COUPON AND CAVITY STUDIES OF SRF THIN FILMS PRODUCED BY ENERGETIC CONDENSATION*

M. Krishnan, B. Bures and K. Wilson Elliott
Alameda Applied Sciences Corporation (AASC), San Leandro, California 94577

X. Zhao, A-M Valente-Feliciano, L. Phillips, B. Xiao and C. Reece
Thomas Jefferson National Accelerator Facility (Jefferson Lab), Newport News, Virginia 23606

K. Seo
Norfolk State University (NSU), Norfolk, Virginia 23504

presented at

6th SRF Materials Workshop

National High Magnetic Field Laboratory, Tallahassee, FL

Thursday, February 18 – Saturday, February 20, 2010

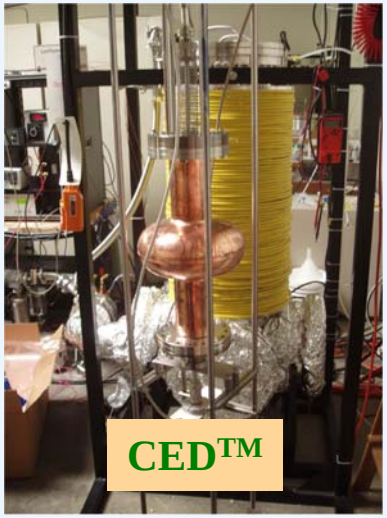
This research is supported at AASC by DOE SBIR Grant DE-FG02-08ER85162

and at JLab by DE-AC05-06OR23177

Approach of the AASC-JLab/NSU collaboration

Approach of the AASC-JLab/NSU collaboration

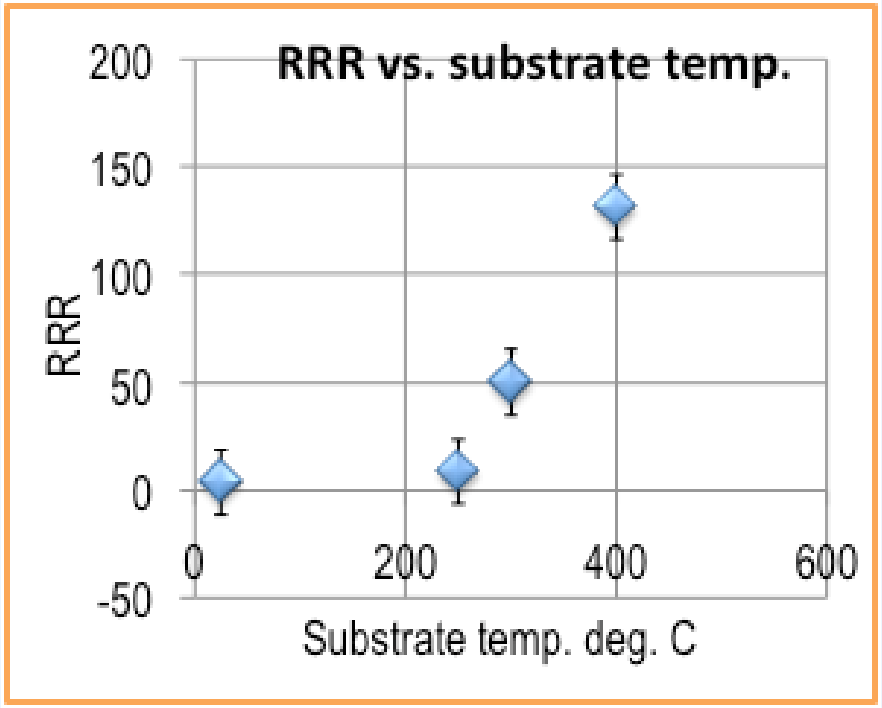
- Use CED™ and FCAD techniques to coat sapphire and Cu coupons
- Use surface analysis techniques at JLab/NSU to characterize morphology
- Measure RRR and T_c from sapphire coated coupons
- Use SIC facility at JLab to measure impedance of films in cavity
- Improve our understanding of the relationships between surface characteristics and superconducting properties



