13th International Workshop on RF Superconductivity

DIFFERENT SPUTTERING CONFIGURATIONS FOR COATING 1,5 GHz COPPER CAVITIES

G.Lanza, E.Bemporad, F.Carassiti, S.Deambrosis, N. Patron, C.Pira, M.Sebastiani, S.Stark and H.Padamsee, V.Palmieri

Is it possible:

- to improve the Nb/Cu cavities performances?

- to straighten the Q-slope of Niobium thin films?

Introduction

PLASMA DENSITY

BIAS MAGNETRON PLASMA

HIGH IONIZED PLASMA

APPARATUS

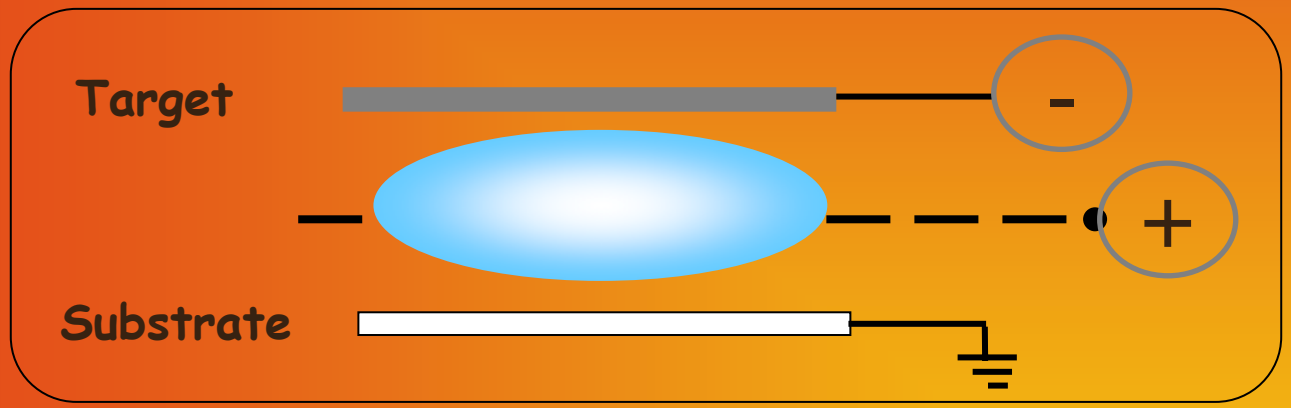
SUPERCONDUC. vs MORPHOLOGY

RF RESULTS

FUTURE STUDIES

Densify the Sputtering Discharge

- Positive electrode insert in the diode configuration



- Positive ions bombardment of the growing film
- Impurities are preferentially removed relative to the atoms of the main film
- Densification of the crystal structure
- Increasing of the coating hardness
- Adhesion improvement

PLASMA DENSITY

BIAS

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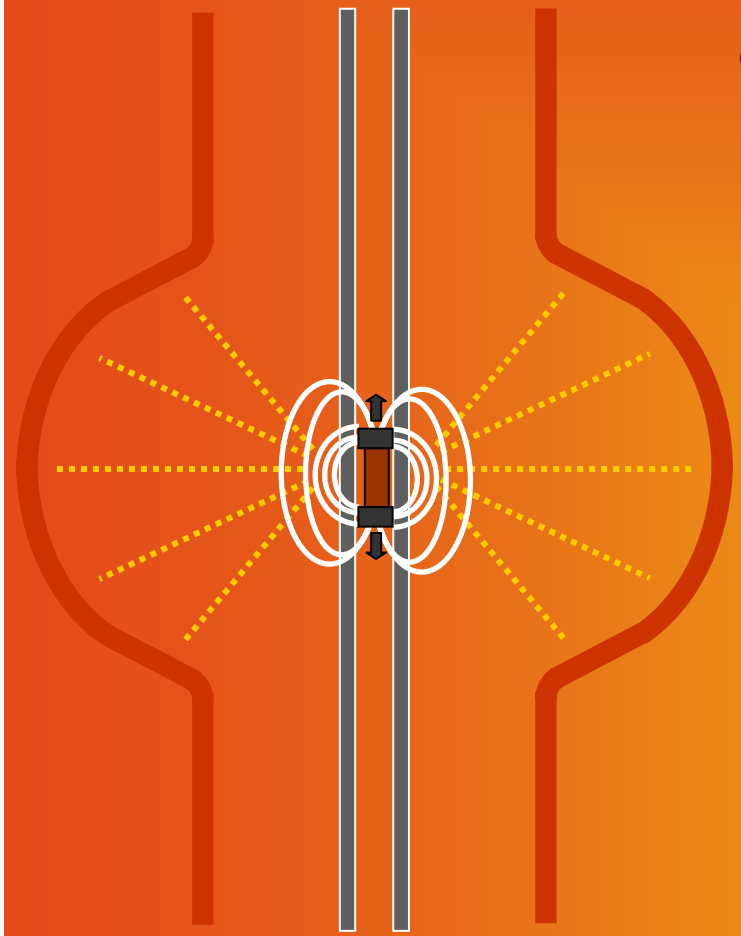
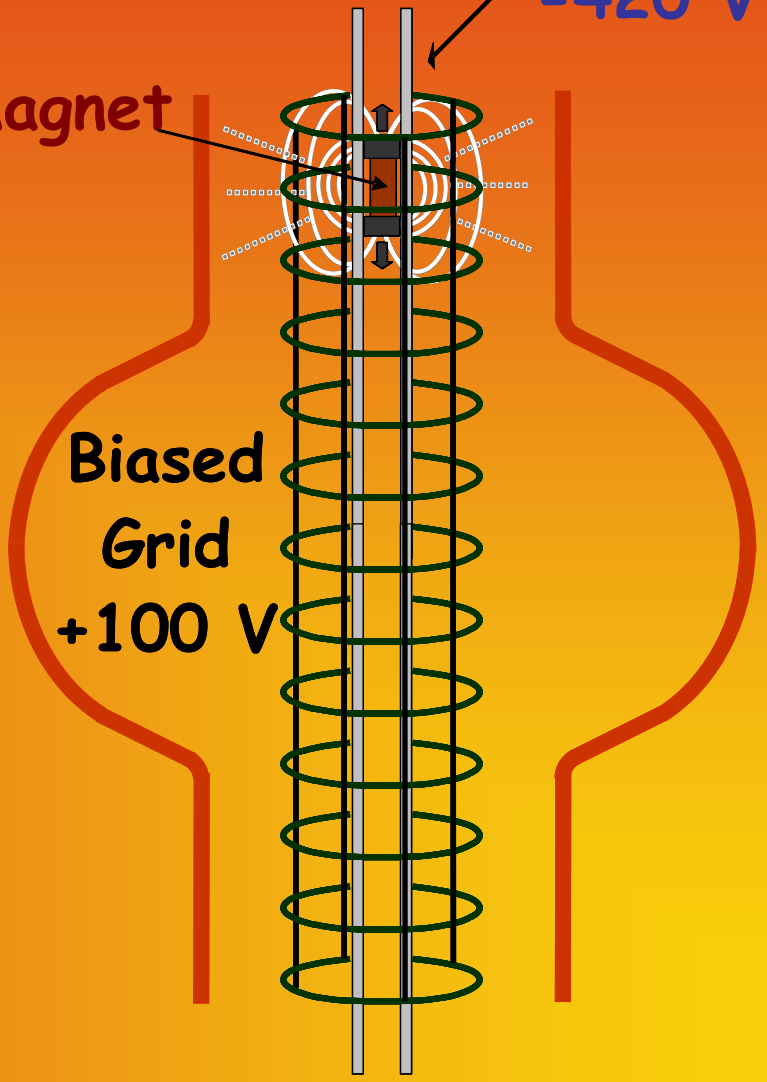
Techniques Comparison





STANDARD CERN PLASMA

BIAS MAGNETRON PLASMA

PLASMA DENSITY

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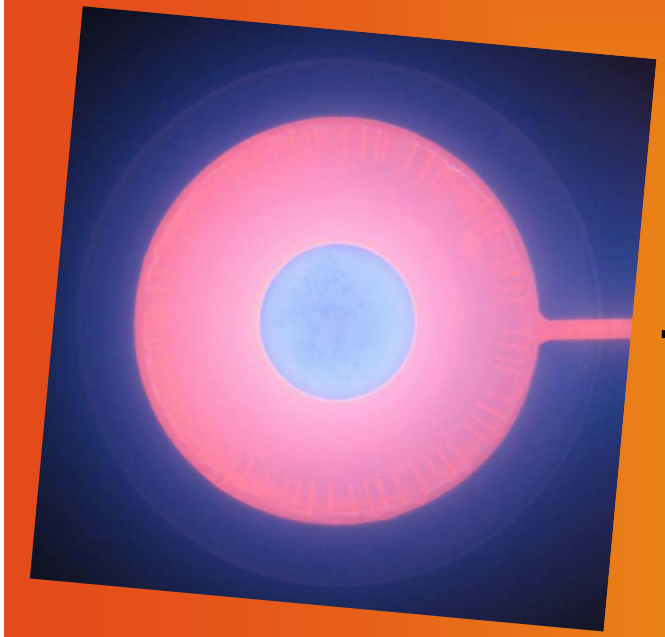
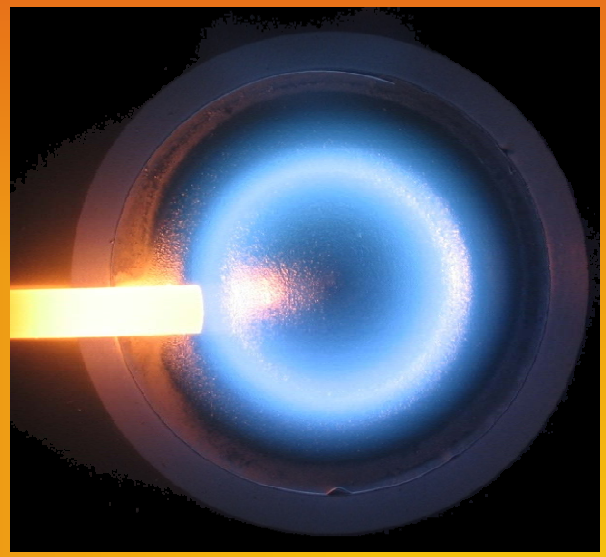
Densify the Sputtering Discharge

