



ARIES Work package 15

Thin Films SRF

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on behalf of the ARIES WP15 group

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Cristian Pira, Eduard Chyhyrynets (INFN Legnaro)

Michael Vogel, Stewart Leith (Uni Siegen)

Claire Antoine (Saclay)

Eugen Seiler (IEE Bratislava)

Artūrs Medvids (Riga TU)

Alban Sublet, Guillaume Rosaz, Giovanna Vandoni, Walter Venturini (CERN)



ARIES WP15 scope – Pathway to sc film

Substrate preparation

- SUBU, EP
- tumbling
- Laser cleaning



Sc film deposition

- sputtering
- (PE)CVD, (PE)ALD



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Film characterisation

- SEM, FIB, AFM
- XPS, XRD, RBS
- TEM...



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DC sc properties

- RRR
- AC, DC susceptibility
- local magnetometry



RF sc properties

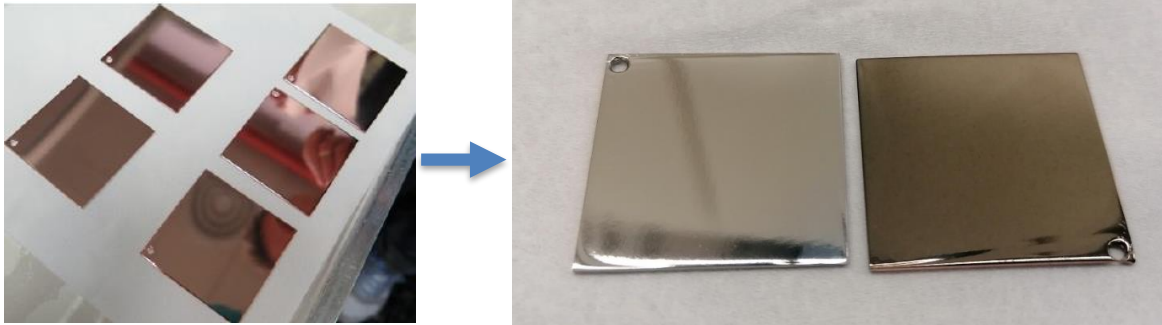
- QPR at HZB, CERN
- HW cavity at ASTeC

HZB Helmholtz
Zentrum Berlin



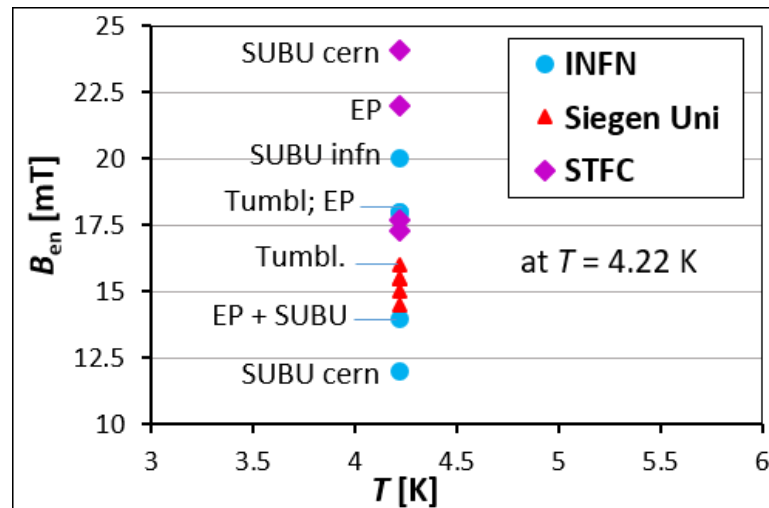
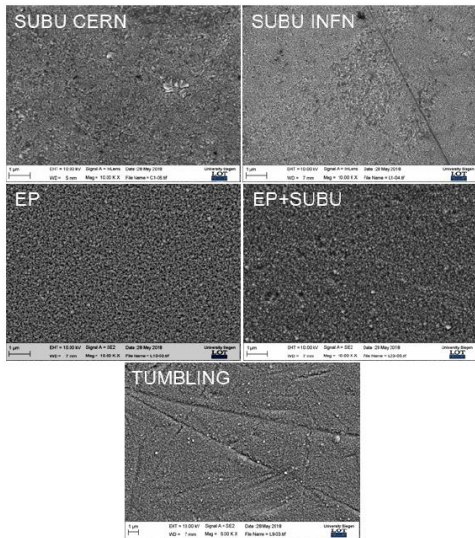
Nb on Cu research - two types of samples

- OFHC (copper) sheet material for film deposition, characterisation and DC measurements



Finding best recipe for Nb on Cu samples

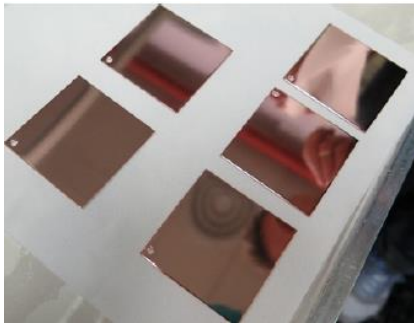
SAMPLE PROCESS #	SAMPLE NAME														
	C1	C7	C10	L1	L19	L20	L10	L13	L16	L23	L18	L21	L9	L4	L8
Sample production	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN
Sample labeling	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN	CERN
Sample shipping				to LNL	to LNL	to LNL	to LNL	to LNL	to LNL	to LNL	to LNL	to LNL	to LNL	to LNL	to LNL
SUBU Polishing Process	CERN	CERN	CERN	LNL	LNL	LNL									
EP Polishing Process							LNL	LNL	LNL						
EP+SUBU Polishing Process										LNL	LNL	LNL			
Tumbling Cleaning procedure													LNL	LNL	LNL
Surface characterisation				LNL	LNL	LNL	LNL	LNL	LNL	LNL	LNL	LNL	LNL	LNL	LNL
Sample shipping	to U.Siegen	to STFC	to LNL	to U.Siegen	to STFC		to U.Siegen	to STFC		to U.Siegen	to STFC		to U.Siegen	to STFC	
Nb coating	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL
Sample cutting	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL
Surface characterisation	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL	U.Siegen	STFC	LNL
Sample shipping	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE	to IEE
SC magnetization characterisation	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE	IEE
Sample shipping			to RTU			to RTU			to RTU			to RTU			to RTU
Laser post-treatment			RTU			RTU			RTU			RTU			RTU



Courtesy Cristian Pira & Eugen Seiler

Nb on Cu research - two types of samples

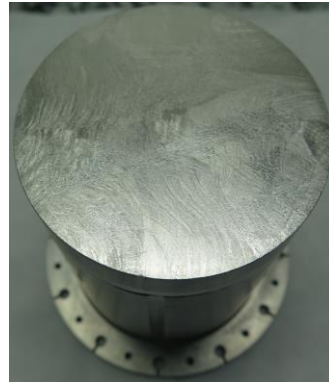
- OFHC (copper) sheet material for film deposition, characterisation and DC measurements



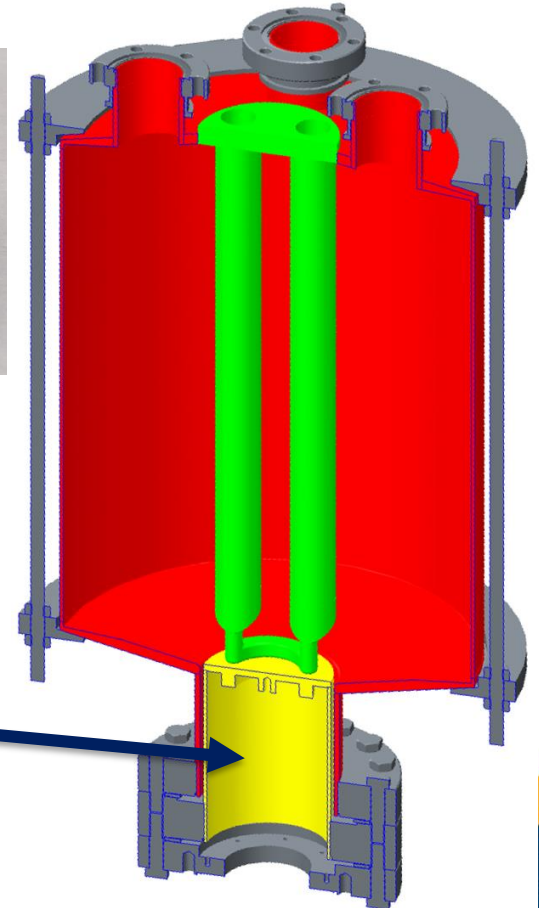
- QPR samples for RF measurements



Cu sample



Nb sample



Peculiarities of QPR samples

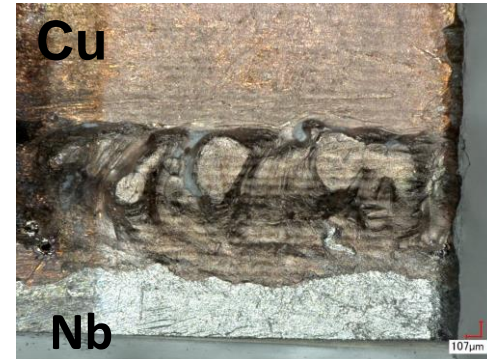
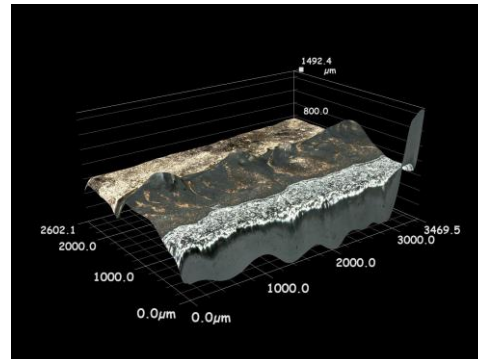
QPR samples easier to manufacture than cavity, but ...