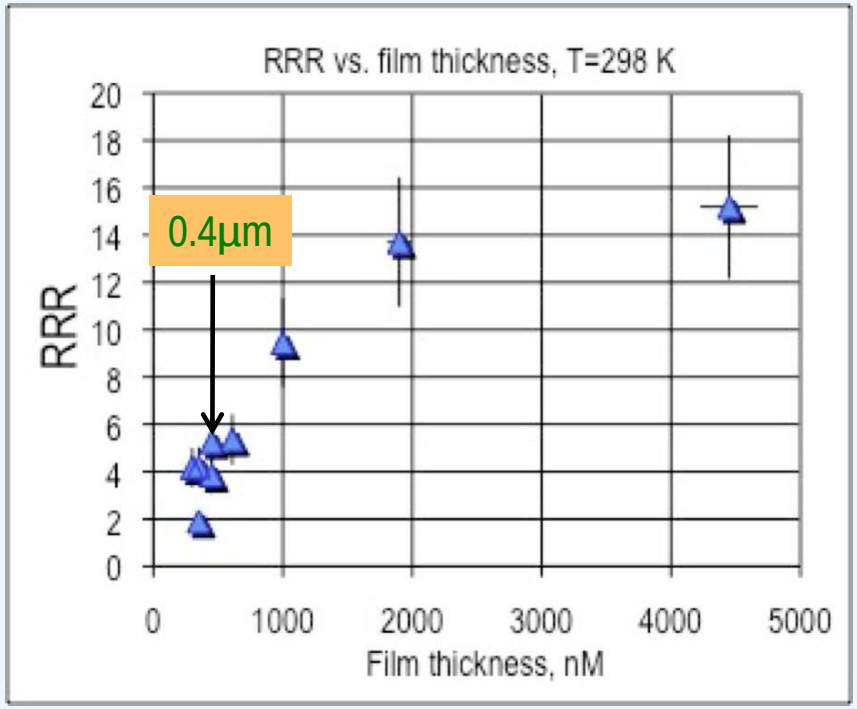
RRR of 131 measured in thin film Nb deposited by CED™

Is RRR~300 possible?

RRR strongly influenced by substrate temperature and film thickness



Strong RRR variation for fixed thickness (0.4μm) and variable substrate temperature



Strong RRR variation with film thickness at fixed temperature (25 deg. C)

- We are growing thicker films at higher temperature to see if RRR increases

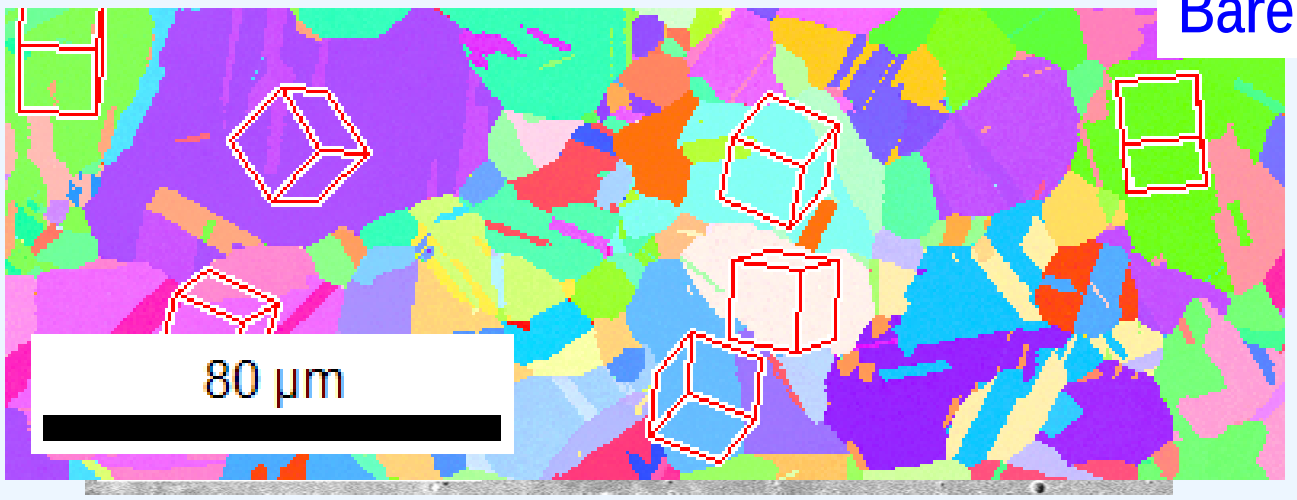
A survey of RRR from various Nb thin films

