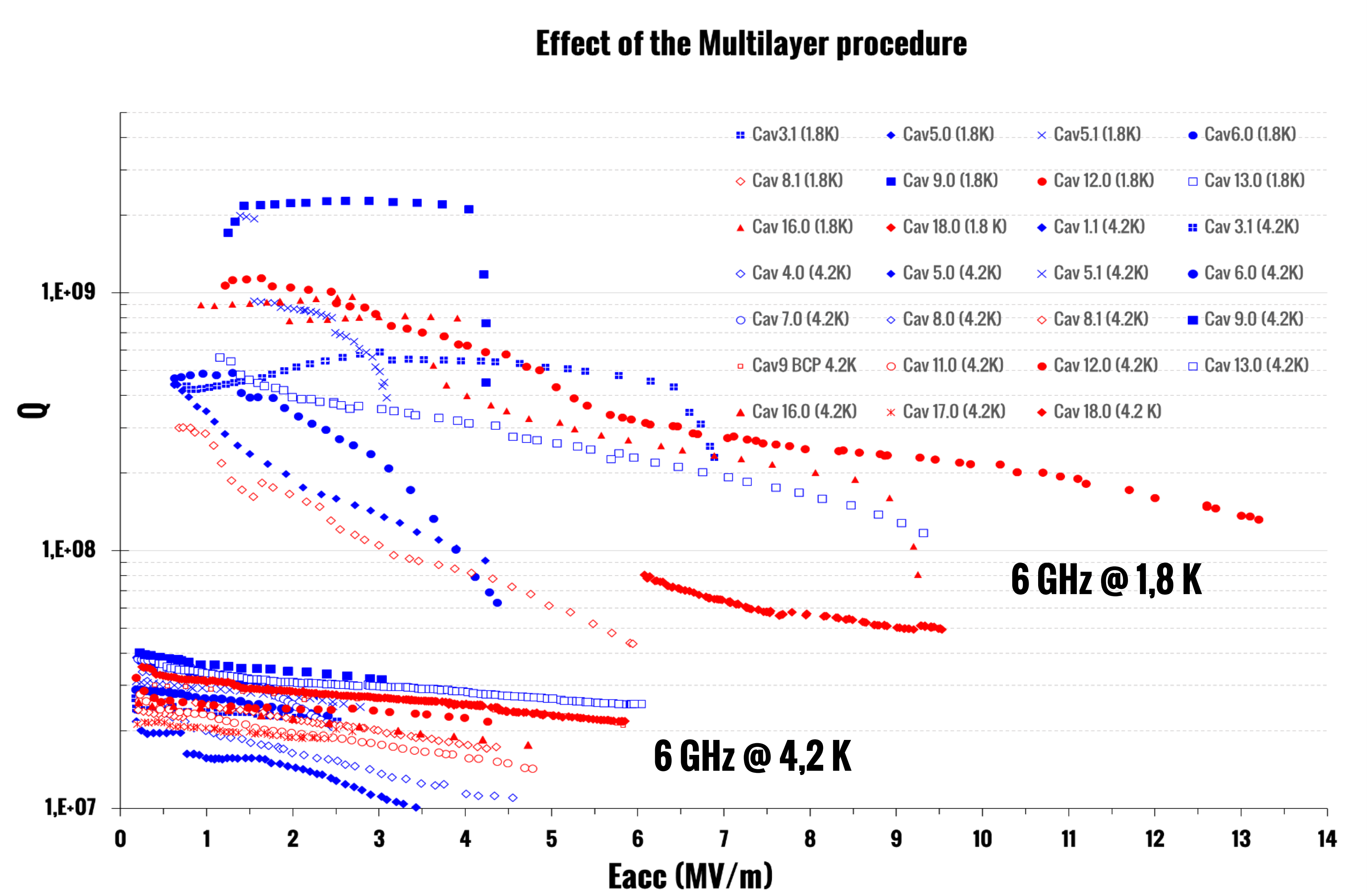


Multilayer

One shot deposition

Multilayer Deposition