Cu-disk had to be „weld“ into Nb cylinder
(no braze in order to avoid temperature or chemistry related restrictions)
Sides of cylinder had to remain superconducting
Rim should be Nb
(in order to require coating of flat surface only)



close up picture of test „weld“



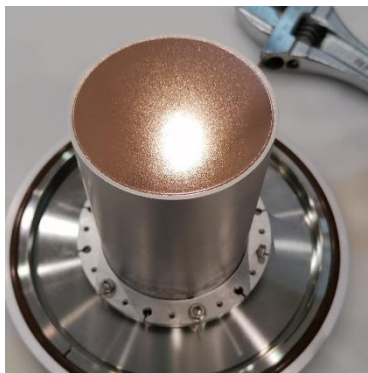
after LASER cleaning
with Nd:YAG laser
(1064 nm) at RTU

Research topics for Nb on Cu QPR samples

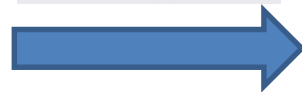
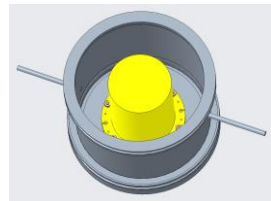
- Apply EP and SUBU (best 2 methods from sheet samples) to QPR sample
- Study the influence of Cu surface preparation on RF properties
- Study different coating techniques
- Use as baseline samples for further multilayer / other materials



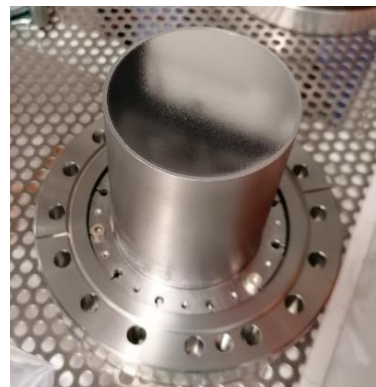
Surf. preparation,
polishing (INFN LNL)



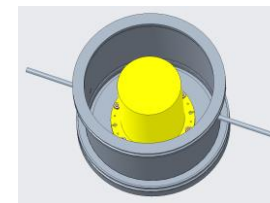
Niobium coating
(Uni Siegen, CERN, STFC)



Shipping in
transport box



RF testing (HZB)



Shipping in
transport box



QPR coating facilities

- A dedicated UHV deposition system was set up to deposit single layer SRF thin film on QPR.
- QPR can be heated to 650 °C during deposition
- Distance between Target and QPR can be adjusted
- Base pressure of 2×10^{-9} mbar is achieved after Bake.








Courtesy of Reza Valizadeh (STFC, Daresbury)

- Nb/Cu QPR sample coating
 - DCMS Nb coating on EP treated Cu
 - HiPIMS Nb, NbN and Multilayer final coating

Courtesy of Michael Vogel (Uni Siegen)



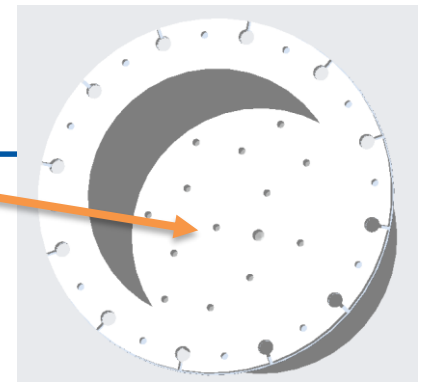
Sample testing plan

Samp	substrate	film	action				
B-1	INFN SUBU	 BUSTED! film	REWELDING?				
B-2	INFN SUBU	 2 μm Nb film	HZB RF test		Comparison between 2 polishing methods	HZB RF test	multil./ new m.
B-3	INFN EP	 3 μm Nb film	HZB RF test		multil./new mat.		Comparison between 2 labs coating procedures
B-4	INFN EP	 3 μm Nb film	HZB RF test		multil./new mat.		
B-5	INFN SUBU	 3 μm Nb film	HZB RF test	 Recoat.: ? μm Nb		HZB RF test	multil./new mat.

	DONE
	IN PROGRESS
	FAILED

Nb on Cu samples

hole pattern for T-sensors
at sample backside visible
in coating:
cause unknown



B-1.4



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sample broken at
Nb/Cu interface

Further materials analysis

B-2.4



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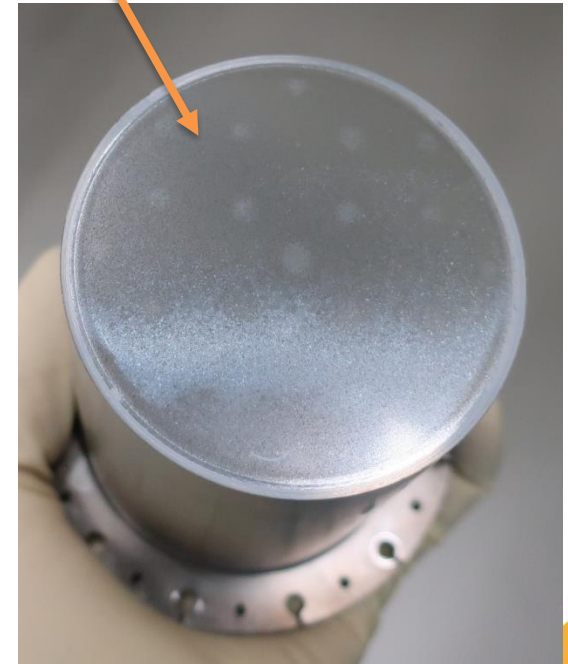


RF testing in QPR

B-5.4



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B-1 Sample state (SUBU, STFC)

Sample disk was cut out and scanned with SEM



B-1.4
SUBU

Large Cu Metal Block

- Observation Condition

Accelerating Voltage : 30 kV

Signal : SE(UD,LD), PDBSE(COMPO,TOPO)

Magnification : 800x

- EDX analysis Condition

Accelerating Voltage : 30 kV (SU7000 + OXFORD Ultimax170)

6 kV (Regulus FE-SEM + Bruker FQ)

Signal : PDBSE(COMPO)



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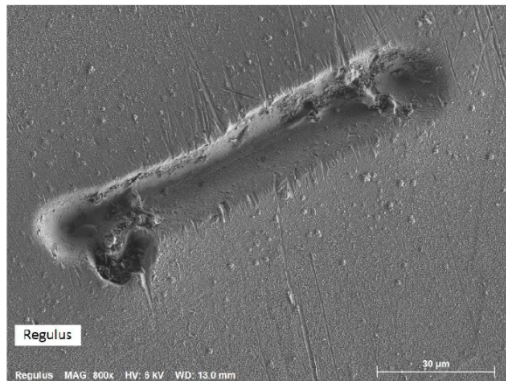
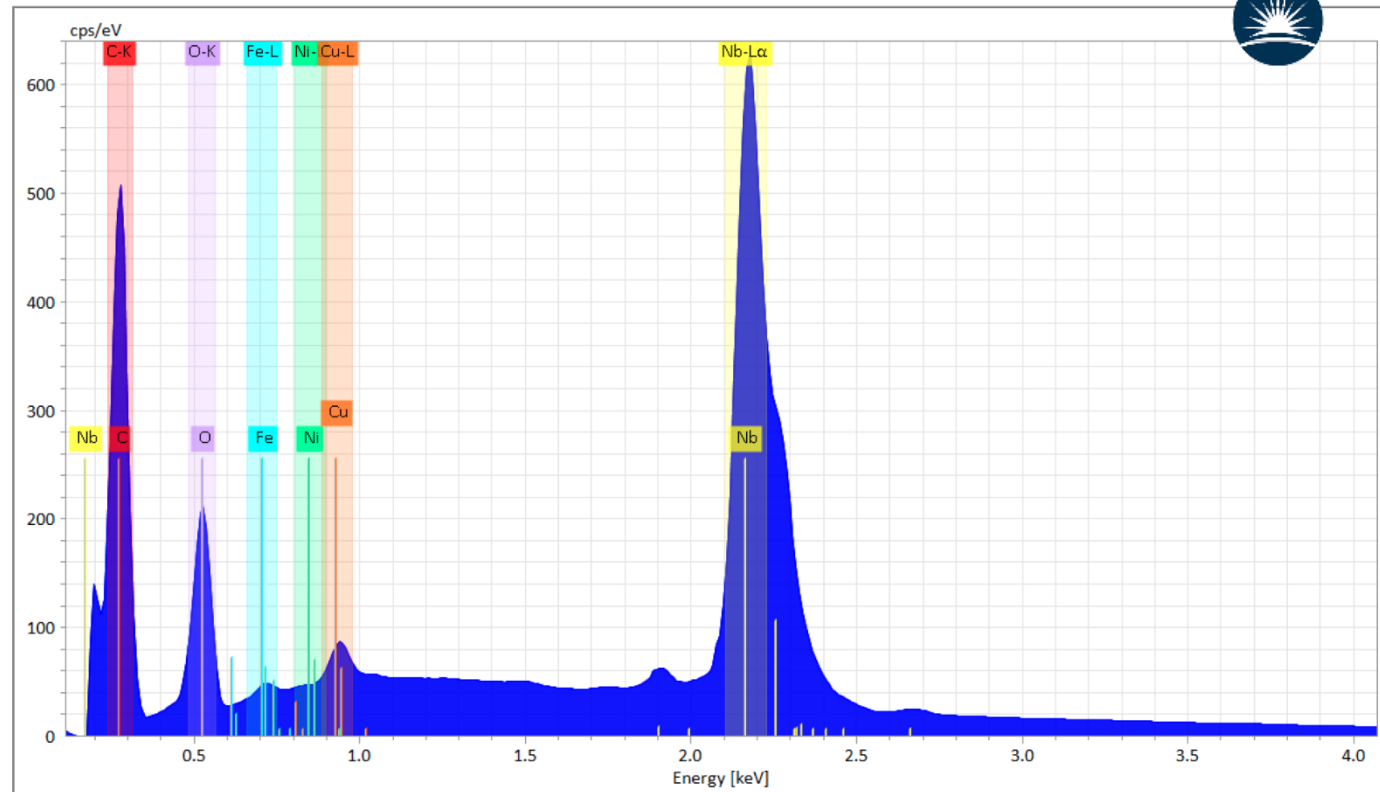
B-1 Sample state (SUBU, STFC)