RRR	Thickness	Method	Substrate . Temp.	Substrate	Reference
2 40		Magnetron Sputtering	R.T. 200 ^{0}C	sap. quartz, Cu	Russo, SC. Sci. Technol. 18 (2005) L41-44, P43 Russo, Meas. Sci. Tech [18. (2007) 2299-2313, p2302
50 80	0.8-1.1µm	Cathodic Arc	R.T. 150 ^{0}C	Sapphire, Bias -80V	Russo, "2LX02", (2008)
50	235nm	ECR plasma (JLab)	R.T.	Sapphire, bias -51V	Genfa Wu, Thin Solid Films, 489 (2005) 56 - 62, p 58
87	600nm	Evap. Epitaxy	850 ^{0}C	Sapphire Orient. [0,1,-1,0] Nb. Or. [211]	Wolf, J.Vac. Sci. Tech. A., Vol4, No.3., May/Jun (1986), p 526.
130	400 nm	CED™ (Cathodic Arc, AASC)	400 ^{0}C	Sap. A-plane, 400 C, no bias	AASC, JLab. (2009)

~50μm grains of Nb measured in 0.4μm thick films on Cu

CED™ Nb Film on polycrystalline Cu substrate: Hetero-epitaxy?

Bare Cu



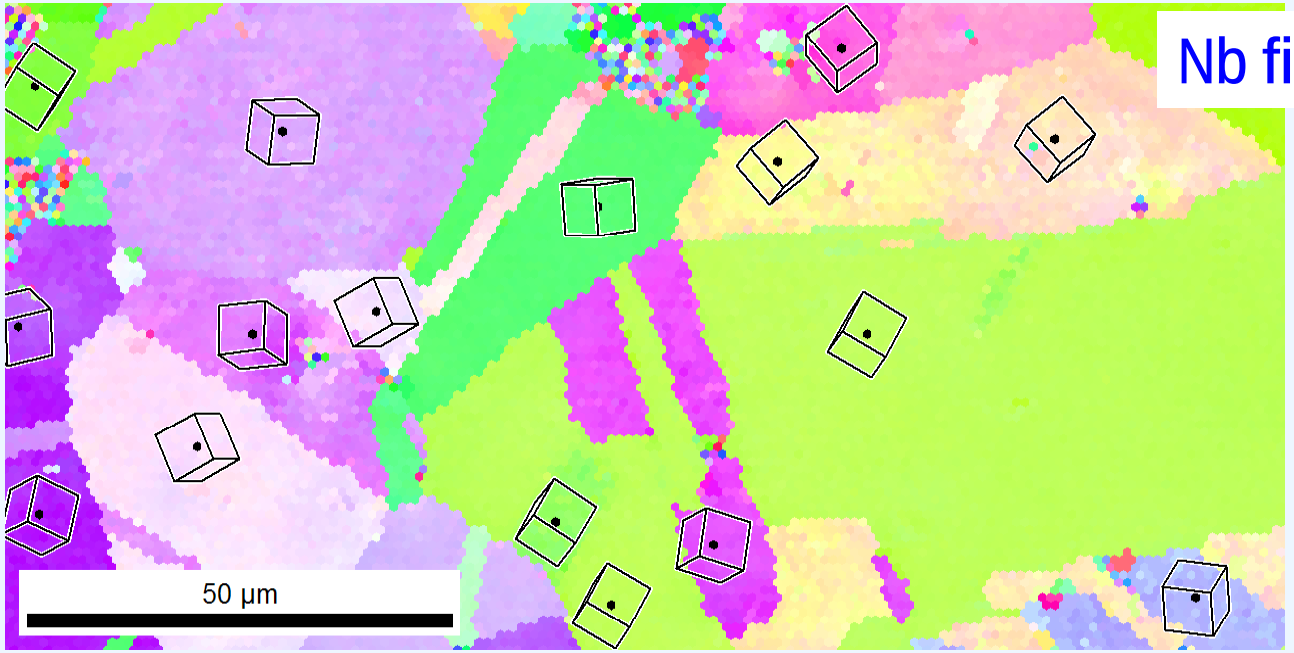
Working Distance: 15.000000

Number of points: 13094
Number of good points: 13093

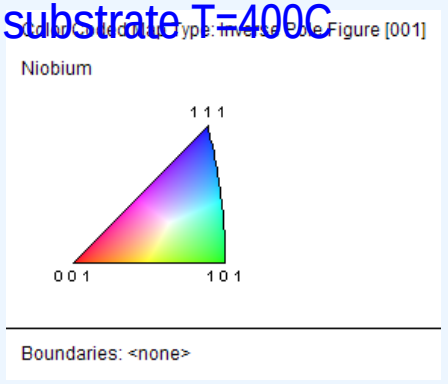
150.00 microns x 74.48 microns
Step: 1.00 microns

Average Confidence Index: 0.42
Average Image Quality: 2633.56
Average Fit [degrees]: 1.35

Nb film



EBSD Image of Sample TF-AASC-CED-Nb-Cu-103,CED™, Cu substrate T=400C

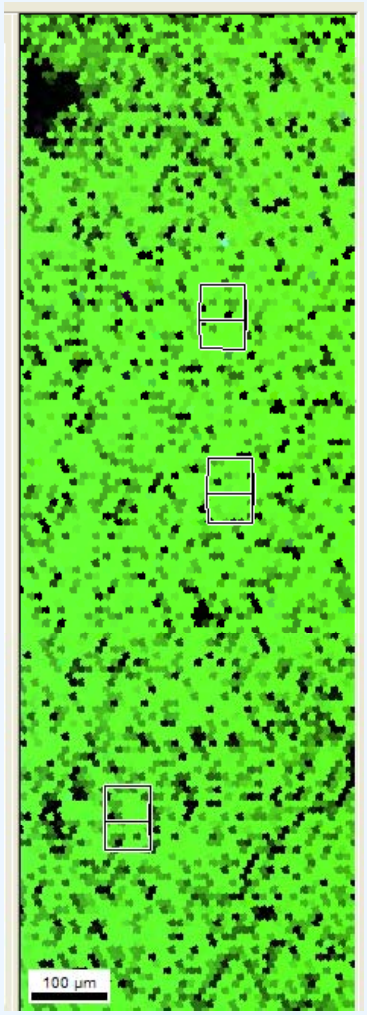


Nb crystal structure also shows strong dependence on substrate temperature

Impact of Substrate Temperature on Growth (25^{0}C, 300^{0}C)

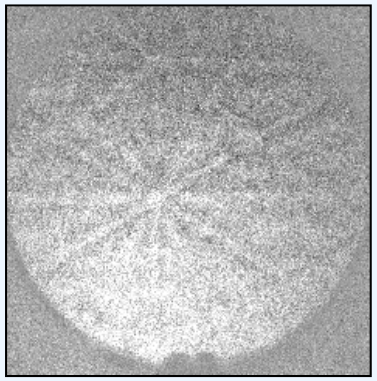
Substrate T = 300^0

Sample: AASC-126-015



Avg. C.I. 0.44,
Max CI 0.96

Both figures are in IPF+CI view (CI grayscale range 0-0.4)