- Feed the magnetron with an electrons extra source





Hollow Cathode

Planar Magnetron

- Deposition rate increases
- Less direzionality of the ions

PLASMA DENSITY

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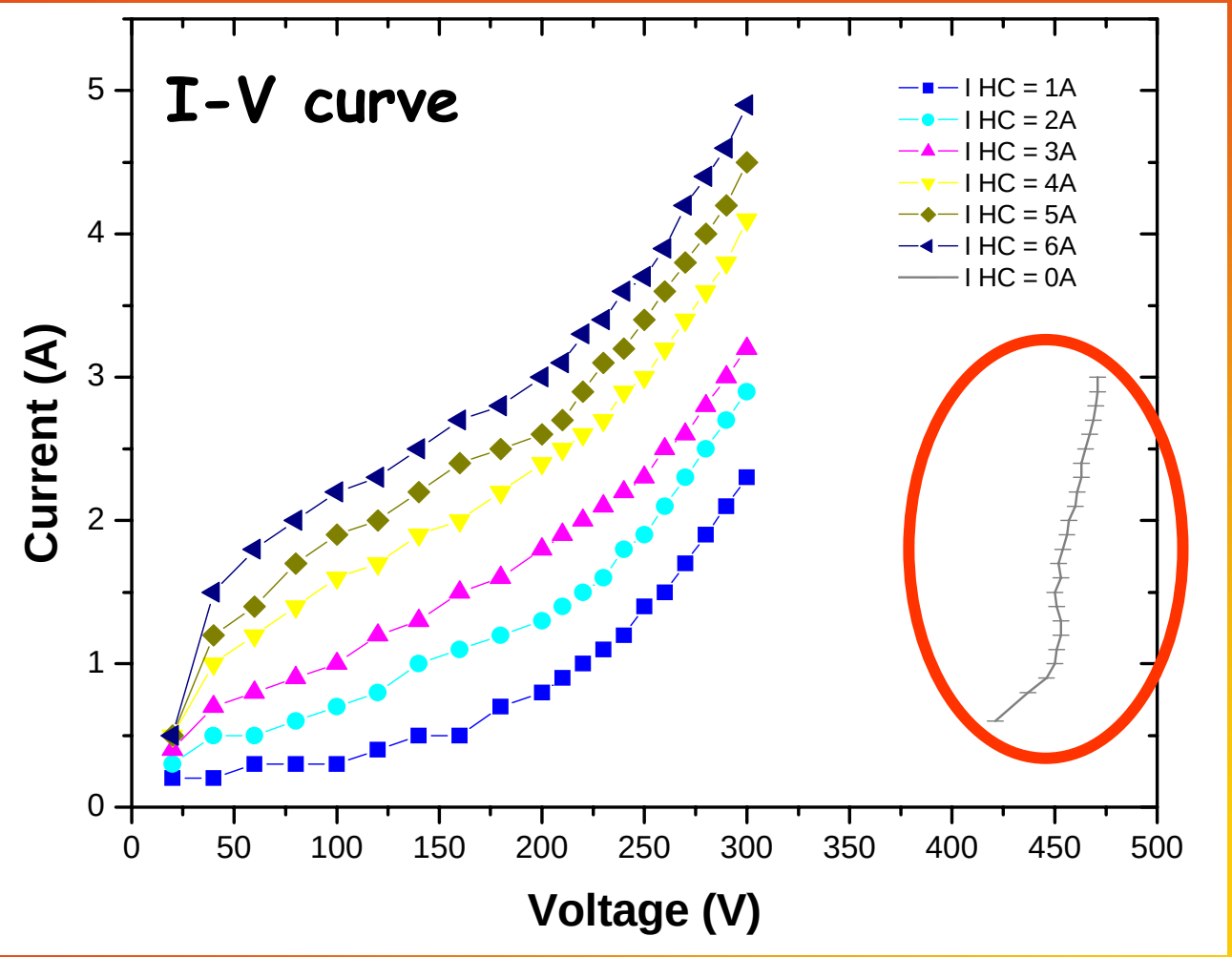
Hollow Cathode Magnetron



hollow cathode magnetron characteristics

plane magnetron characteristic

PLASMA DENSITY

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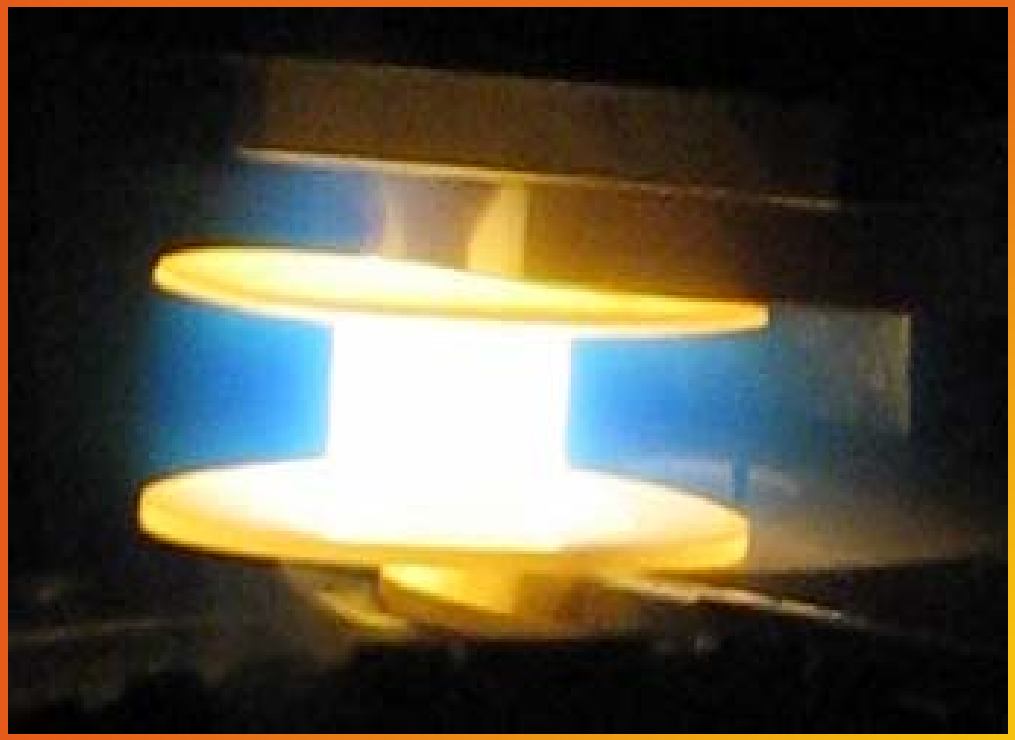
High Ionized Plasma

...let's try heating directly the post-magnetron



In the termoelectronic emission regime the cathode emits avalanches of electrons that feed and densify the plasma

PLASMA DENSITY

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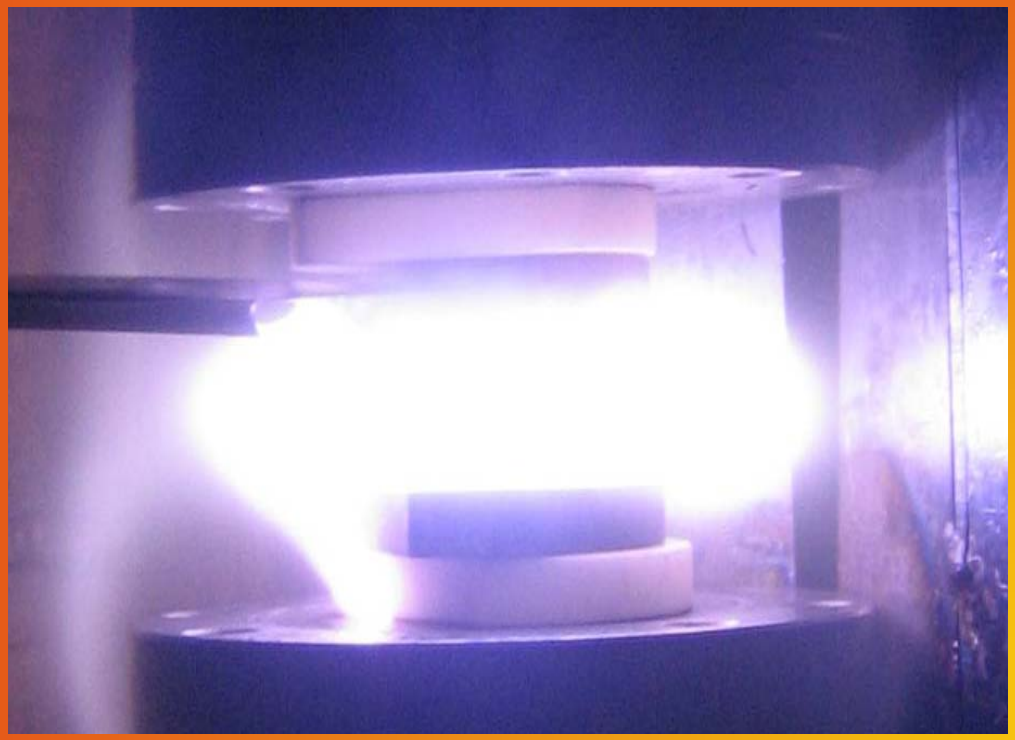