Sample disk was cut out and scanned with SEM

Large Cu Metal Block

Bruker FQ EDX Mapping spectrum 6 kV

B-1.4
SUBU



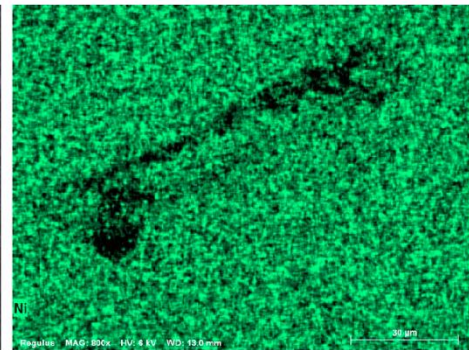
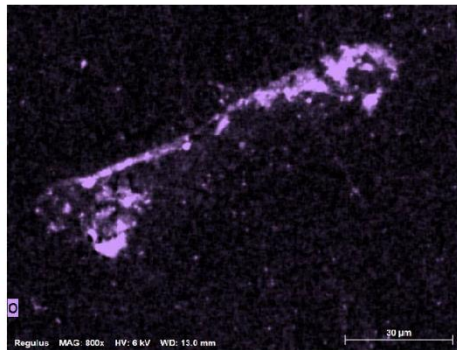
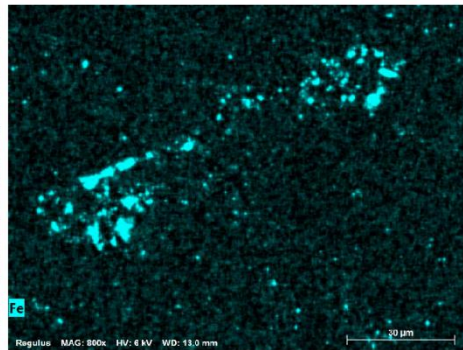
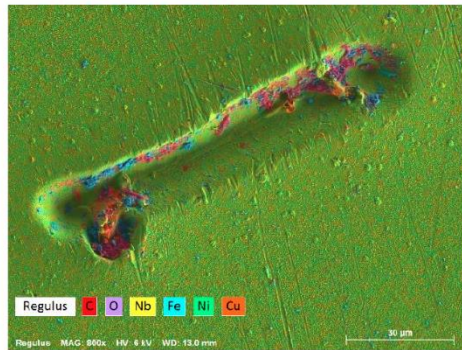
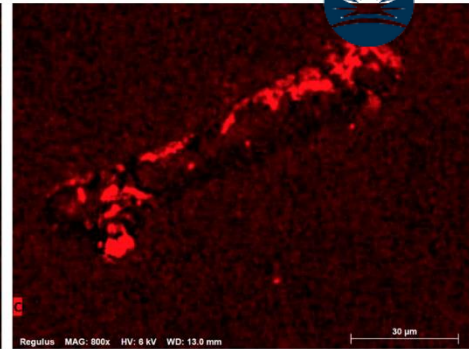
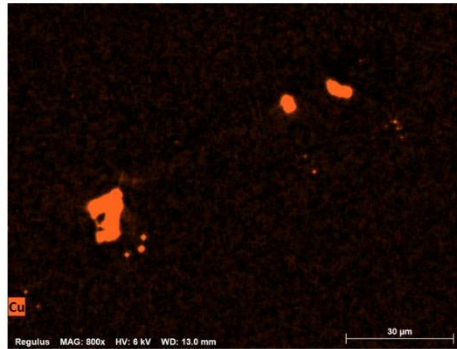
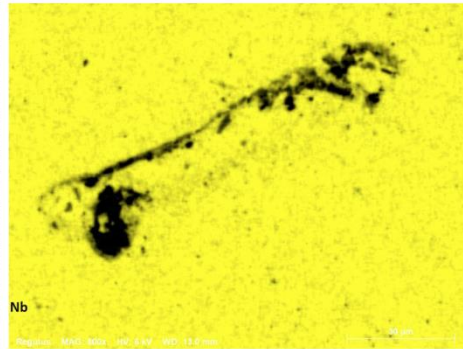
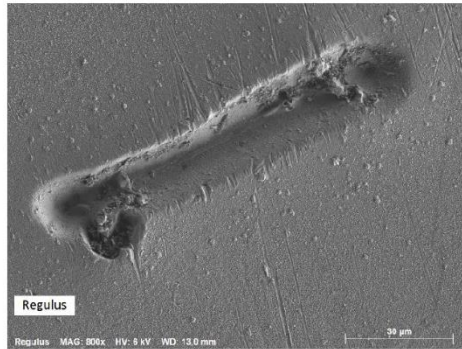
B-1 Sample state (SUBU, STFC)

Sample disk was cut out and scanned with SEM

Large Cu Metal Block

Bruker FQ EDX Mapping 6 kV

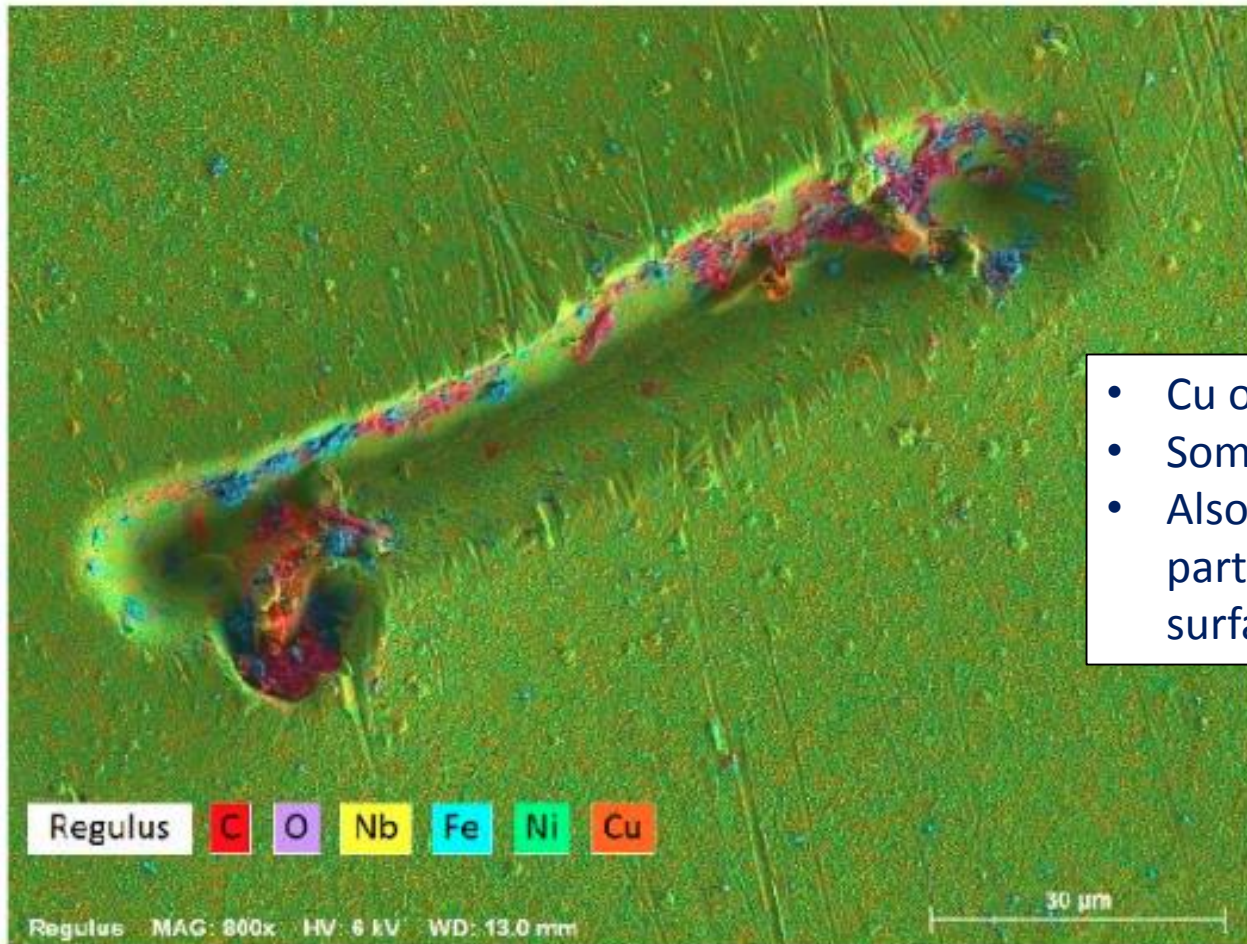
B-1.4
SUBU



B-1 Sample state (SUBU, STFC)

Sample disk was cut out and scanned with SEM

B-1.4
SUBU



- Cu on the surface!
- Some delamination of the film
- Also looks like the original particle was ripped from the surface

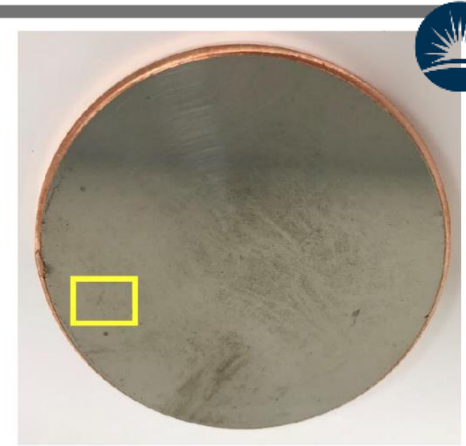
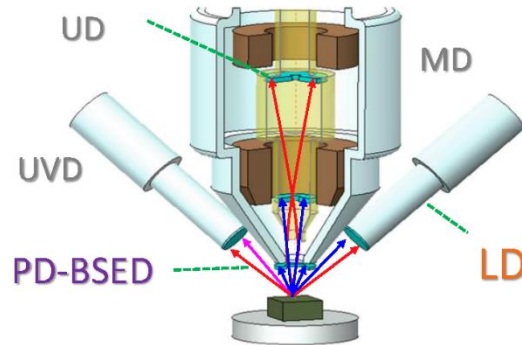
B-1 Sample state (SUBU, STFC)

Other regions

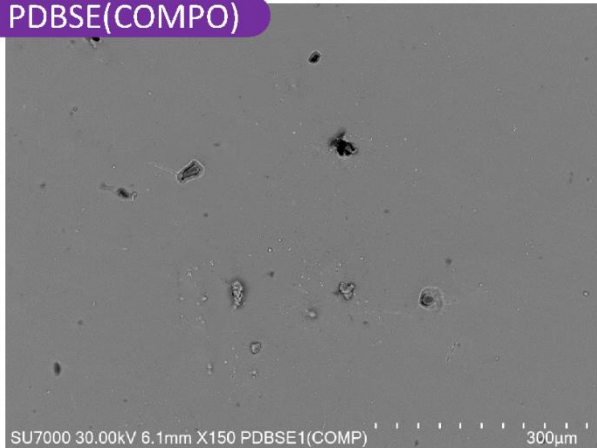
Large Cu Metal Block

Accelerating Voltage : 30 kV

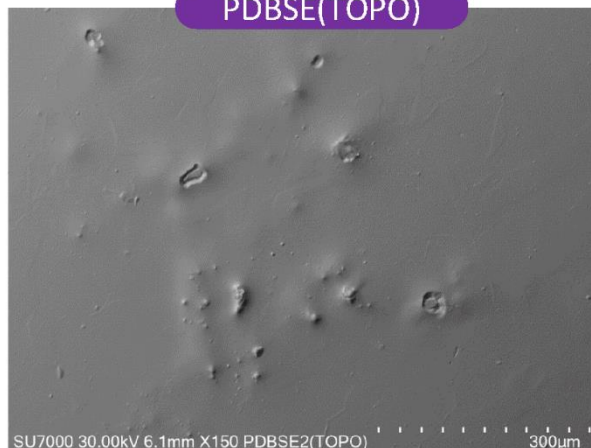
B-1.4
SUBU



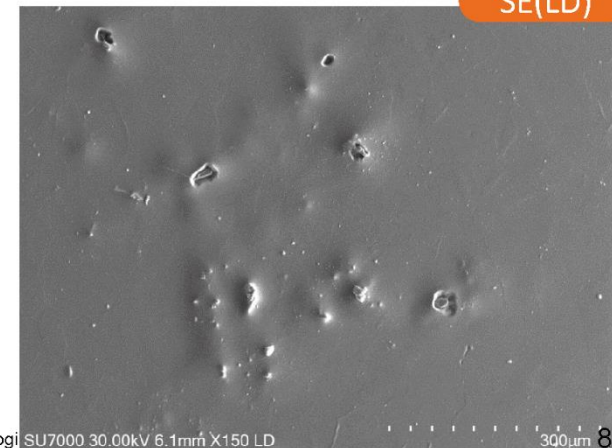
PDBSE(COMPO)



