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I.FAST – 3rd Annual Meeting

16.April 2024 – Paris, France

QPR status

- QPR system, network and cryo infrastructure was fixed after cyber attack
- Suffered from a 9-month halt of measurements
- 1 QPR sample measured (Nb_3Sn from Legnaro)
- 1 QPR sample in pipeline (Nb_3Sn from Daresbury) measured beginning of May
- 2 QPR samples cleaned by IJCLAB and ready for deployment

Nb_3Sn QPR from Legnaro

- Light BCP (10 min, 5 µm removal)
- Baking in UHV (27h, 700 °C at top of sample 870°C inside)
- Base pressure 5e-8 mbar @ 650 °C
- Nb_3Sn Coating, sputtering from stoichiometric Nb_3Sn target
  (approx. 1 µm, 11 h coating at 650 °C)
- Cooldown (approx. 24 h in UHV, 8e-9 mbar @ room temp)

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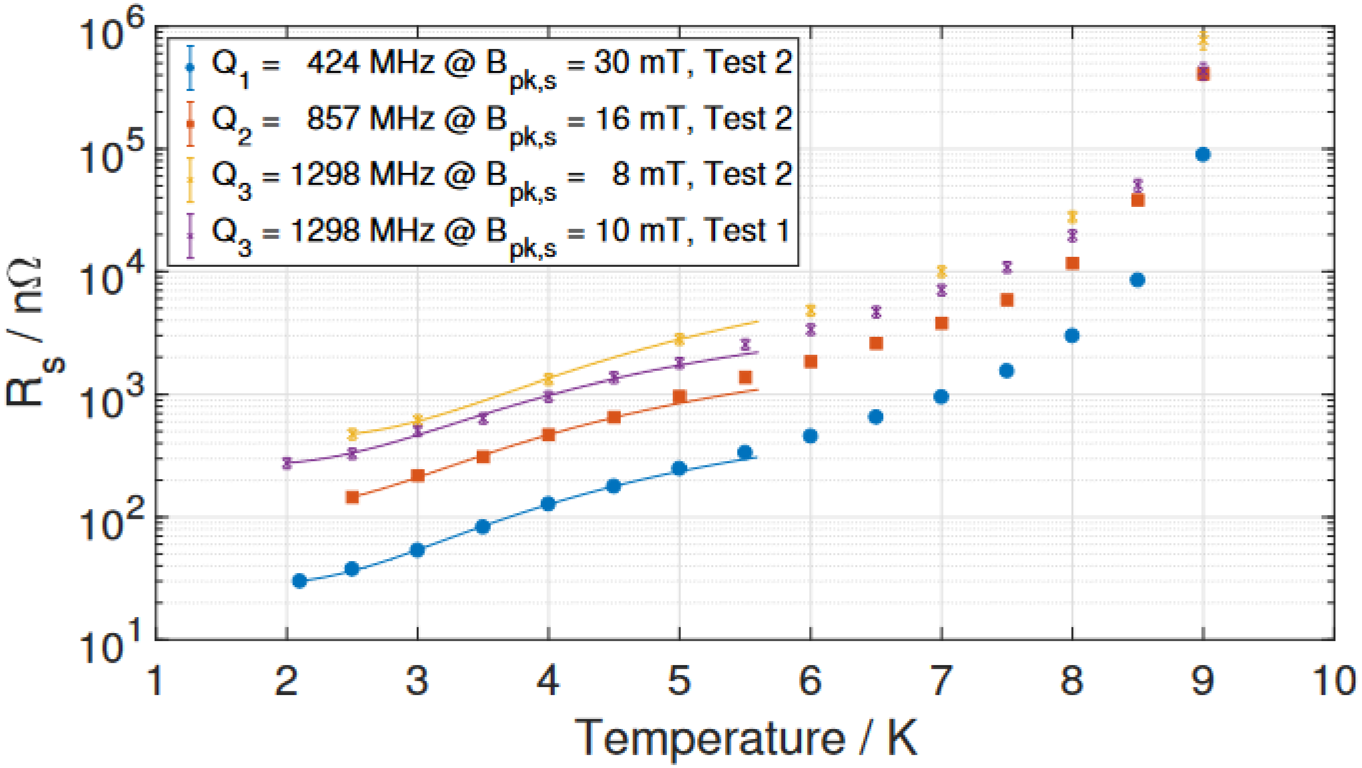
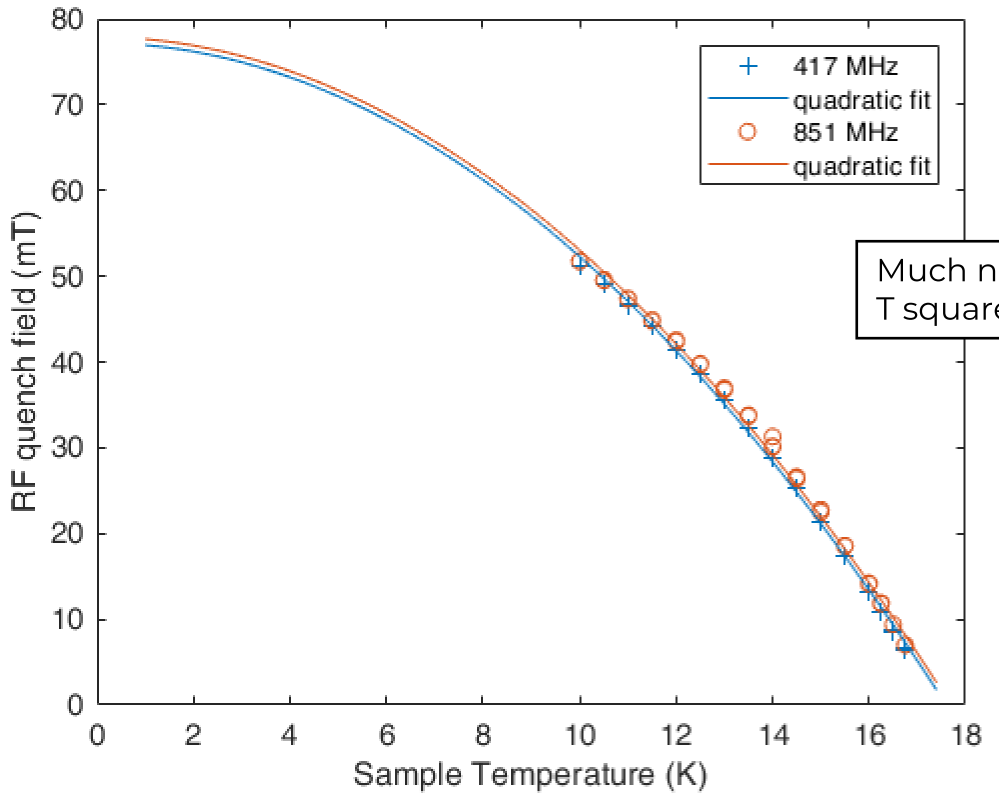
Surface resistance measurement of substrate QPR sample