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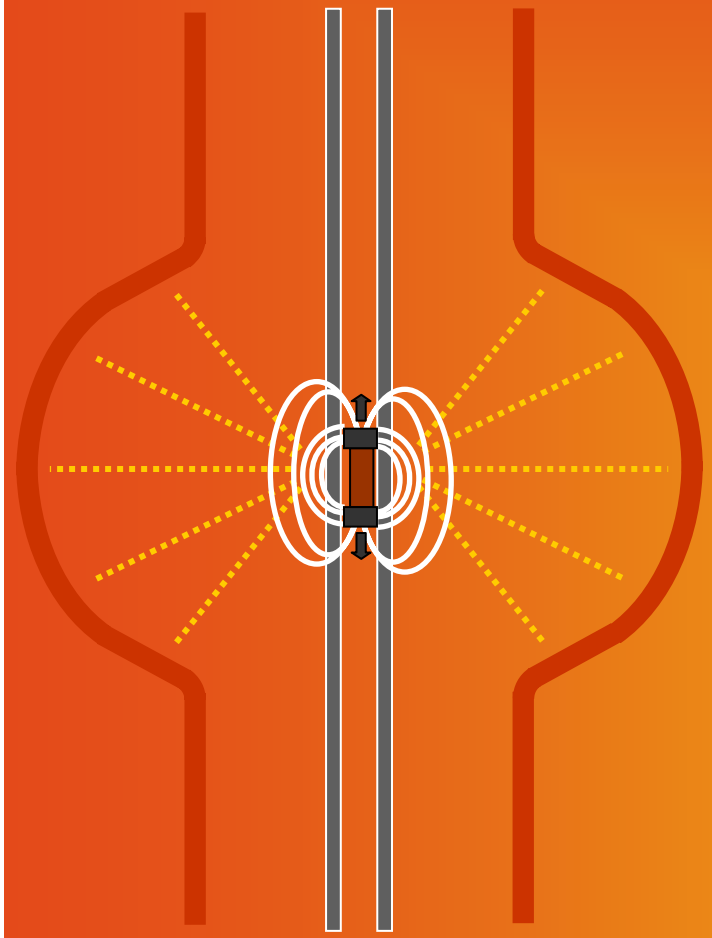

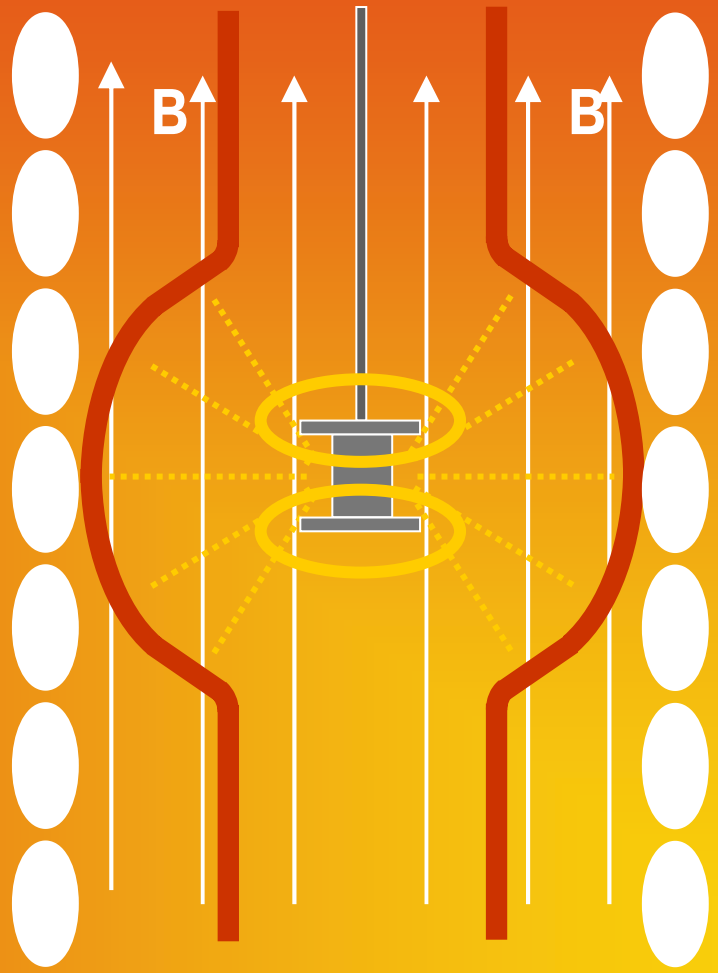

STANDARD CERN PLASMA

HIGLY IONIZED PLASMA

PLASMA DENSITY

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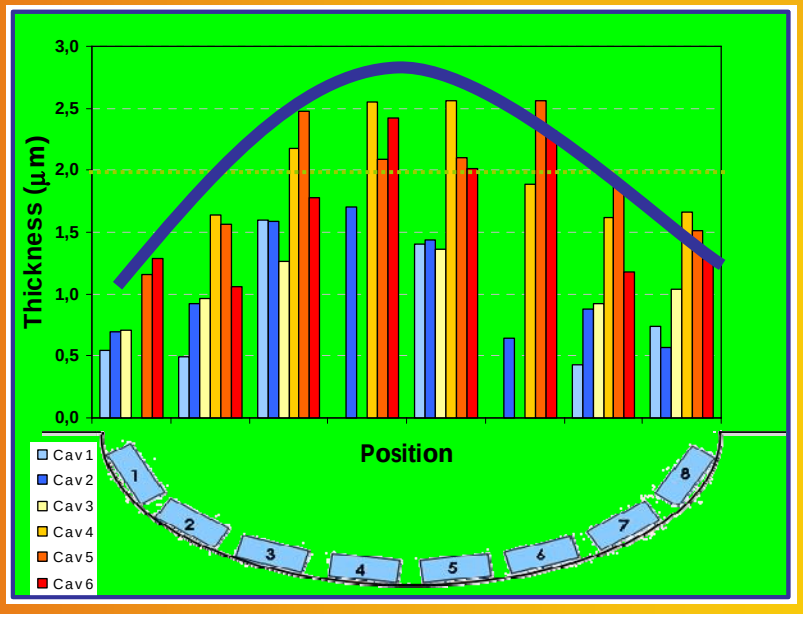
FUTURE STUDIES

High Ionized Plasma Results:

Still low RRR:

- electronic bombardment of the substrate
- high heating of the chamber and successively degassing
- Impurities from BN isolators

Non homogeneous thickness distribution



Bias Results:

Tc always higher than T_c^{bulk}

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RF RESULTS

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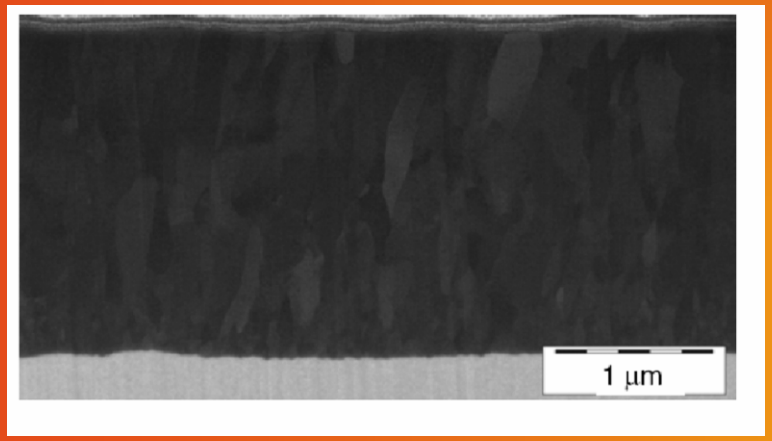
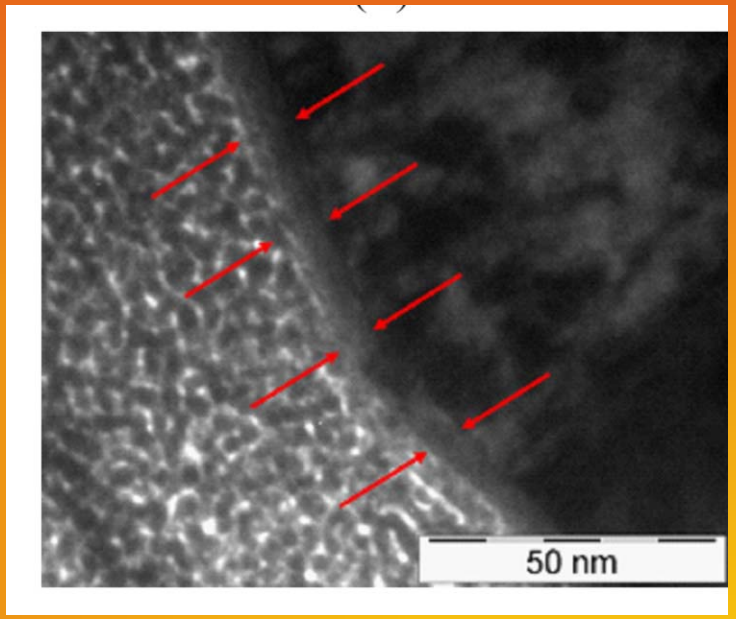
Focused Ion Beam