PDBSE(TOPO)



SE(LD)



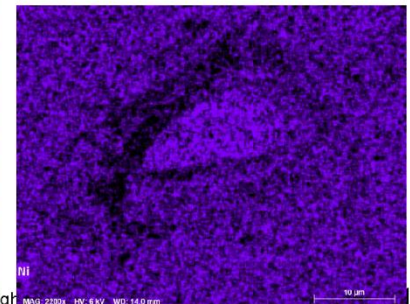
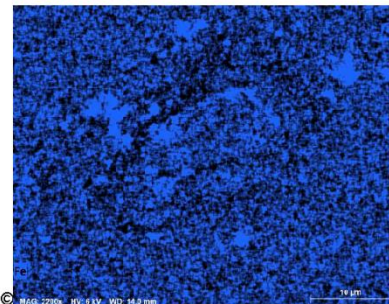
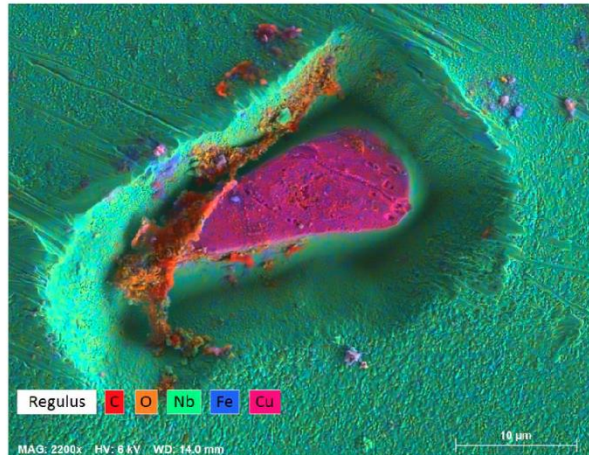
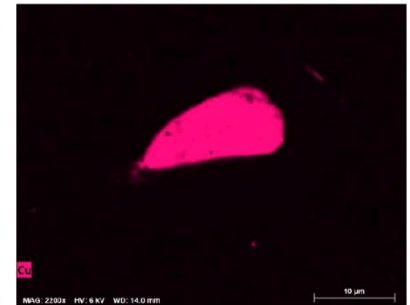
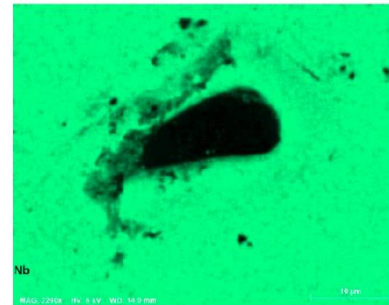
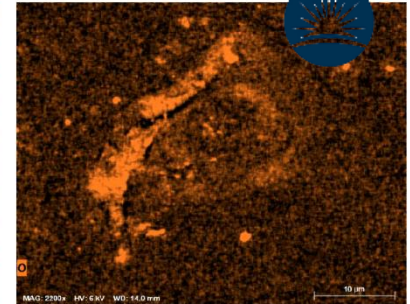
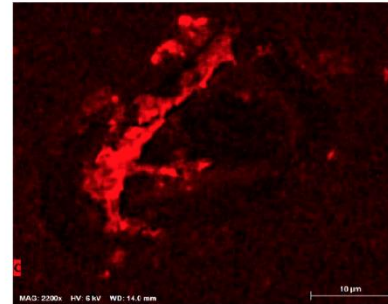
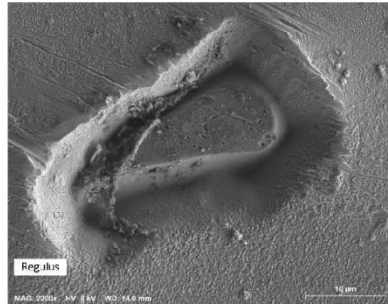
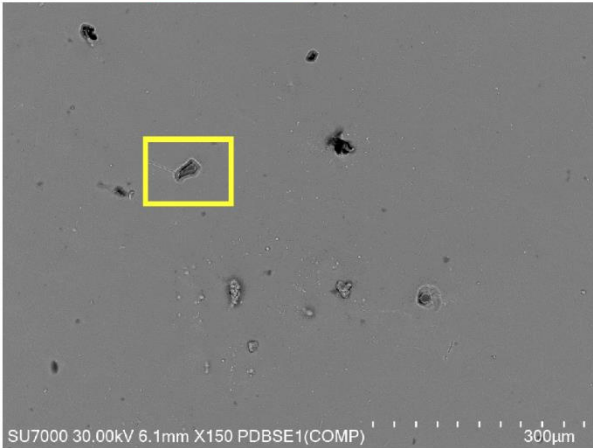
B-1 Sample state (SUBU, STFC)

Other regions

B-1.4
SUBU

Large Cu Metal Block

Bruker FQ EDX Mapping 6 kV



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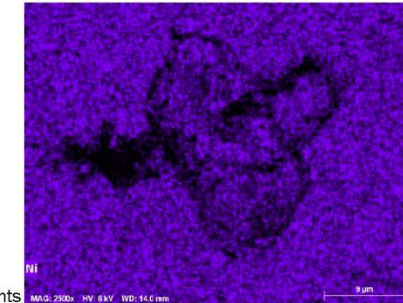
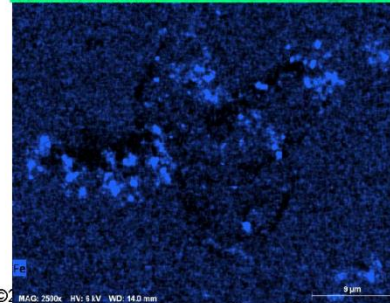
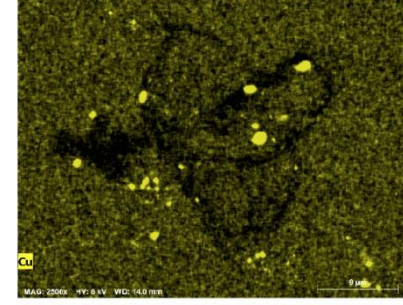
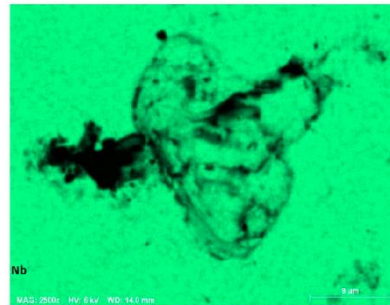
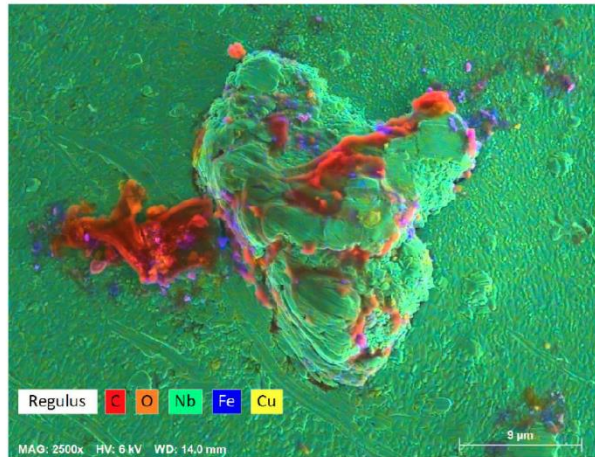
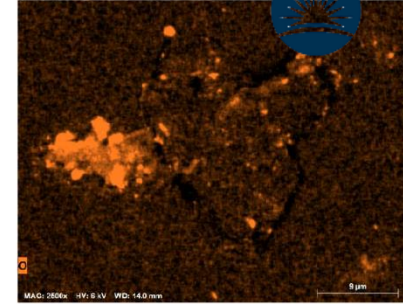
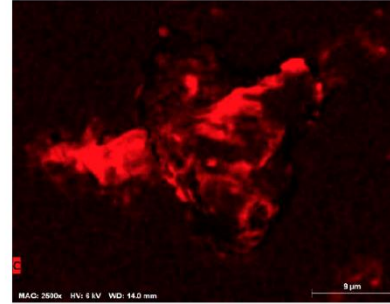
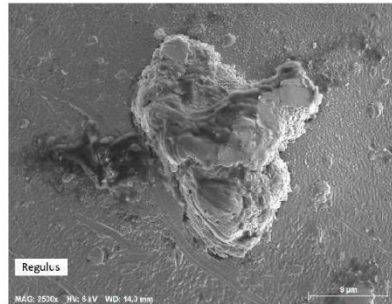
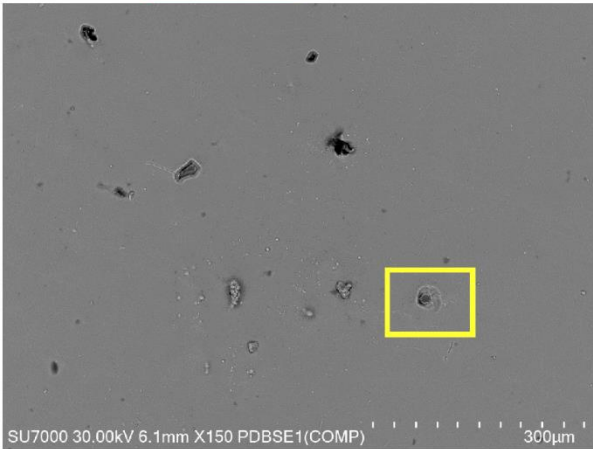
B-1 Sample state (SUBU, STFC)