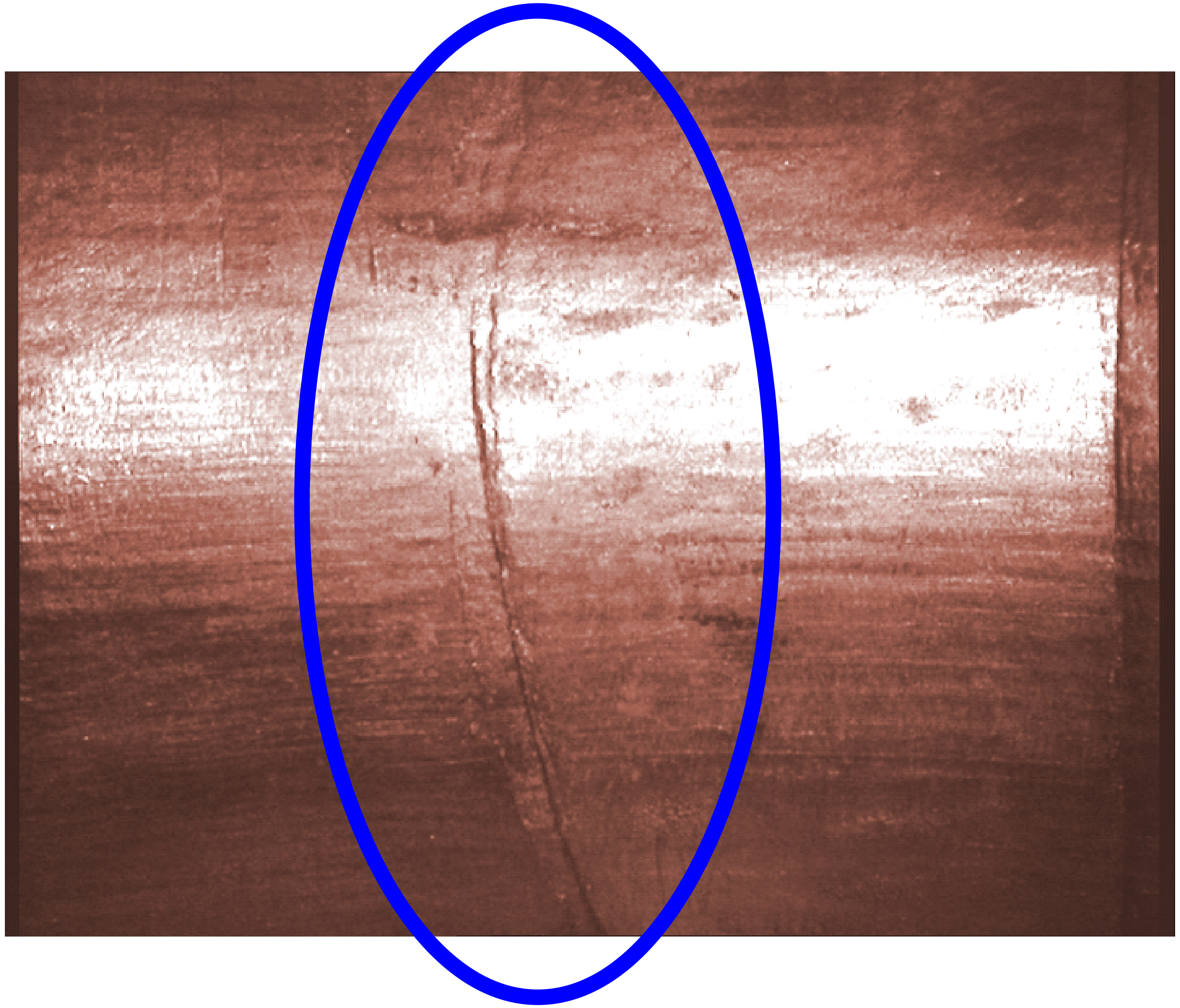
Multilayer process helps to increase accelerating gradient