FEG-SEM SE 3 kV 80000x,
after FIB sectioning



TEM BF 660000X after
FIB lamella thinning

Nb on Cu BIASED

PLASMA DENSITY

BIAS

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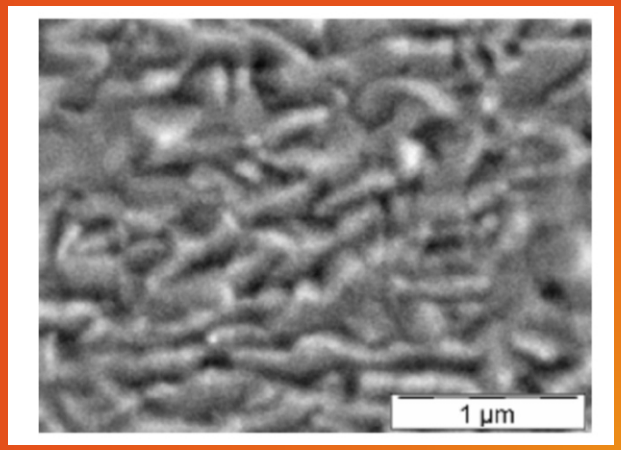
SUPERCONDUC. vs MORPHOLOGY

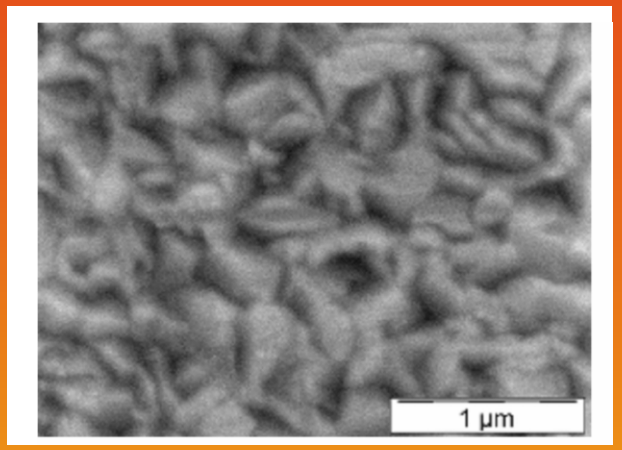
RF RESULTS

FUTURE STUDIES

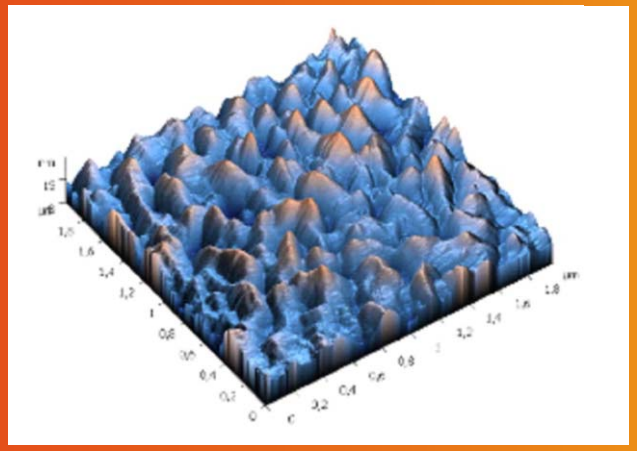
SEM-AFM Surface Analysis



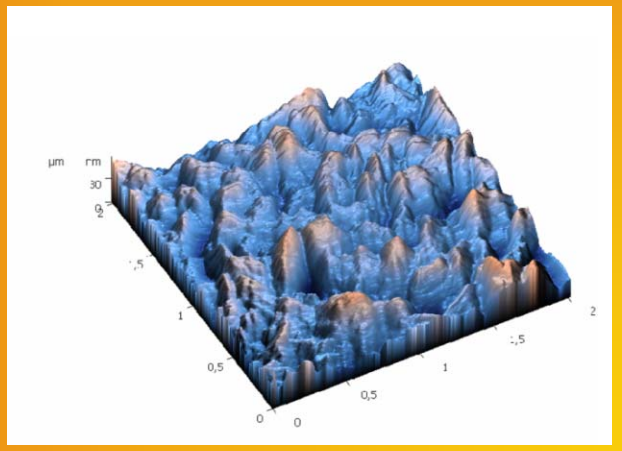
SEM SE 20 kV 40000x



SEM SE 20 kV 40000x



Contact Mode AFM



Contact Mode AFM

Nb on Cu UNBIASED

Nb on Cu BIASED

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BIAS

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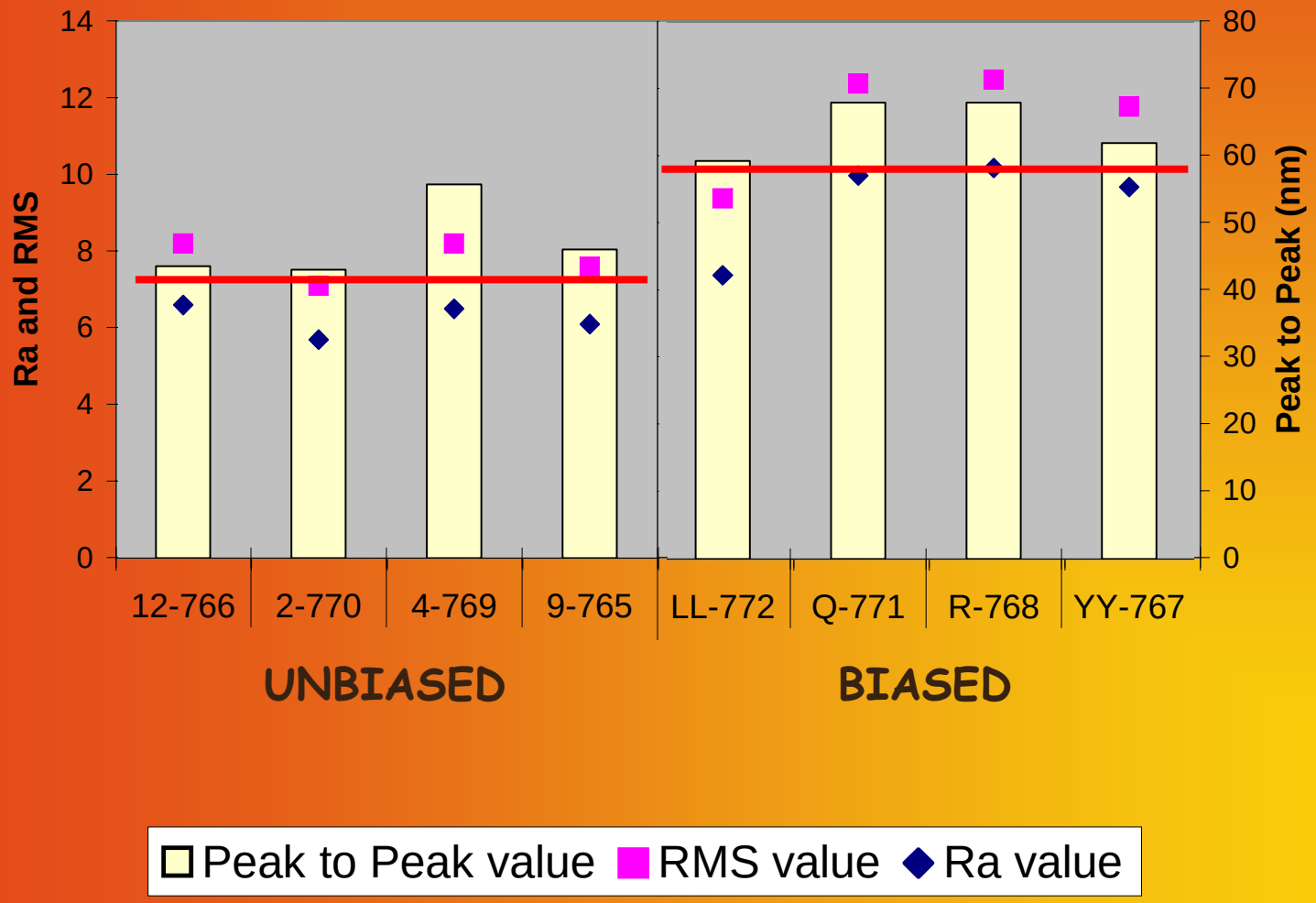
RF RESULTS