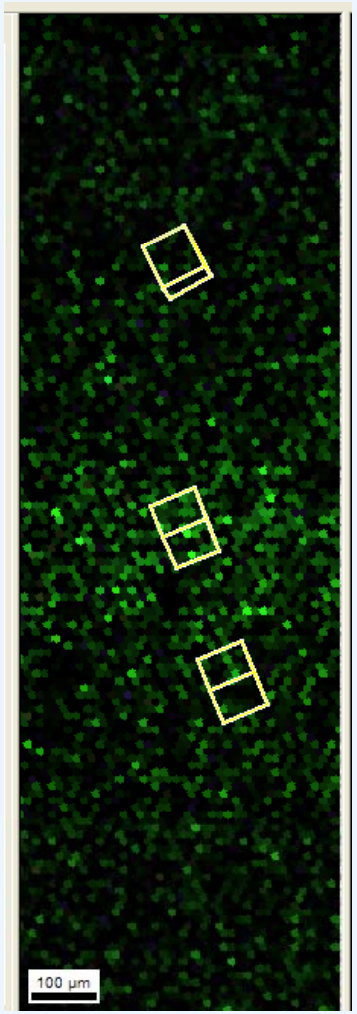


aasc-126-nb-015-1_r0c32.jpg

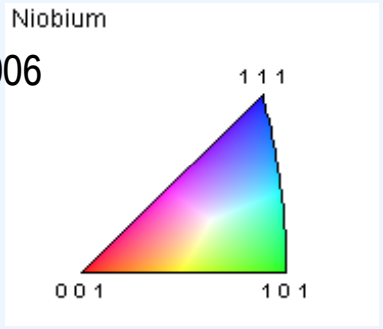
The sample had very sharp Kikuchi patterns. It has monolithic crystal structure Nb (110)