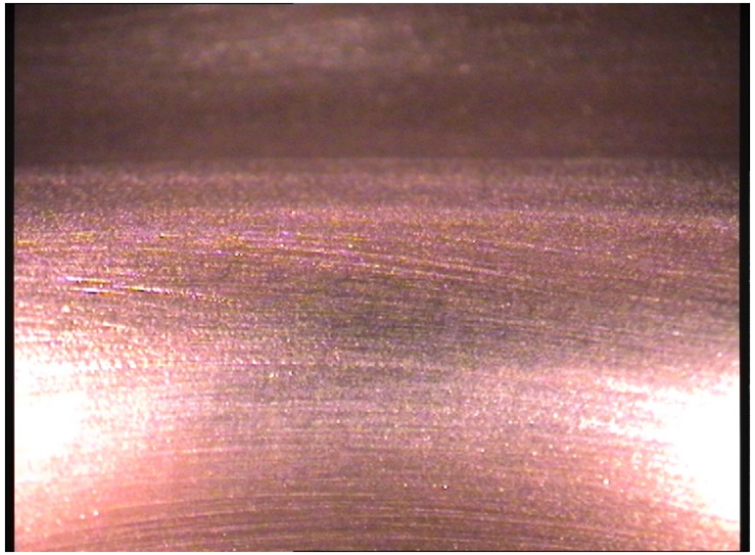
Results interpretation

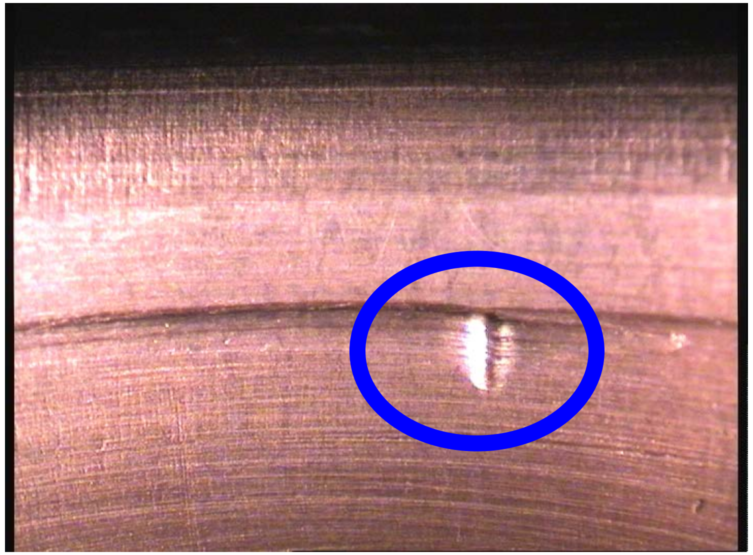
- Sputtering pressure and multilayer deposition reduce film stress
- Film stress reduction reduces film peeling and voids dimension at the interface
- How to explain low reproducibility?