FUTURE STUDIES

Roughness



PLASMA DENSITY

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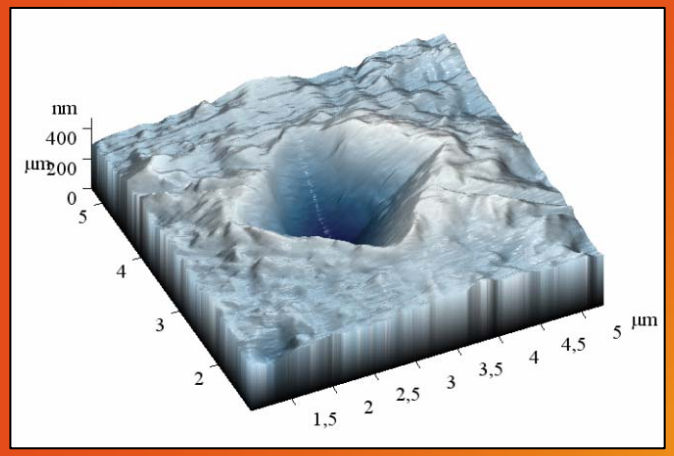
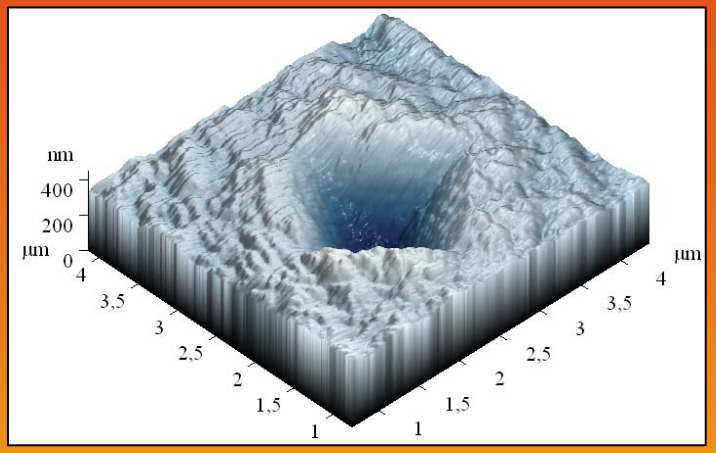
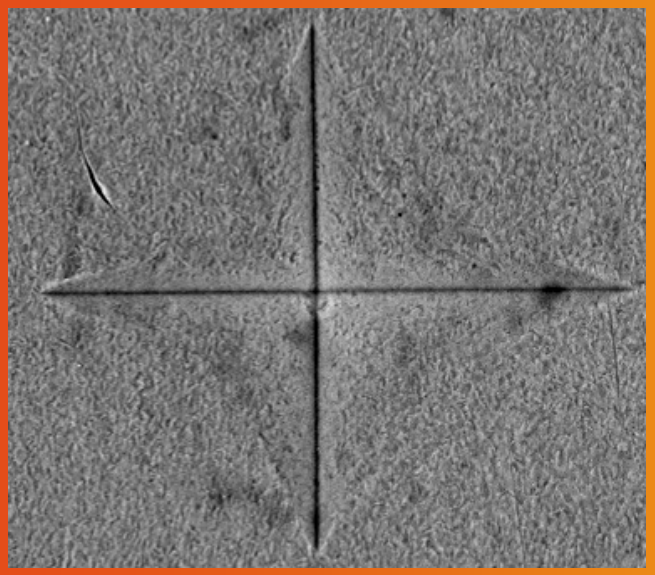
RF RESULTS

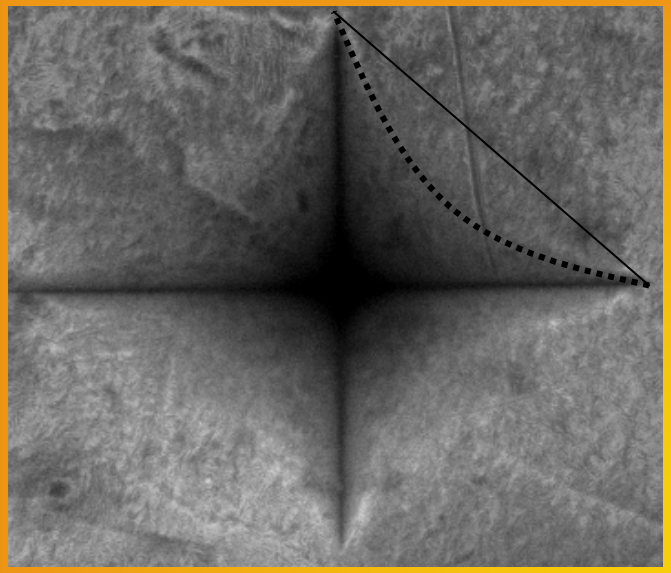
FUTURE STUDIES

Vickers Indentation









Unbiased MS

E = 54,33 GPa

Biased MS

E = 88,95 GPa

PLASMA DENSITY

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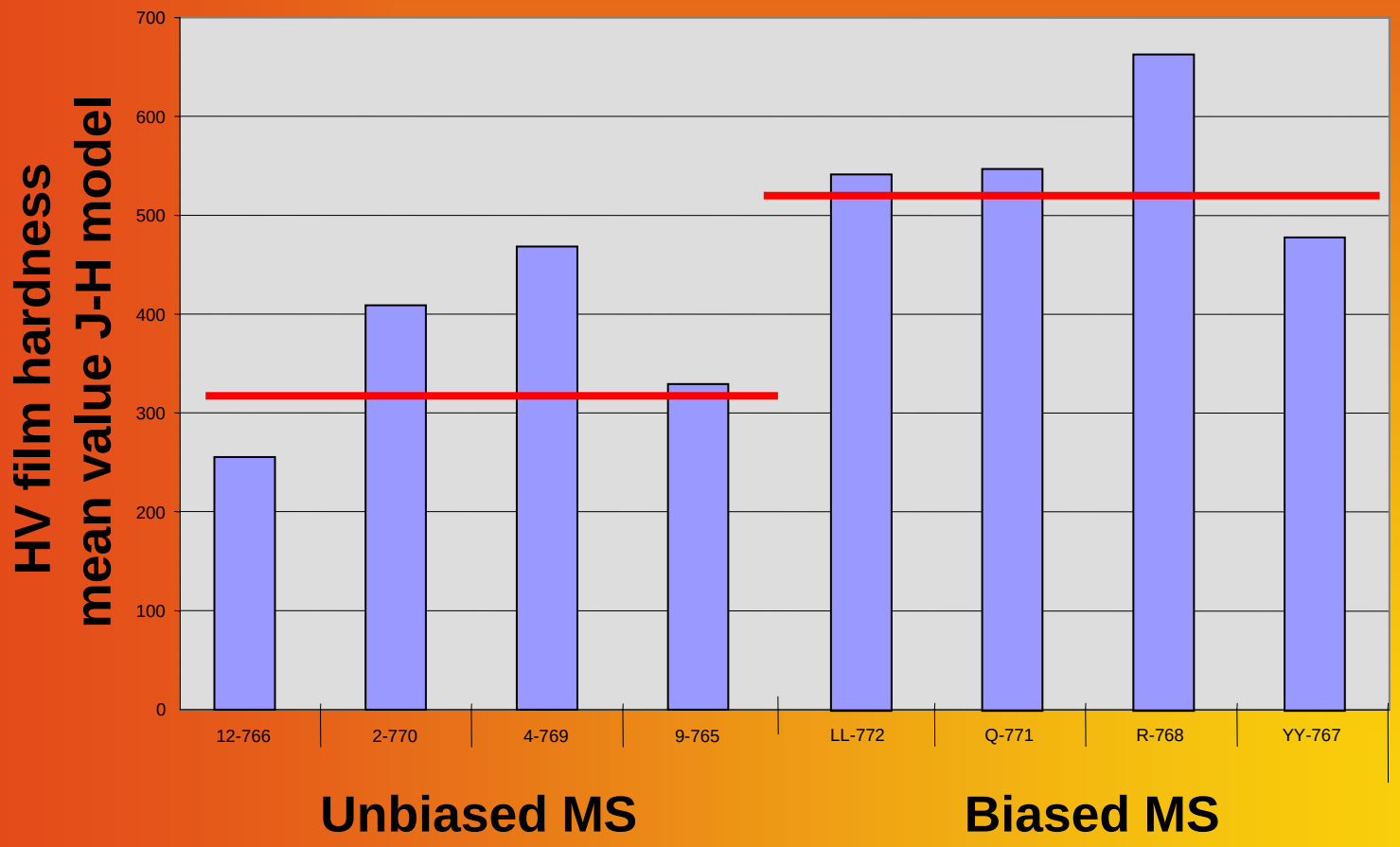
RF RESULTS