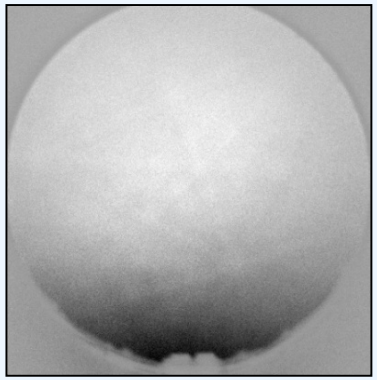
Substrate T = 25^0

Sample: AASC-126-006



Avg. C.I. 0.04, Max CI 0.43





aasc--126-006 180x_r126c33.jpg

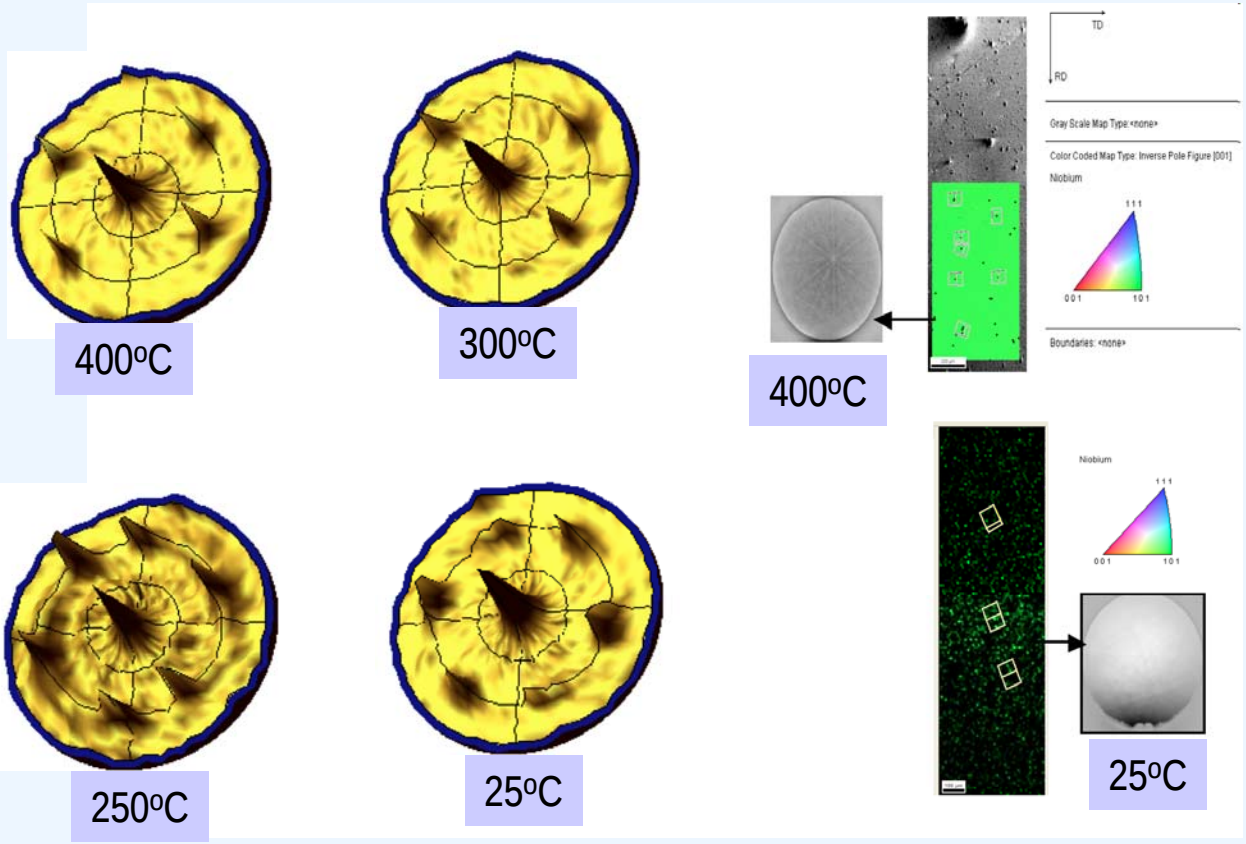
The sample had very faint Kikuchi patterns. It has uneven monolithic crystal structure Nb (110)

XRD Pole figures: 25°C, 250°C, 300°C & 400°C

TABLE I. Summary of Nb films on a-plane Al_2O_3 substrate for crystallographic and electrical properties

Ts	out-of-plane XRD	Pole figure	EBSD	RRR
400°C	(110)	single	Kikuchi pattern	129
300°C	(110)	single	Kikuchi pattern	50
250°C	(110)	twin	•	9
25°C	(110)	twin	no Kikuchi pattern	4