Cavity surface after spinning



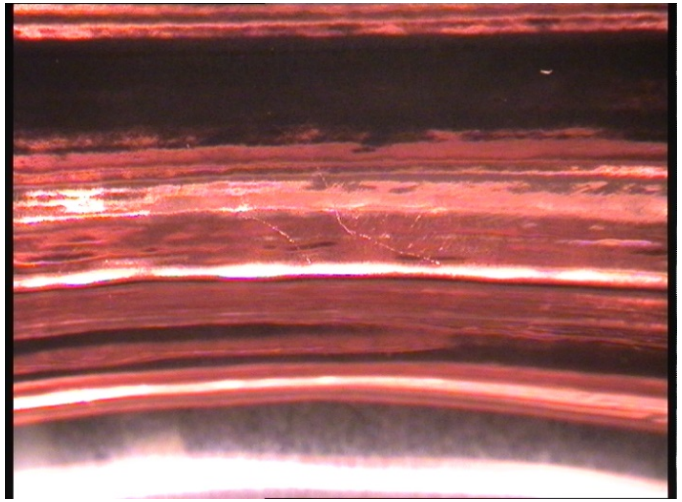
After Mechanical Finishing

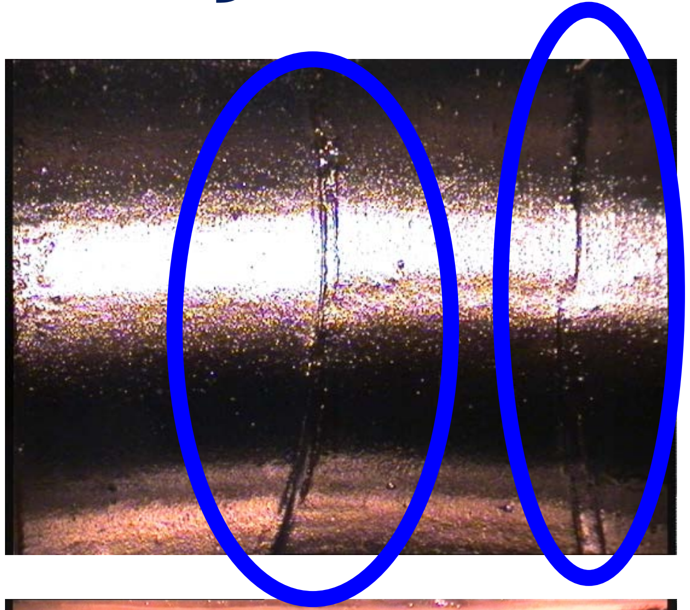


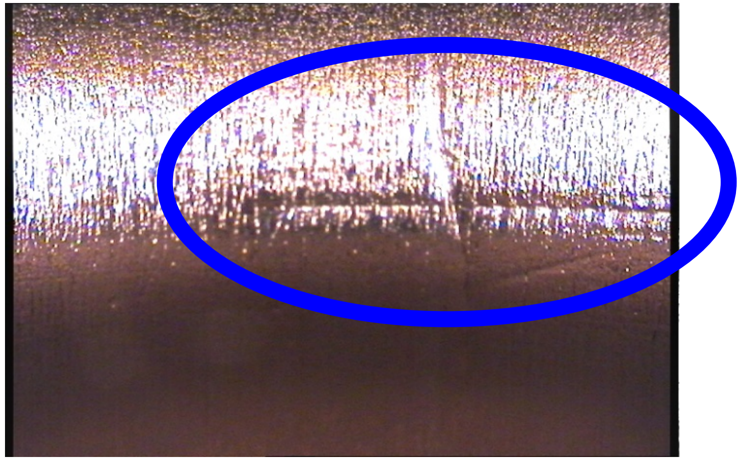


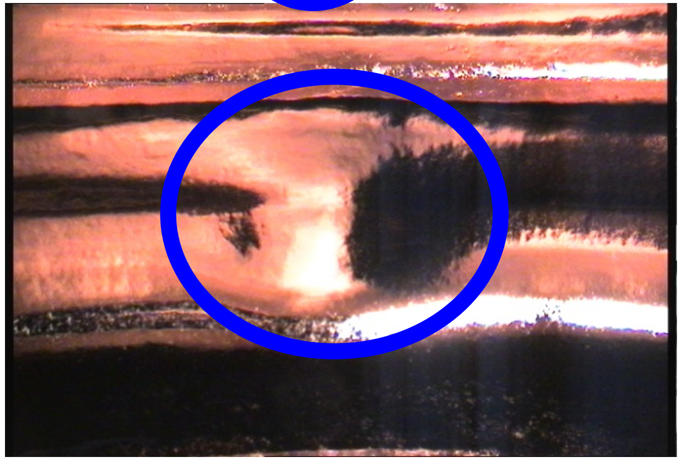
With mechanical grinding some areas of the cell are difficult to access