FUTURE STUDIES

Hardness comparison



PLASMA DENSITY

BIAS

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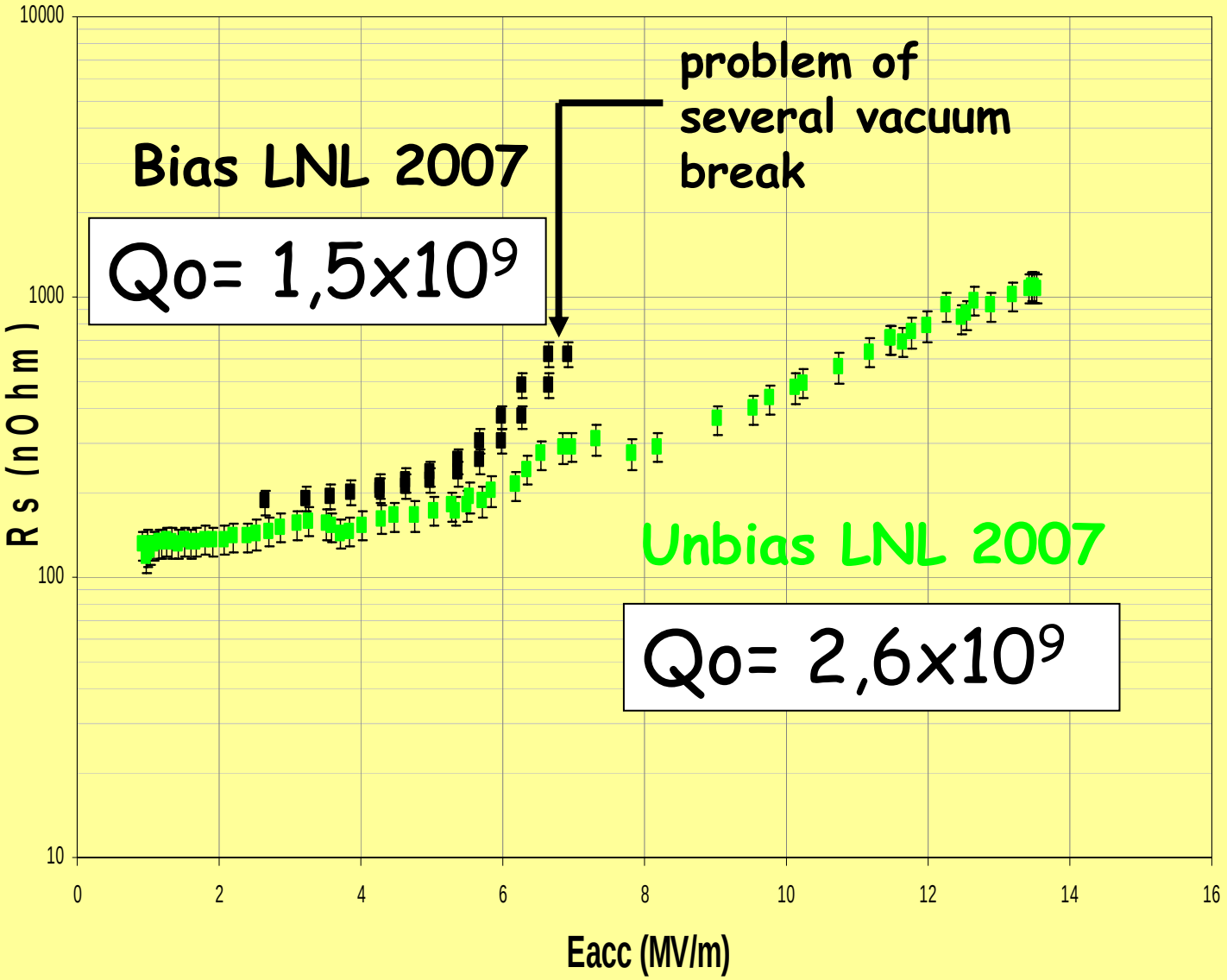
RF RESULTS

FUTURE STUDIES

RF measures on 1,5 GHz cavities



PLASMA DENSITY

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RF RESULTS

FUTURE STUDIES

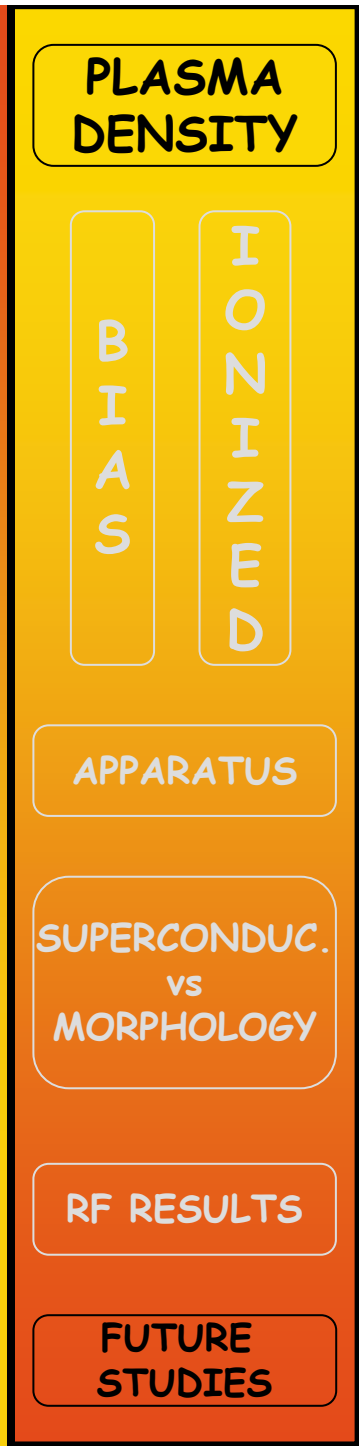
BIAS Results

Biased films show:

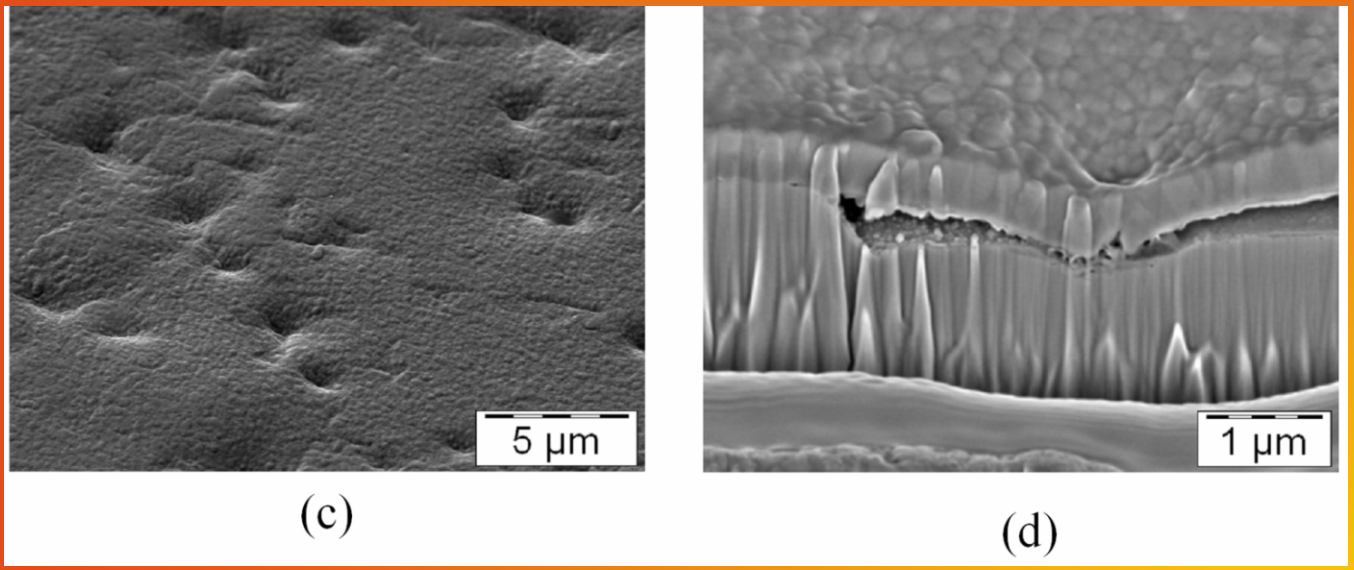
- Higher surface roughness
- Higher hardeness → denser structure
- Lower mean crystallite size
- RRR lower than unbiased film
- first RF measure of biased cavity had problems of vacuum breaks and test will be repeated

Future Studies

- **Combine both techniques**
- Increase film thickness
- Use Kripton as sputtering gas
- Apply new cleaning treatment technique
- Check all cavities preparation steps