Other regions

B-1.4
SUBU

Large Cu Metal Block

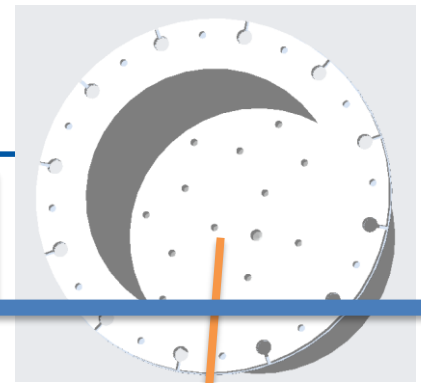
Bruker FQ EDX Mapping 6 kV



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Nb on Cu samples

hole pattern of sample
backside revealed in coating



B-1.4



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sample broken at
Nb/Cu interface

Further materials analysis

B-2.4



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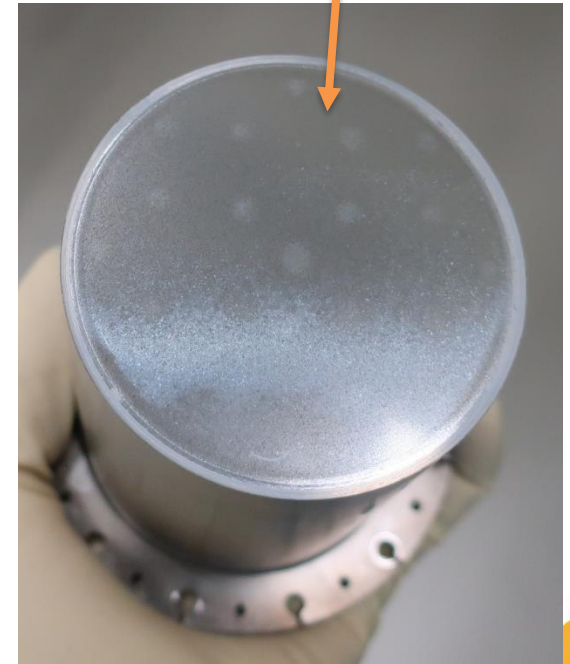


RF testing in QPR

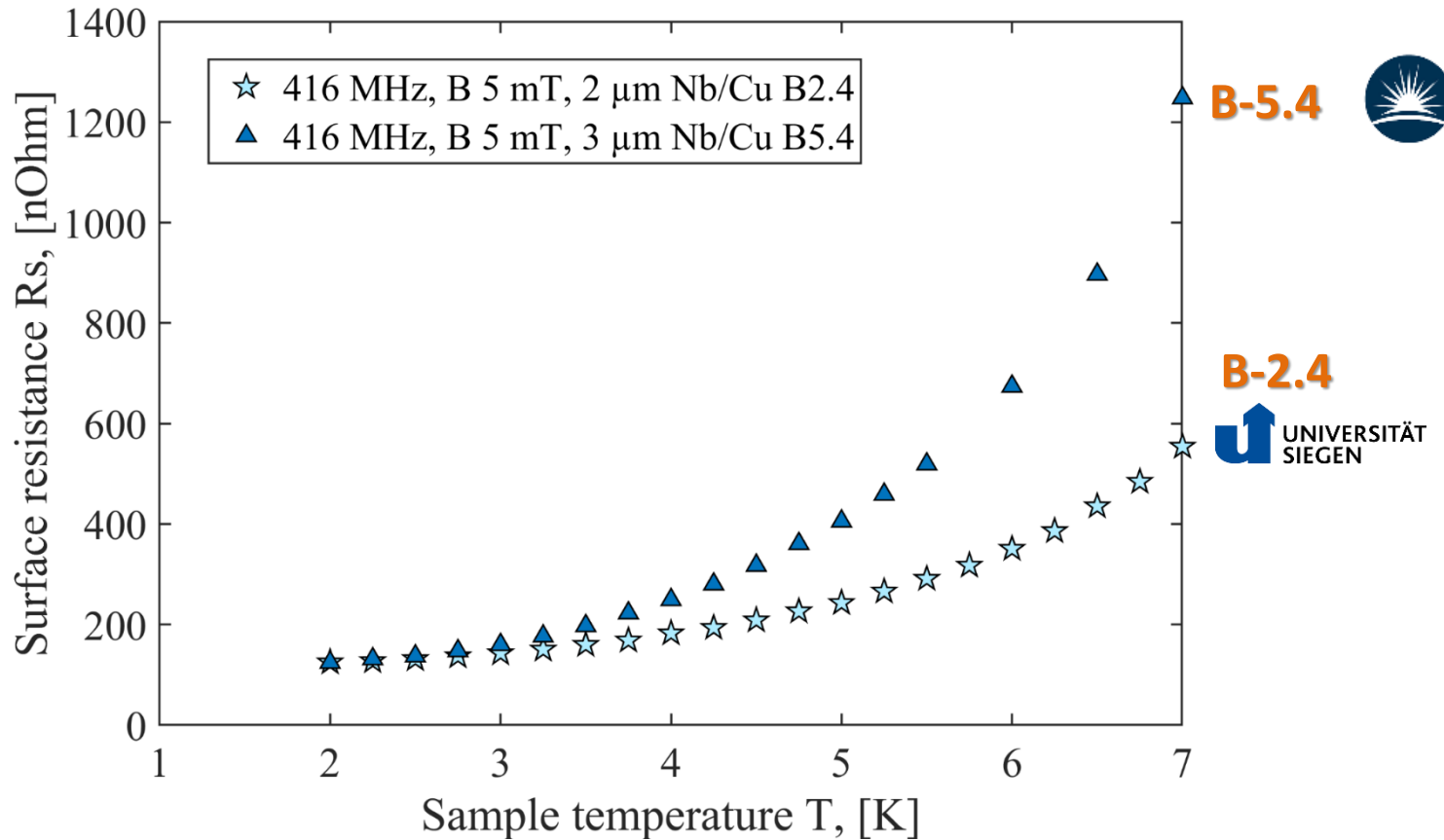
B-5.4



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R_s vs T measurements 415 MHz



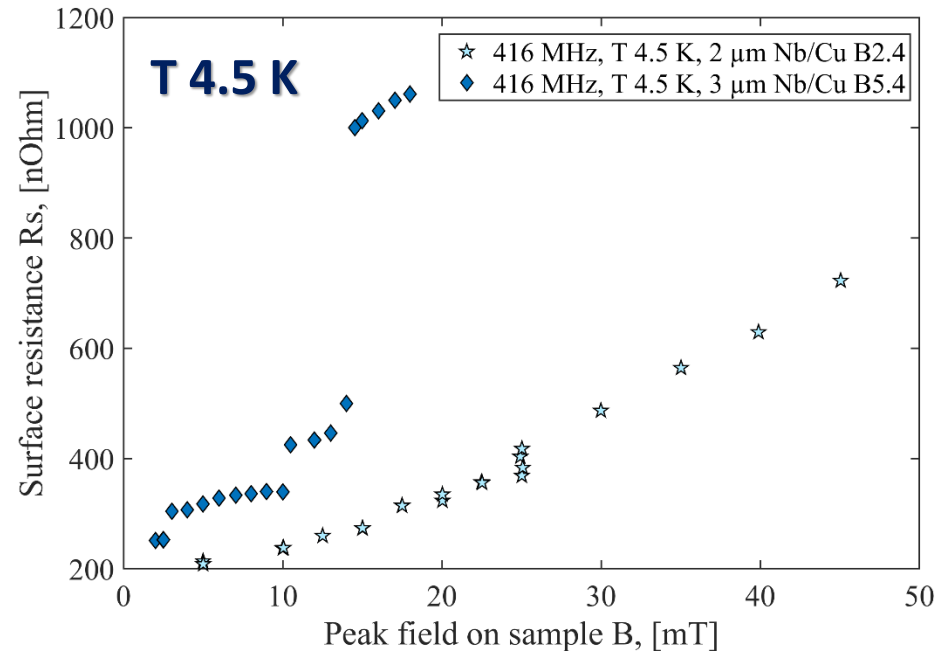
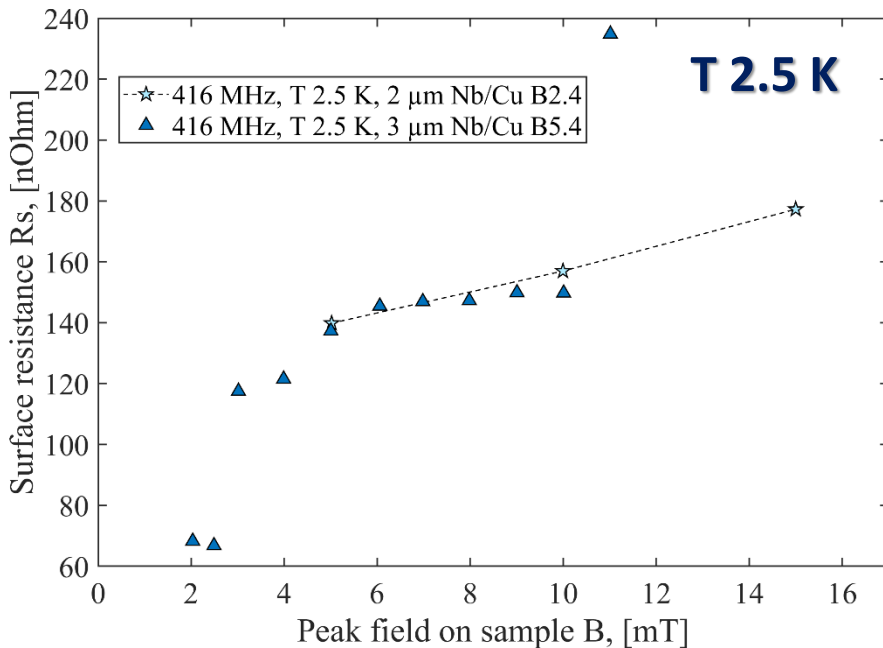
$R_{res} \sim 125$ nOhm