Surface defects after chemistry



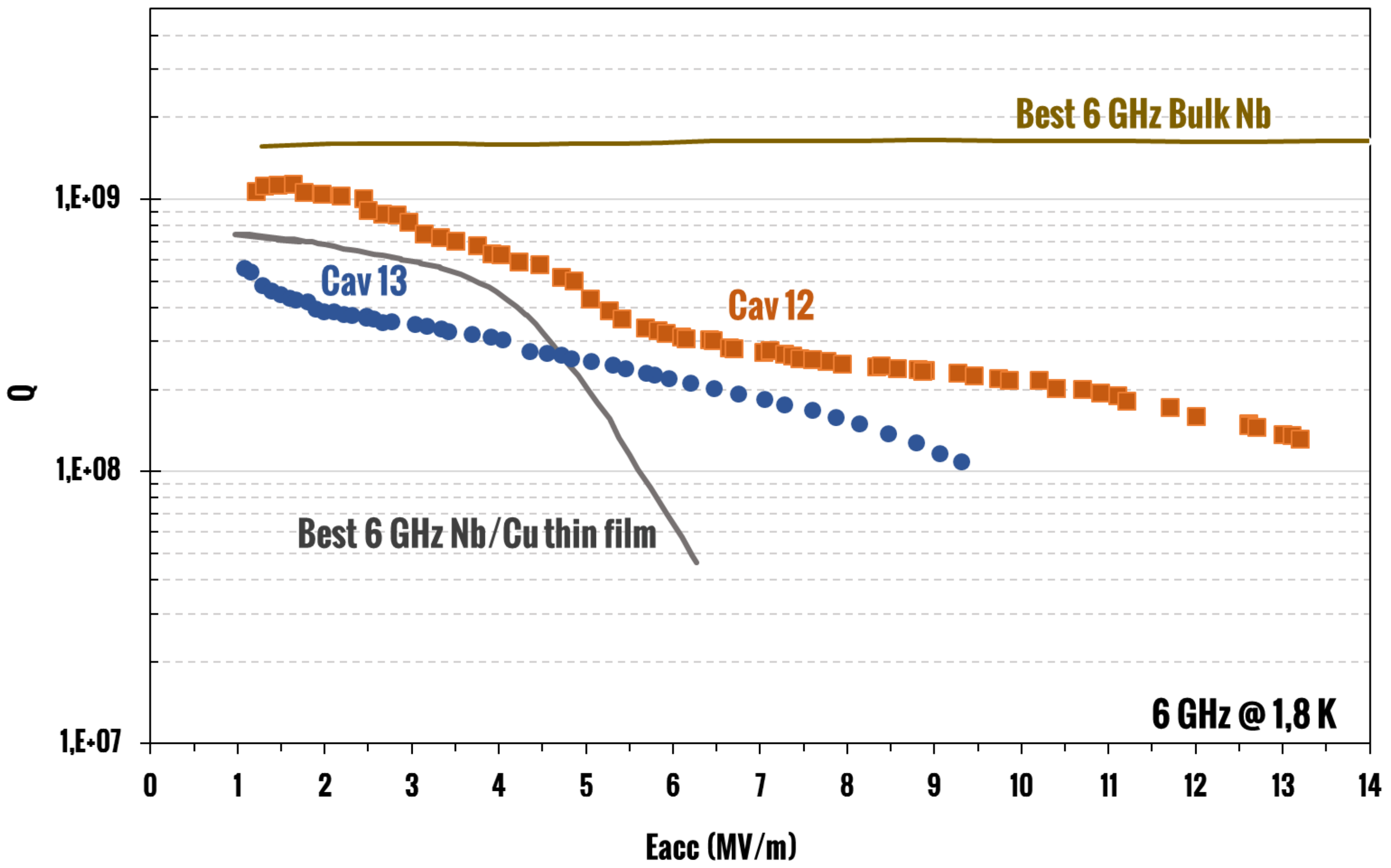