Thanks



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PLASMA DENSITY

BIAS

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TESTS

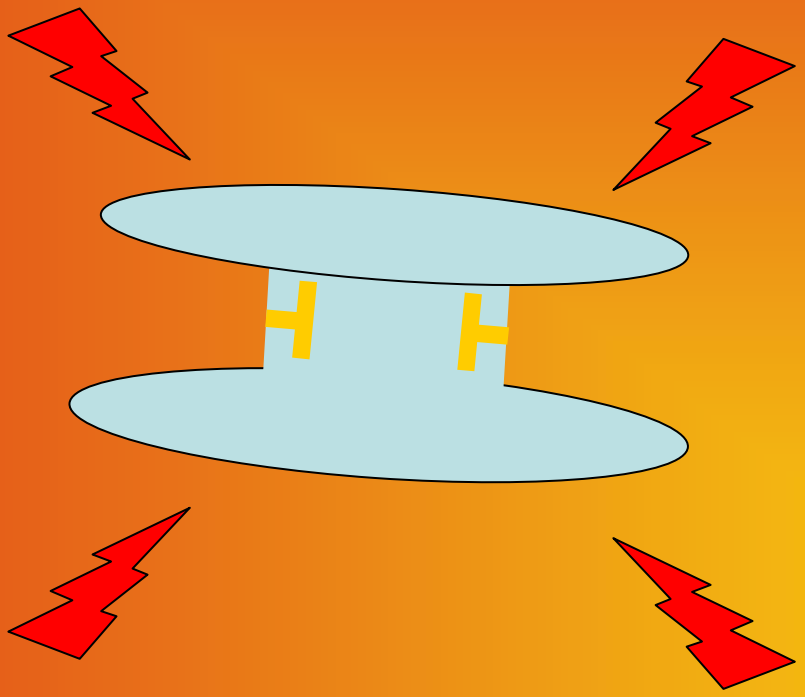
SUPERCONDUC. vs MORPHOLOGY

RF RESULTS

FUTURE STUDIES

High Ionized Plasma

...let's try heating directly the post-magnetron with holes inside it



PLASMA DENSITY

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SUPERCONDUC. vs MORPHOLOGY

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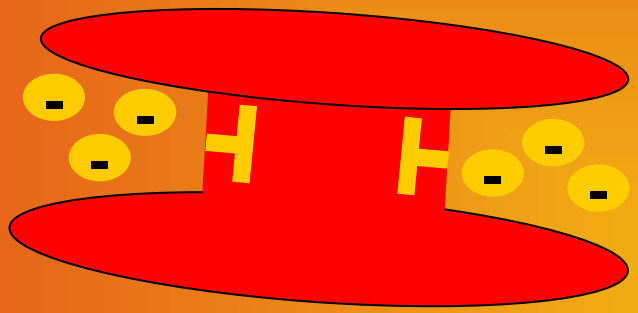
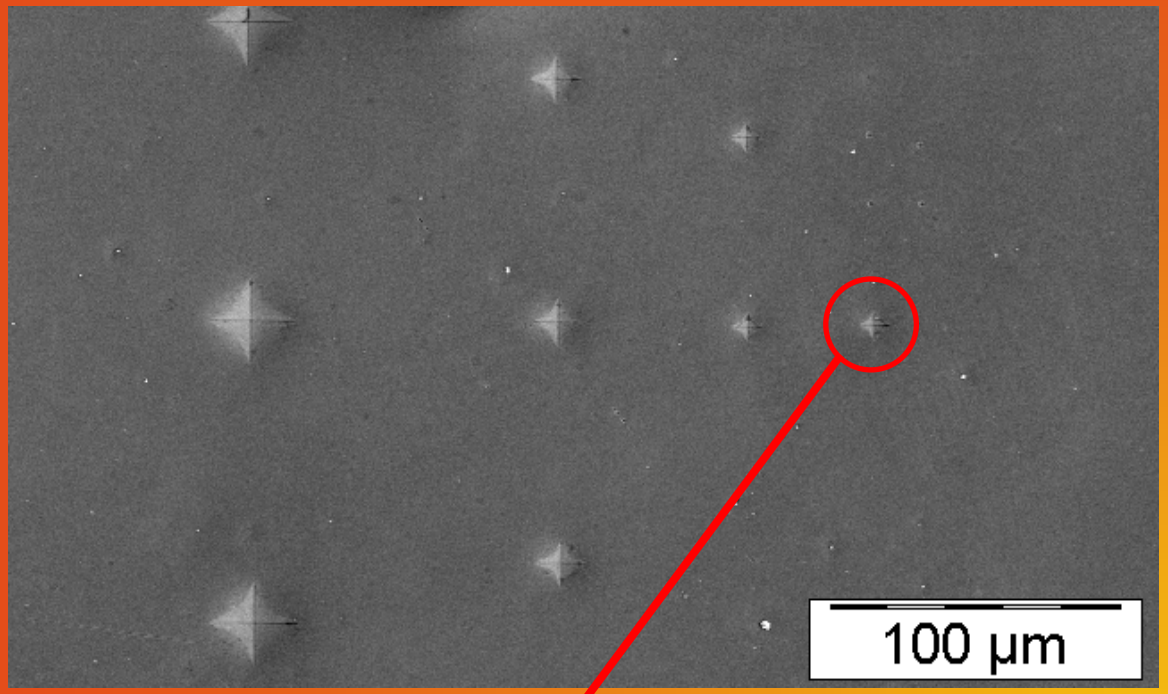
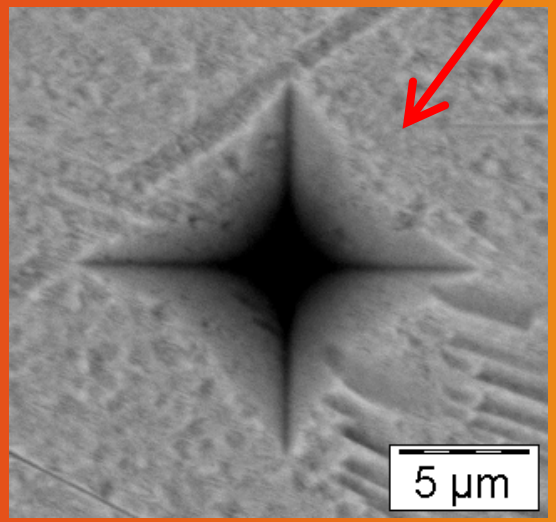


In the termoelectronic emission regime the cathode emits avalanches of electrons that feed and densify the plasma