$B_{quench} > 70$ mT

Courtesy Dmitry Tikhonov

R_s vs B_{pk} measurements at 415 MHz

Samples B-5.4 & B-2.4, SUBU

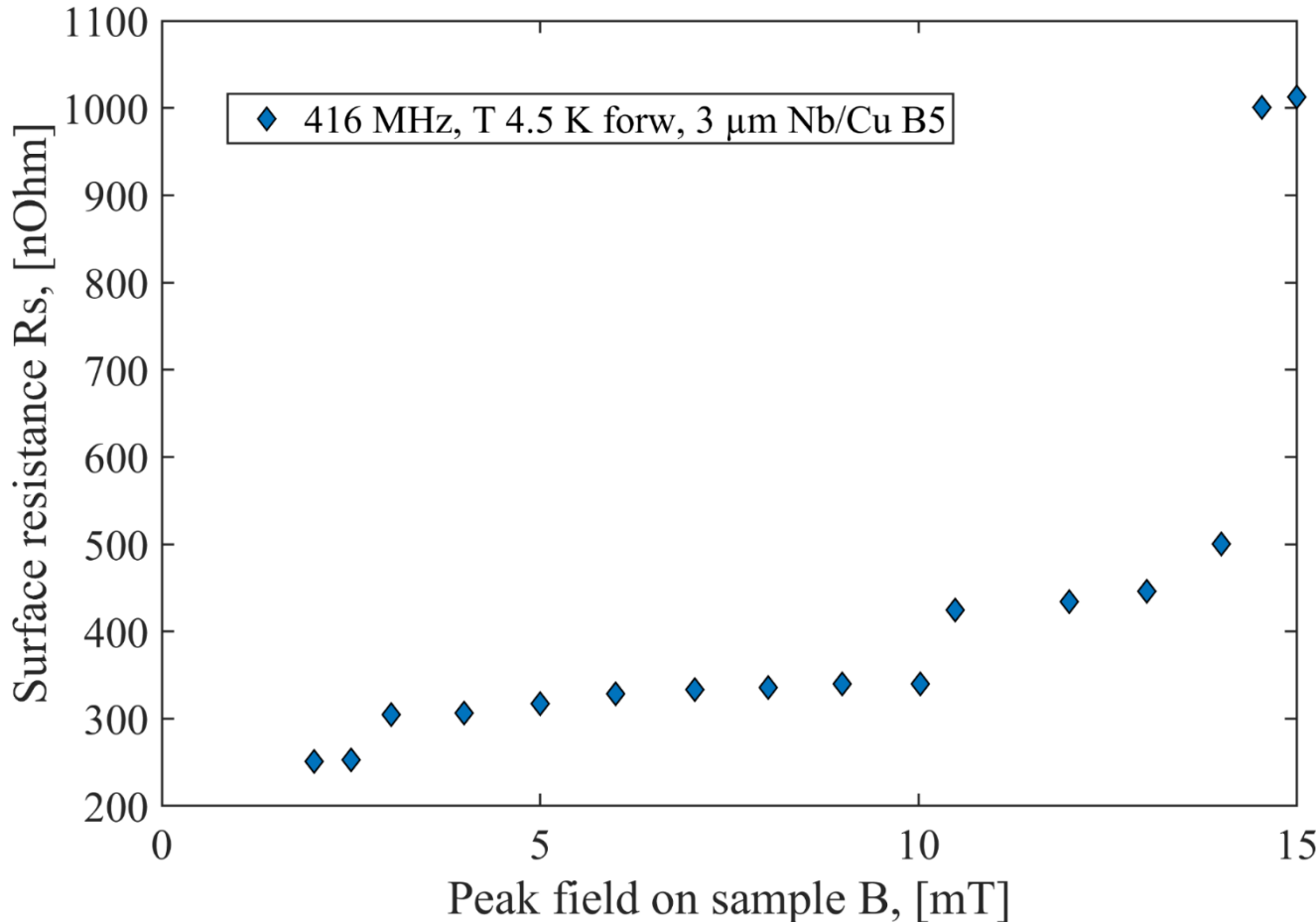


~415 MHz
~850 MHz
~1.3 GHz



Courtesy Dmitry Tikhonov

R_s vs B_{pk} measurements at 415 MHz



B-5.4
SUBU

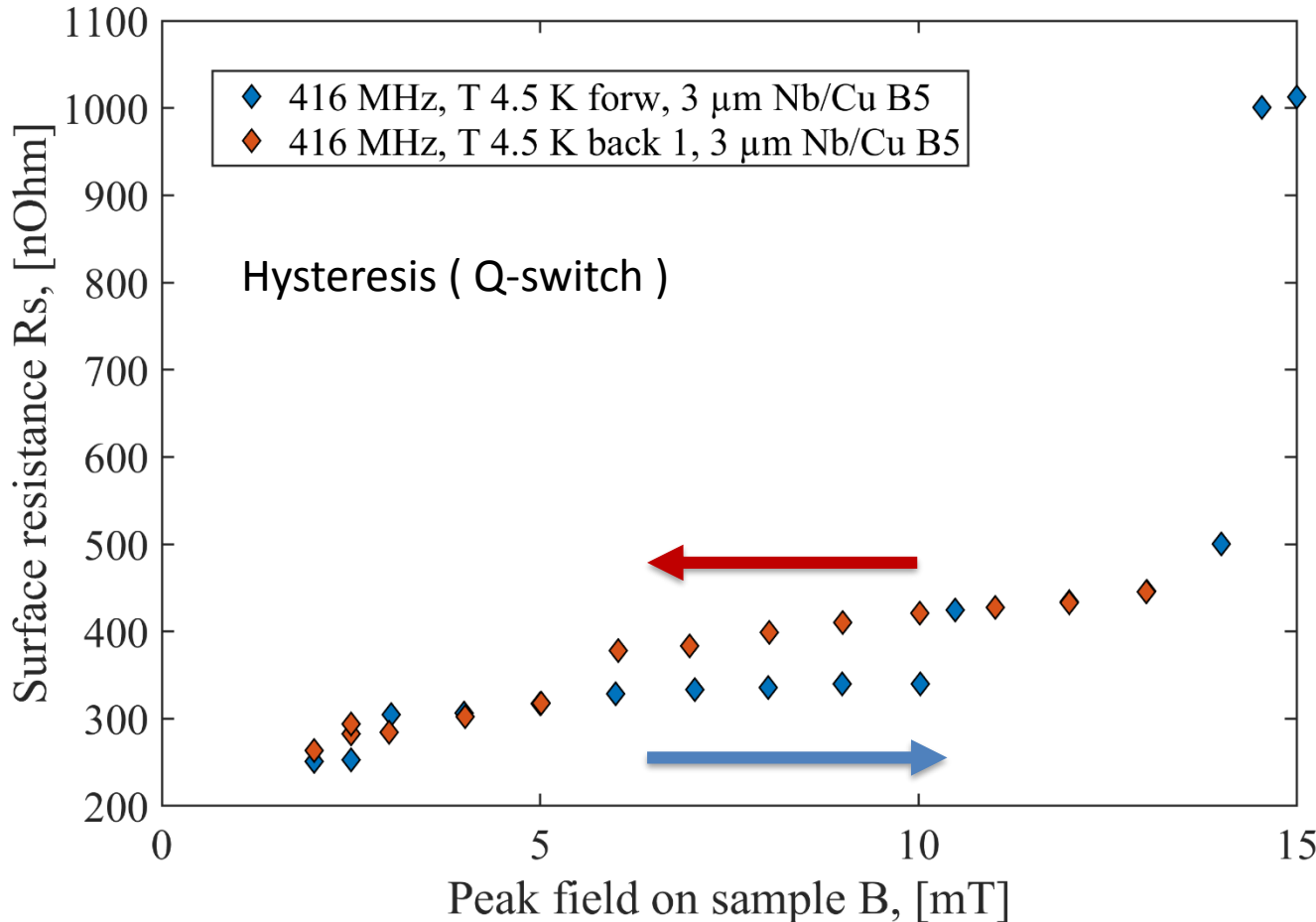


~415 MHz
~850 MHz
~1.3 GHz



Courtesy Dmitry Tikhonov

R_s vs B_{pk} measurements at 415 MHz



B-5.4
SUBU

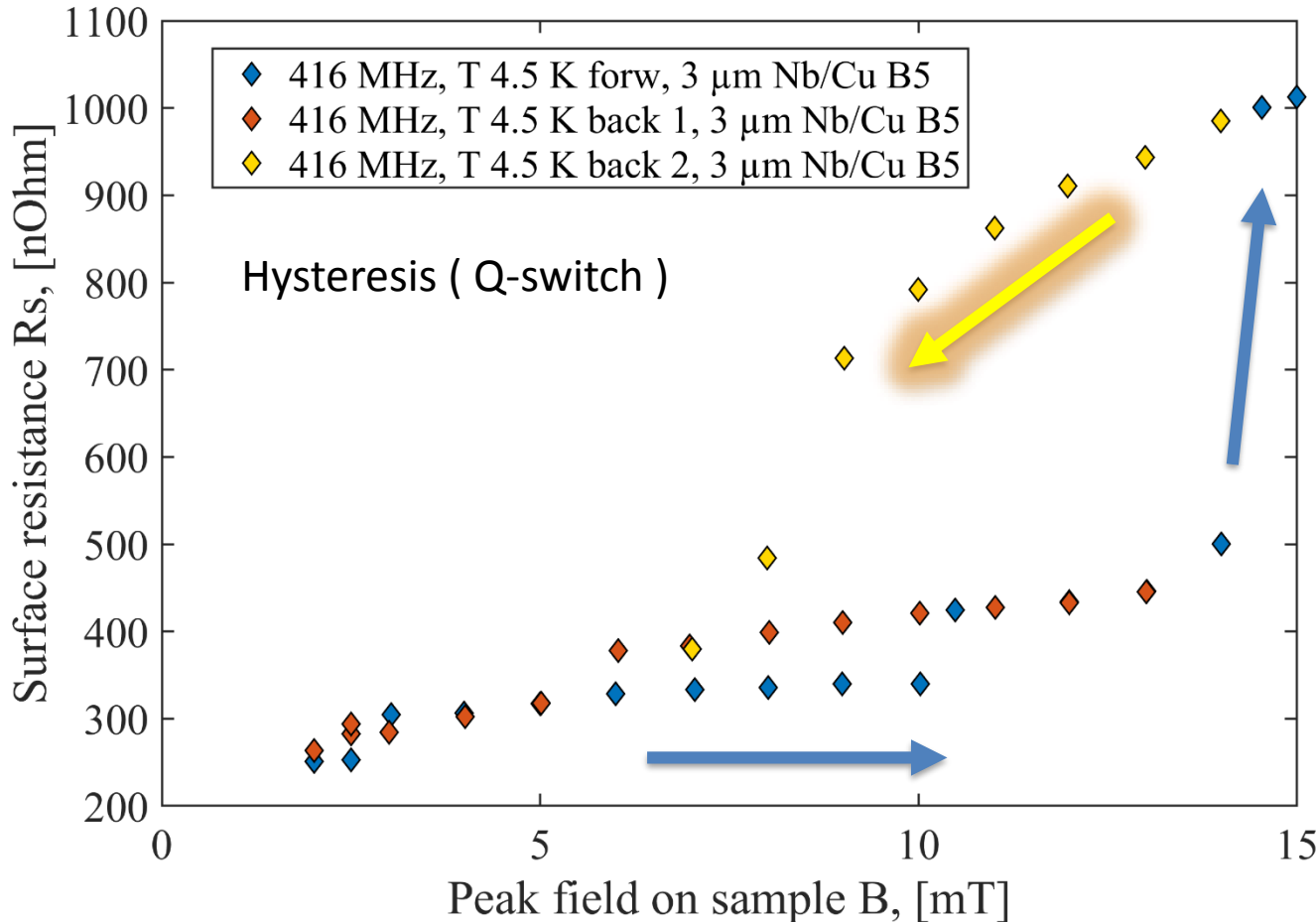


~415 MHz
~850 MHz
~1.3 GHz



Courtesy Dmitry Tikhonov

R_s vs B_{pk} measurements at 415 MHz



B-5.4
SUBU

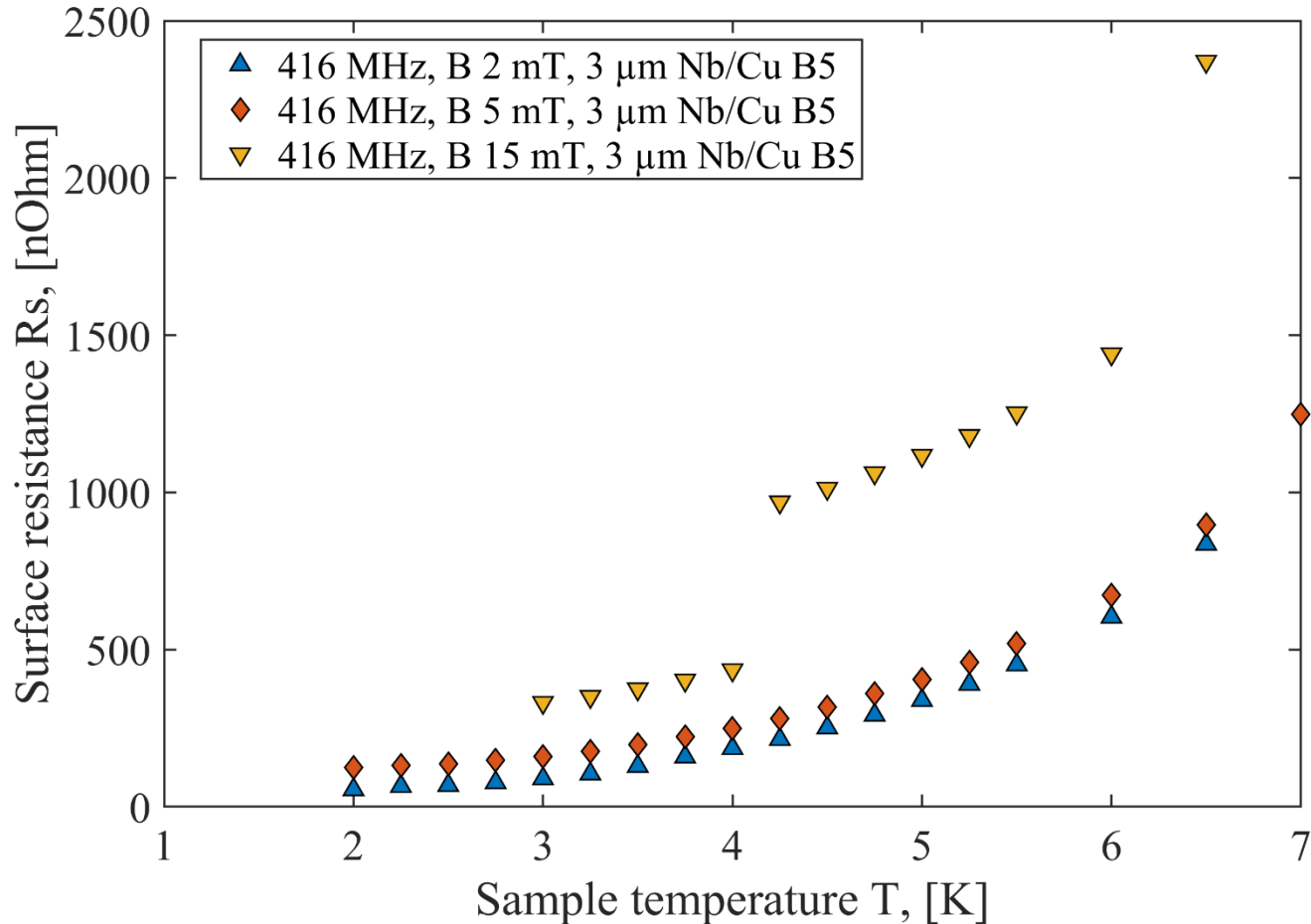


~415 MHz
~850 MHz
~1.3 GHz



Courtesy Dmitry Tikhonov

R_s vs T measurements at 415 MHz



B-5.4
SUBU



~415 MHz