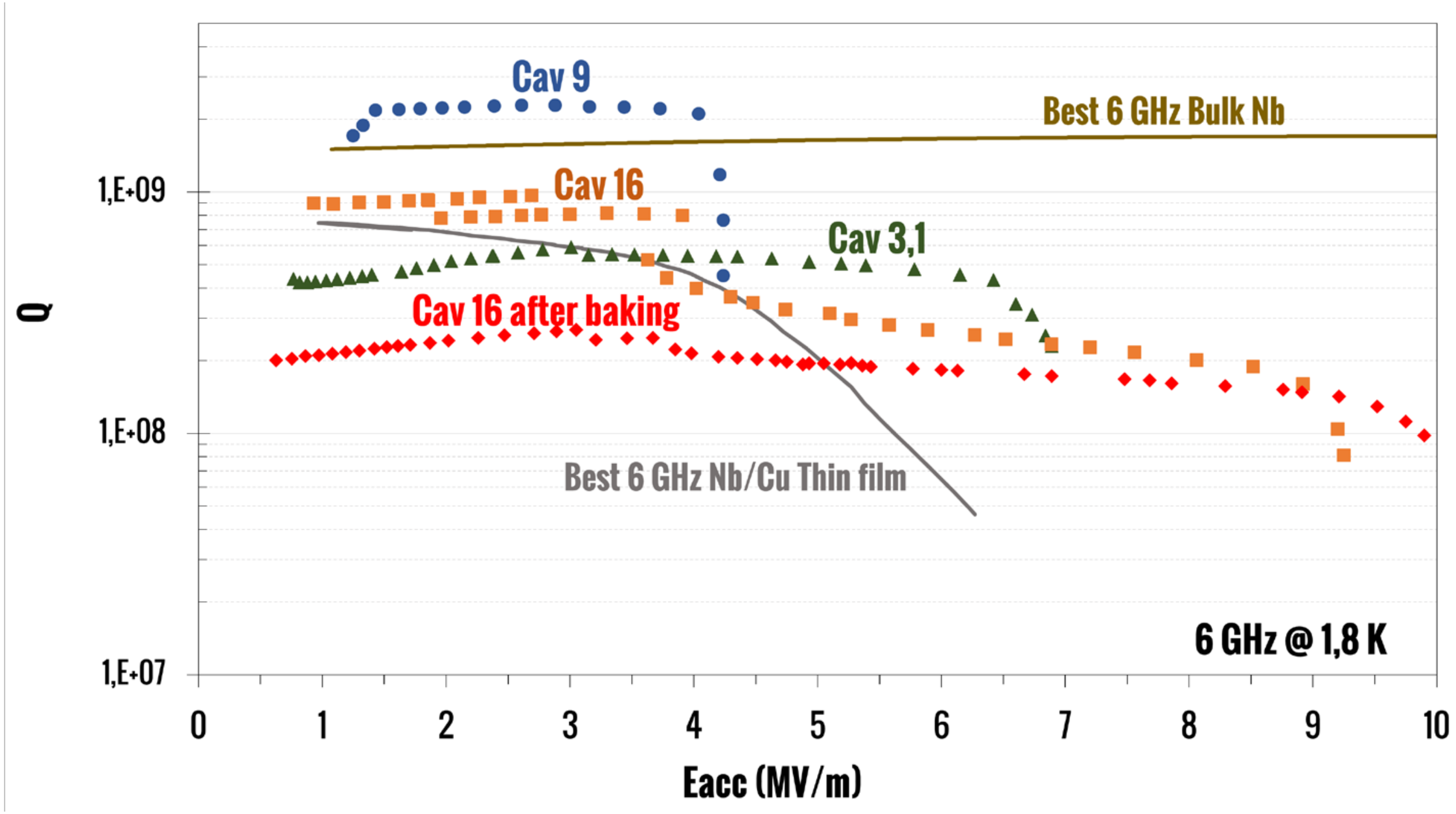


Thick films help on Q-slope problem?

Q-slope remains in many cavities...