Vickers indentation





at different loads

PLASMA DENSITY

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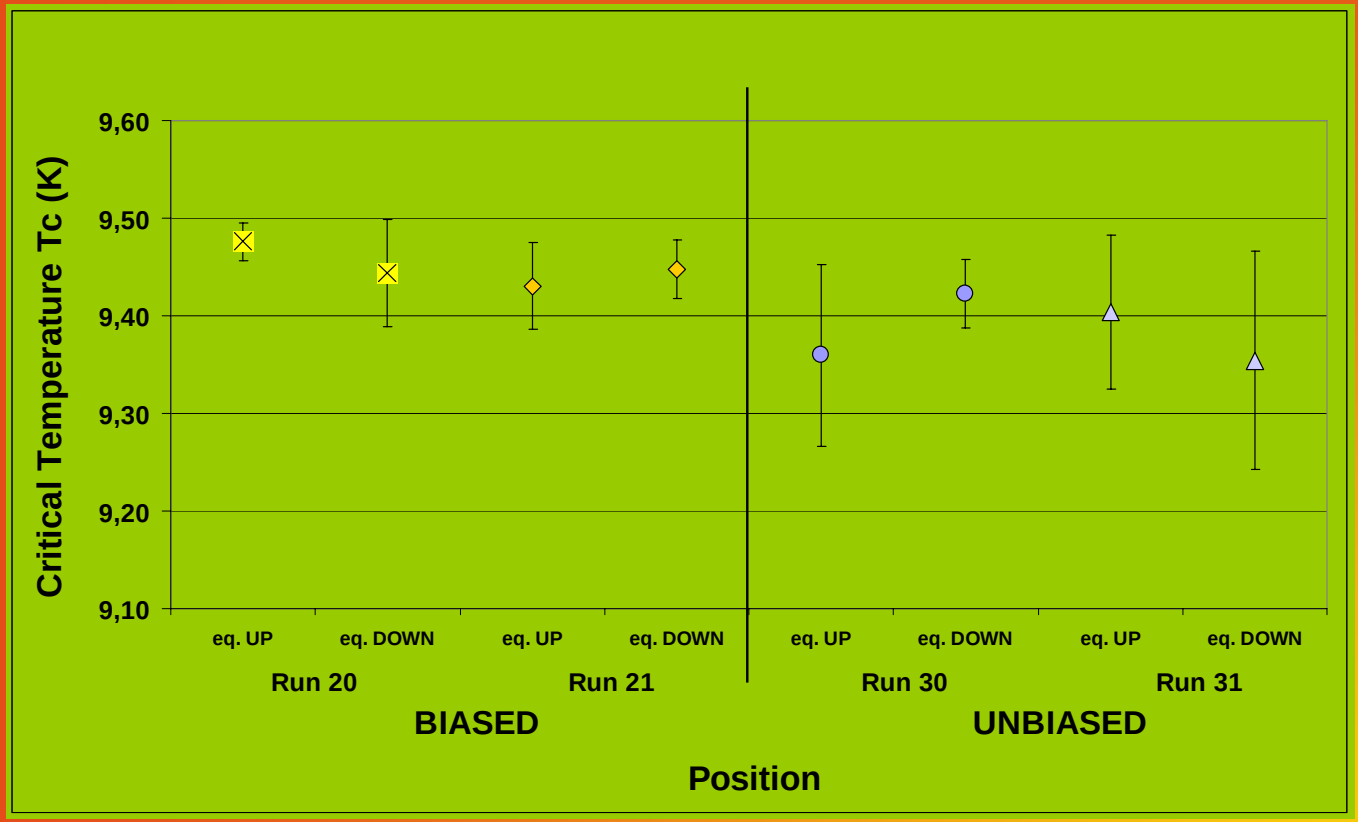
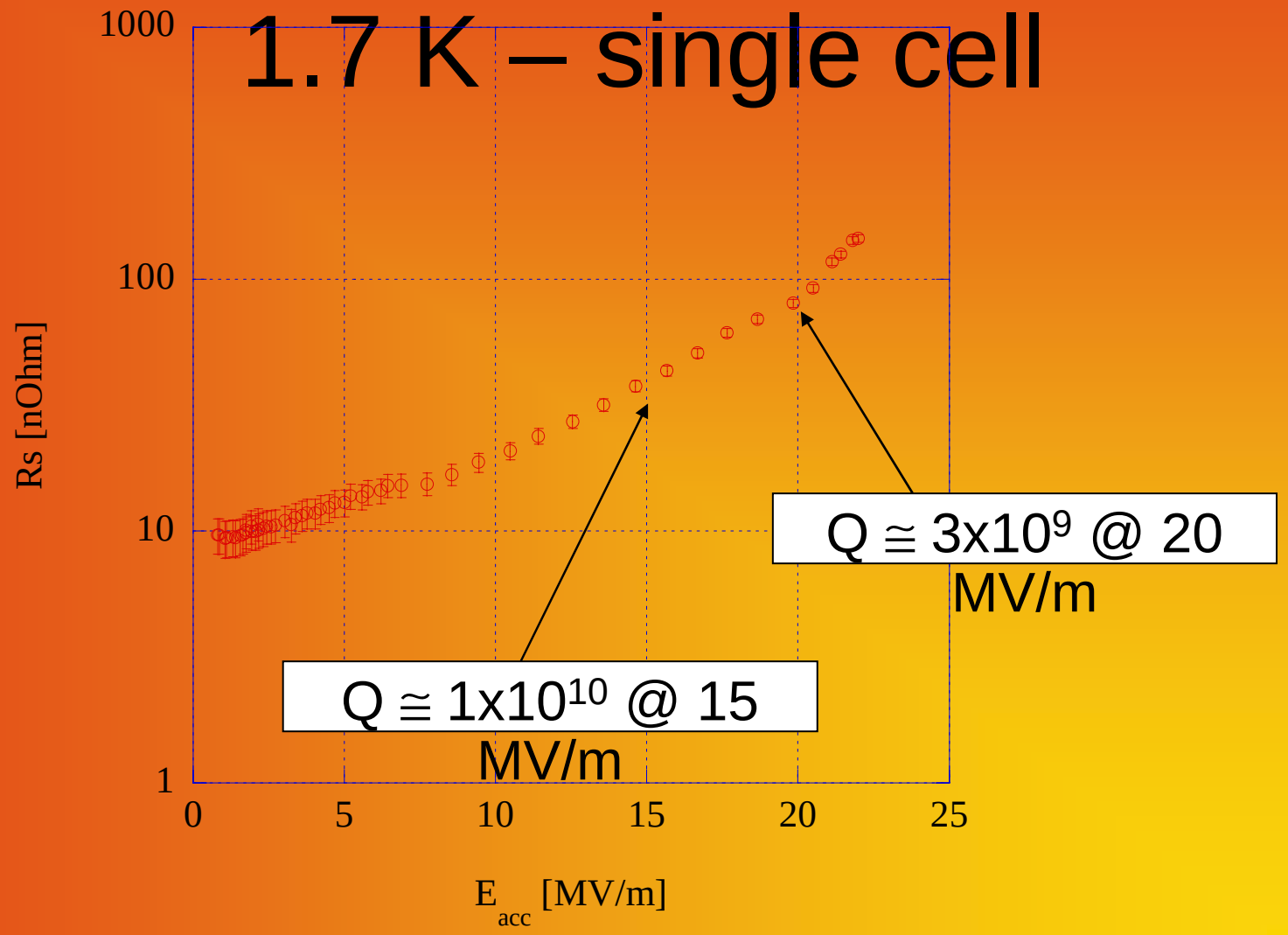
BMP: Critical Temperature



BMP: Thickness

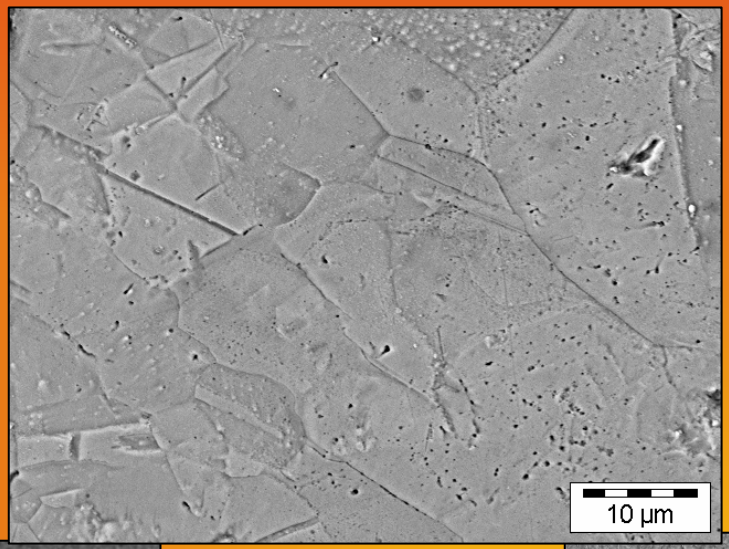
State-of-the-art at 1500 MHz – 1.7 K – single cell



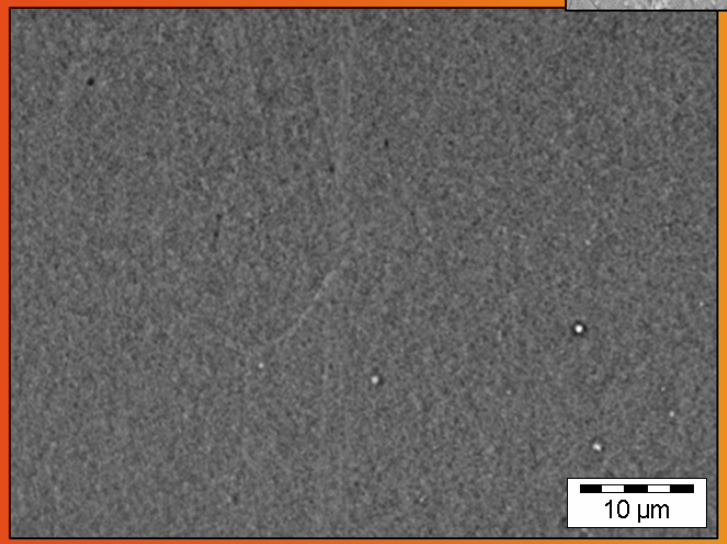
28 MV/m reached in a large LEP cryostat (He evaporation at large power)

Micro morphology

Cu substrate



unbiased MS



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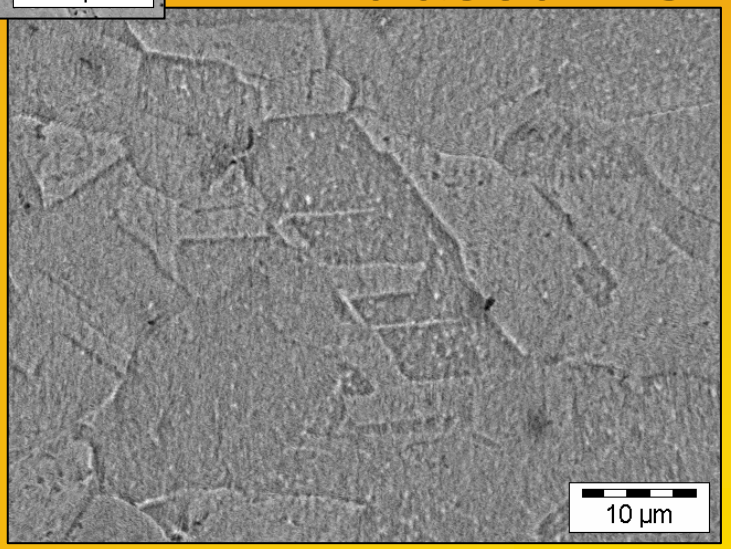

Results

	ID	THICKNESS	ROUGHNESS (7,5 µm² investigated)		
deposition mode	#	[µm]	RMS	R_a	peak- to peak [nm]
unbiased MS	4-769	0,73	8,2	6,5	55,7
	2-770	0,61	7,1	5,7	43
	9-765	1 (±0,1)	7,6	6,1	46
	12-766	1,9 (±0,2)	8,2	6,6	43,5
biased MS	Q-771	1	12,4	10	68
	LL-772	0,98	9,4	7,4	59,3
	YY-767	1,3	11,8	9,7	62
	R-768	0,9 (±0,1)	12,5	10,2	68

Sputtering Parameters

	CERN type	BIAS INFN-LNL
Cathode Current (A)	7	7
Cathode Power (kW)	1.54	1.86
Bias Voltage (V)	0	100
Pressure (mbar)	2×10^{-3}	3×10^{-3}
Time (min)	20	20

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