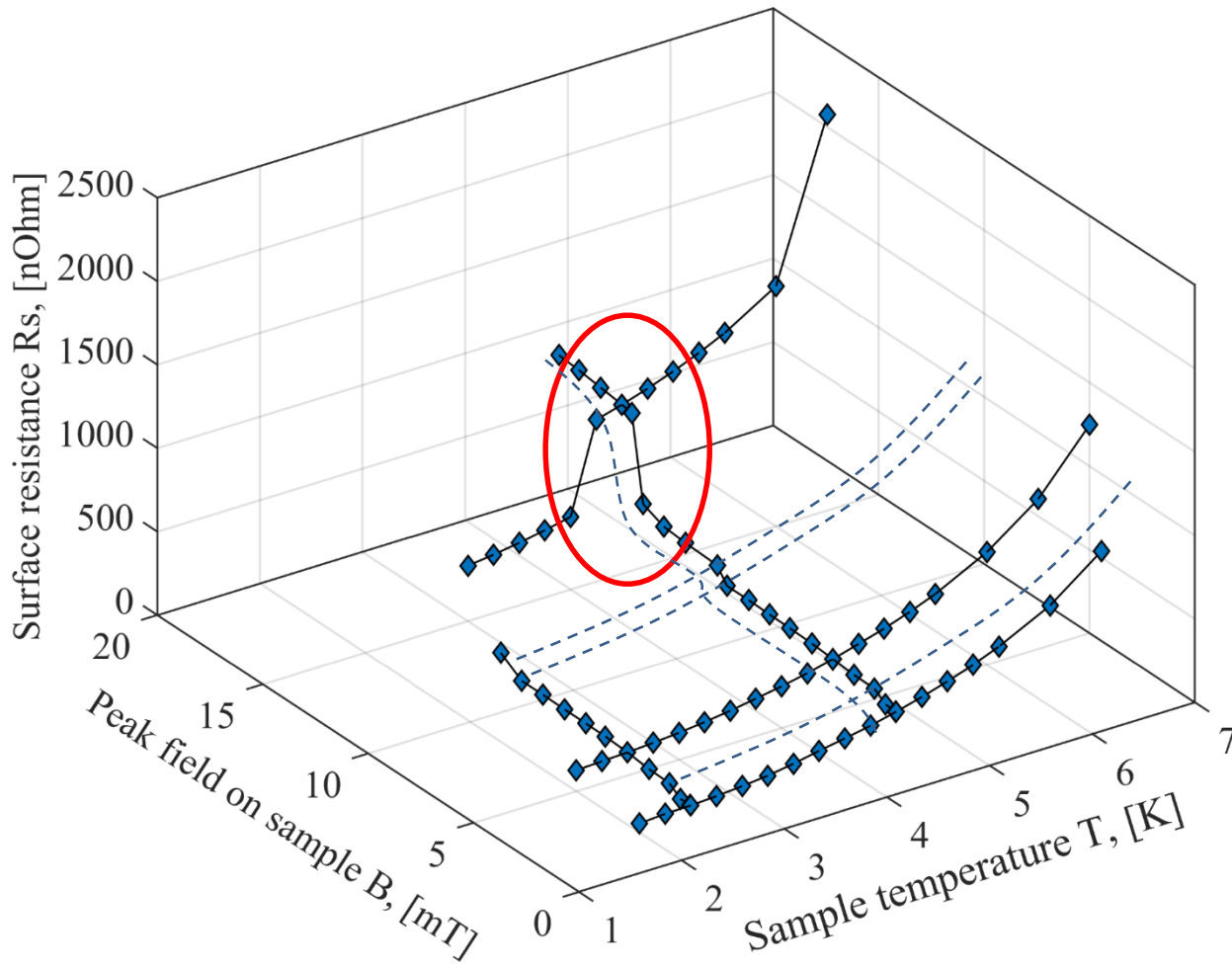
~850 MHz

~1.3 GHz

Courtesy Dmitry Tikhonov

R_s measurements 415 MHz

B-5.4
SUBU



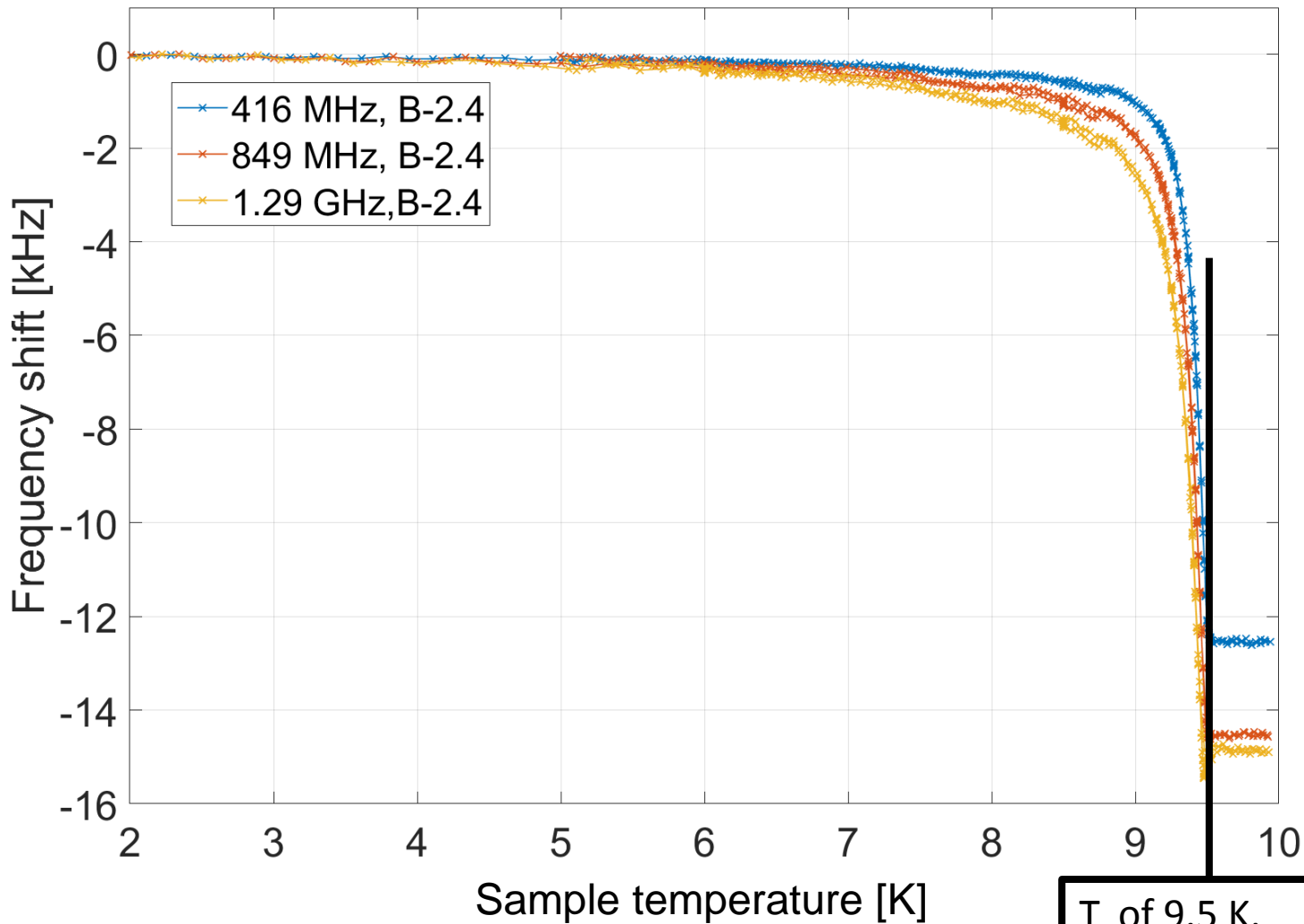
~415 MHz

~850 MHz

~1.3 GHz

Courtesy Dmitry Tikhonov

Frequency shift vs Temperature



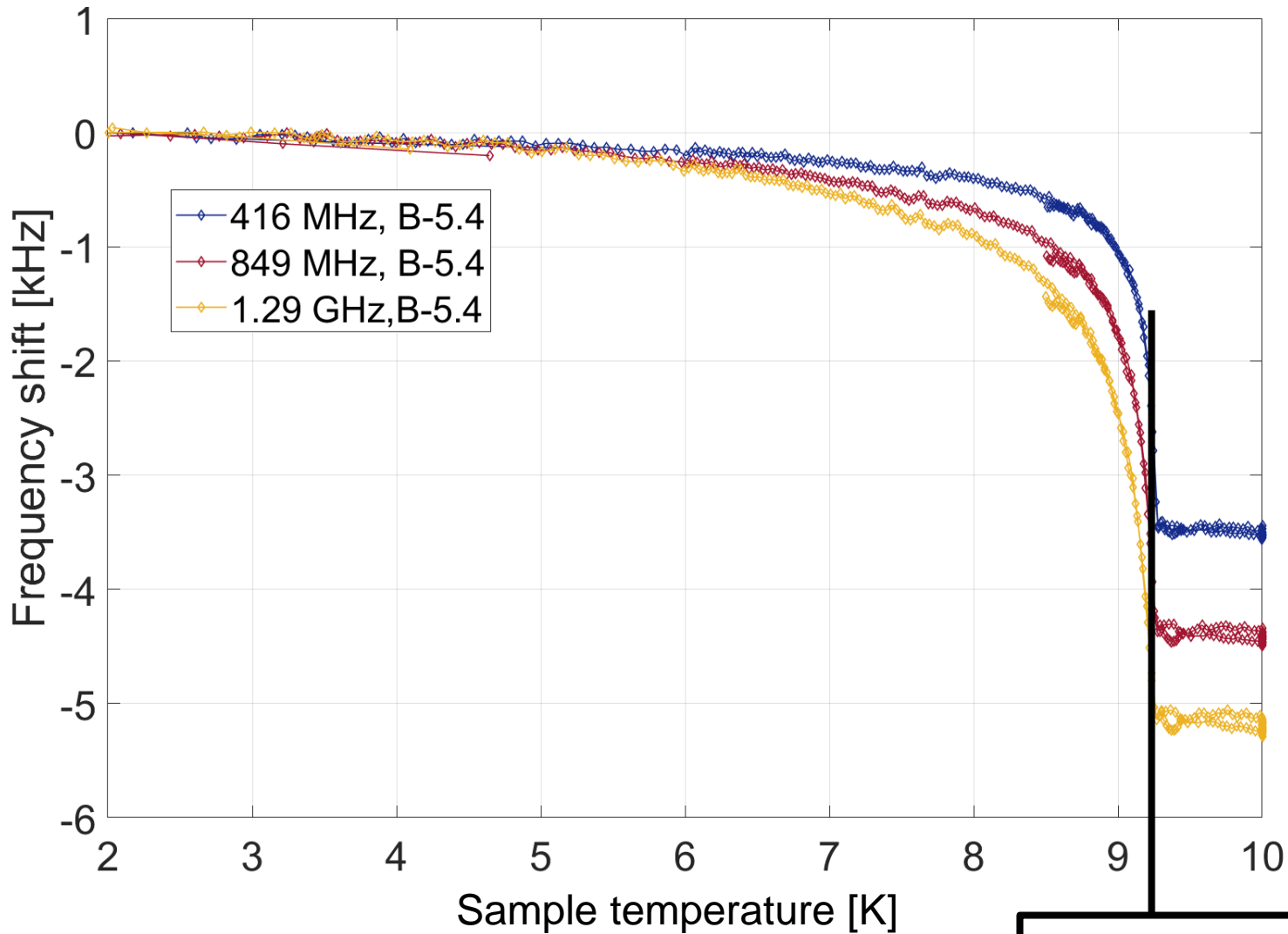
B-2.4
SUBU



T_c of 9.5 K,
too high for Nb

Courtesy Dmitry Tikhonov

Frequency shift vs Temperature



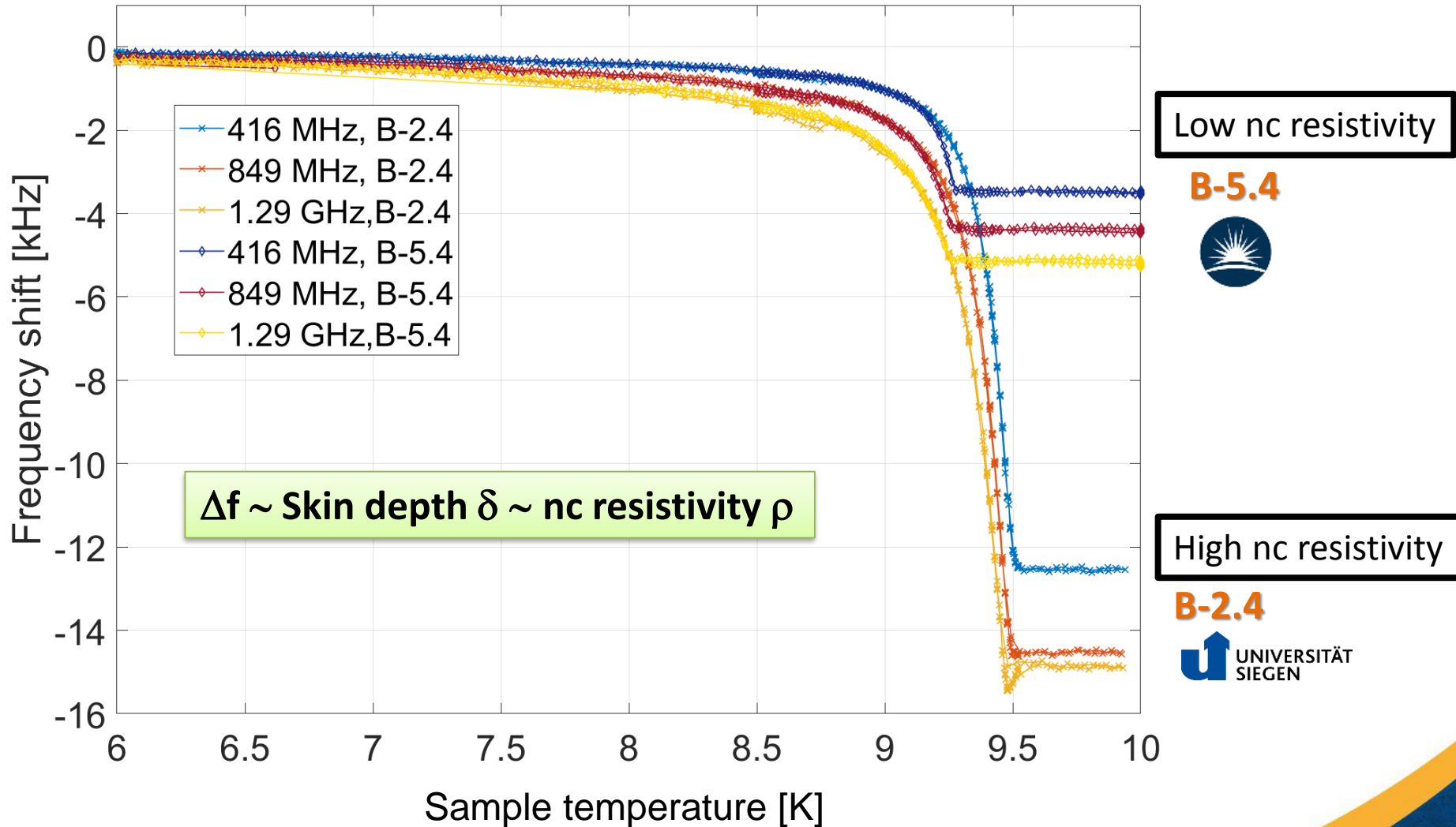
B-5.4
SUBU



T_c of ~ 9.27 K

Courtesy Dmitry Tikhonov

Frequency shift vs Temperature



Courtesy Dmitry Tikhonov

Summary

- Collaboration ARIES WP 15 in European framework set up
- Nb on Cu procedure on substrates films and QPR chambers
- RF measurements in QPR
- Optimization ongoing

ARIES WP15 – Outlook to IFAST

Substrate preparation

- SUBU, EP
- tumbling
- Laser cleaning



Sc film deposition

- sputtering
- (PE)CVD, (PE)ALD



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Film characterisation

- SEM, FIB, AFM
- XPS, XRD, RBS
- TEM...



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DC sc properties

- RRR
- AC, DC susceptibility
- local magnetometry



RF sc properties

- QPR at HZB, CERN
- HW cavity at ASTeC



HZB Helmholtz Zentrum Berlin



Cavity deposition and measurements

Scope of WP 9 of ARIES successor IFAST



ARIES WP15 – Outlook to partners



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Thank you for listening!



This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 730871.