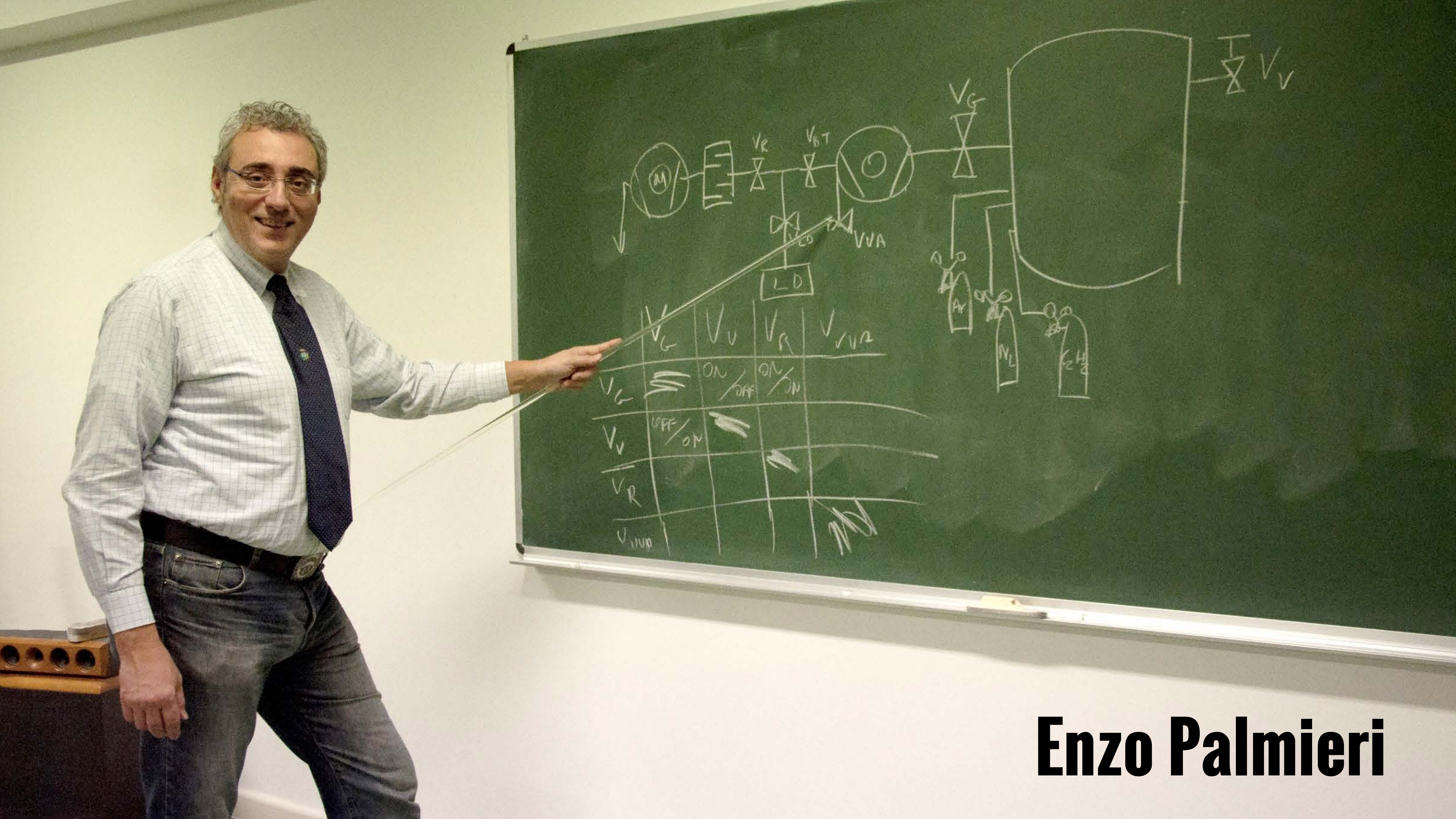


...but not in all ones!



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



Enzo Palmieri

8th International Workshop on

Thin Films and New Ideas for Pushing the Limits of RF Superconductivity

October 8-10, 2018

Legnaro National Laboratories INFN
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