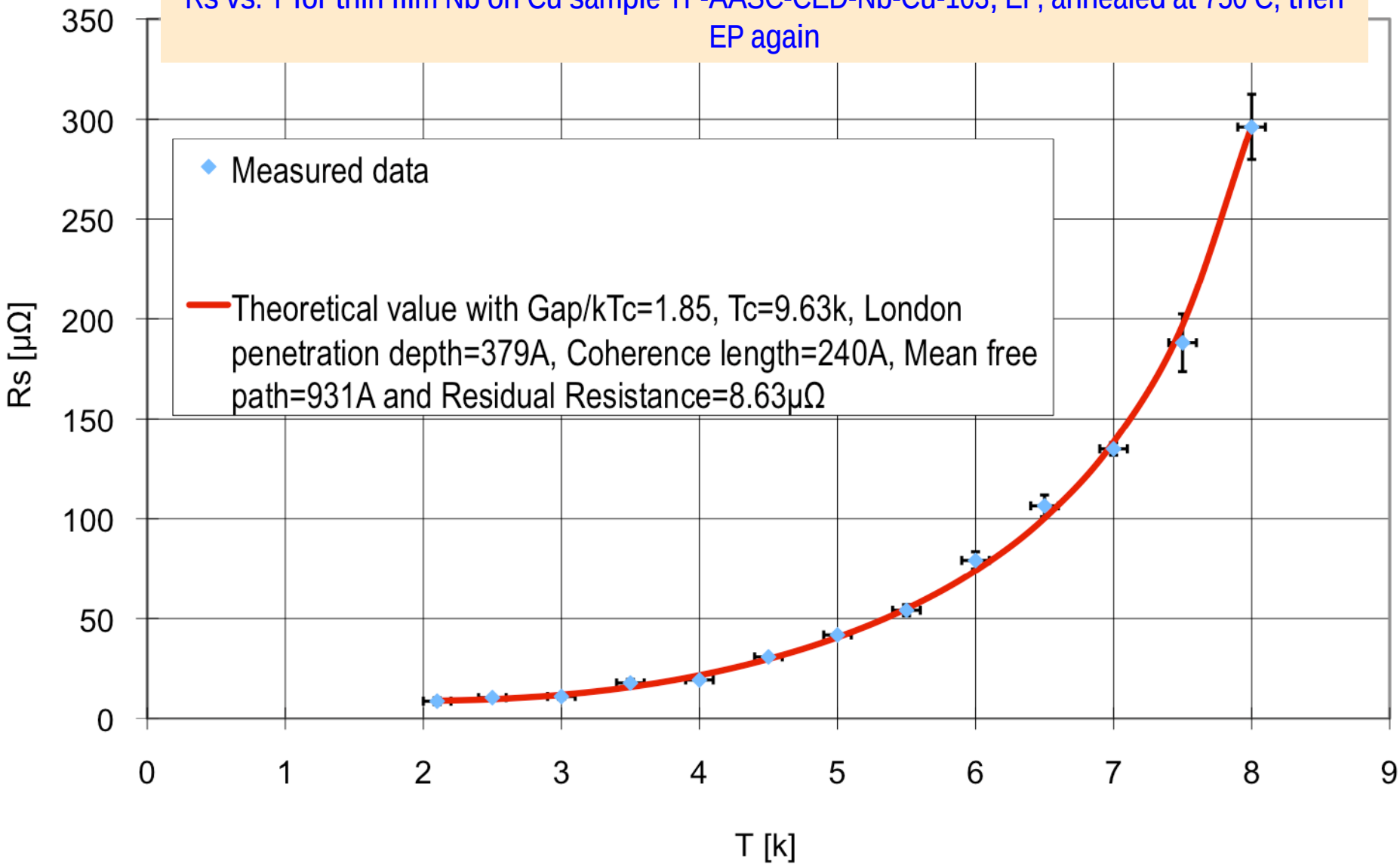
Ts; substrate temperature, RRR; the ratio of residual resistivity



JLab SIC cavity is a useful tool

SIC measurements at JLab

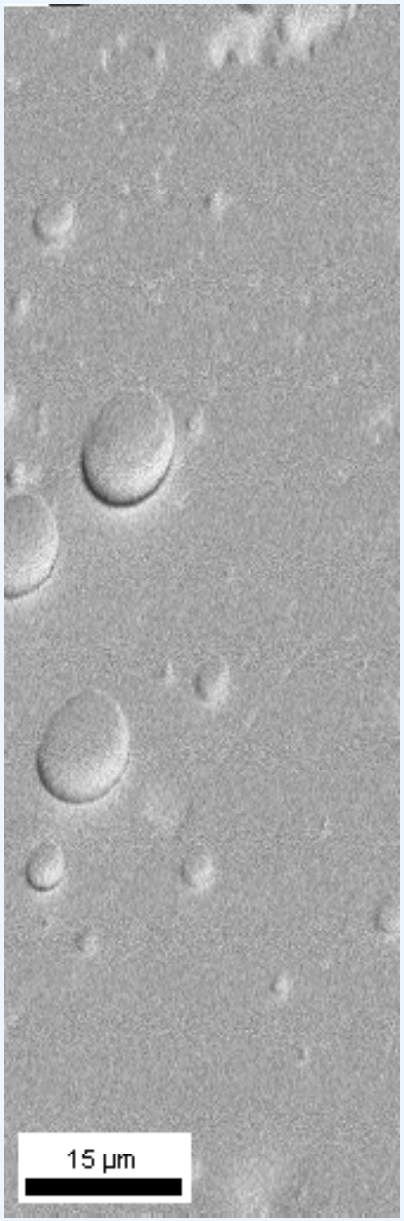
Rs vs. T for thin film Nb on Cu sample TF-AASC-CED-Nb-Cu-103; EP, annealed at 750 C, then EP again

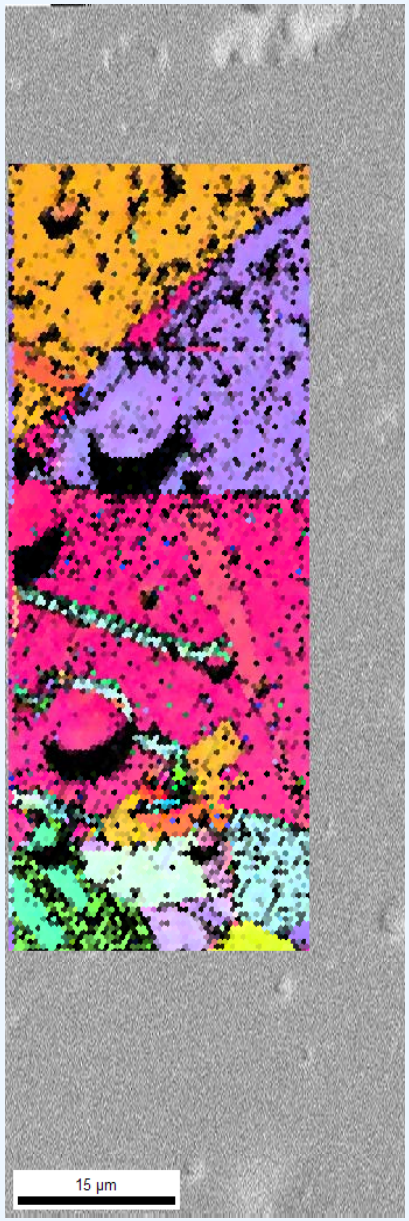


The AASC/JLab/NSU team hopes to continue our methodical investigation of Nb and other thin film SRF candidates, culminating in high field cavity tests after better understanding

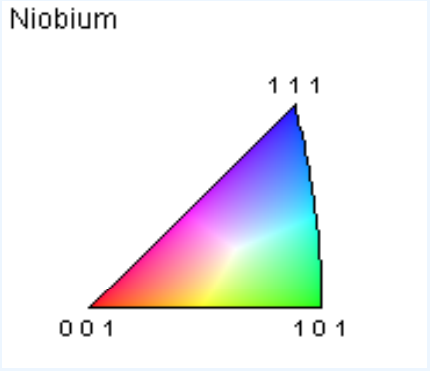
Macroparticles of Nb appear to capture surface properties!

Nb macro-particles have same crystal orientation as does the base plane!





EBSD IPF View of Sample DOE-138-08B Substrate: "UNS C 10100 Quarter Hard"



Average C.I. 0.44

Energetic Nb Ion Species Might Promote Long-Range Surface Diffusion, Thus Reconciling Macroparticles' Surface Crystal Orientation to Cu Substrate?