Performed by R. Monroy with Uni-HH QPR
(only for qualitative reference)

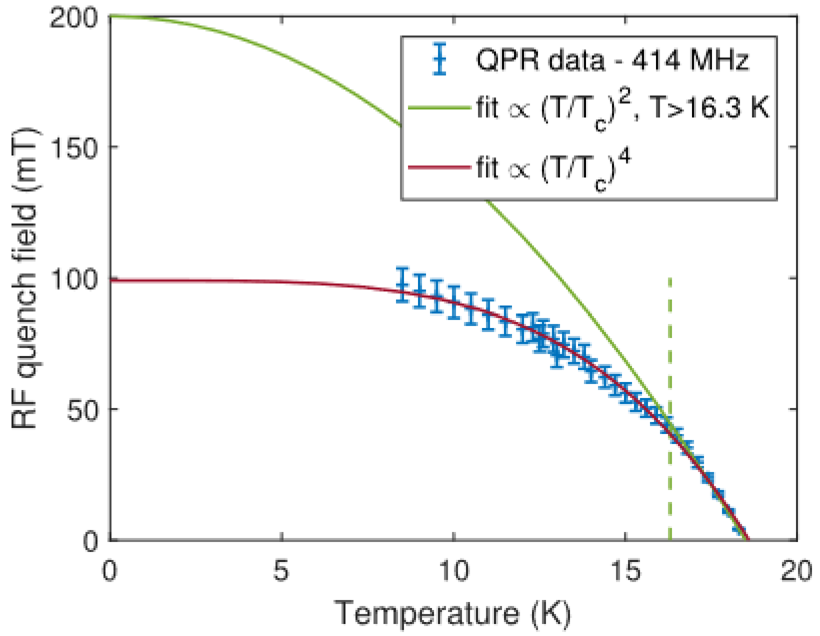
RF quench field vs T



Much nicer fit to T square behavior

Tc = 17.4 K

Fits with DC measurements on similarly produced samples

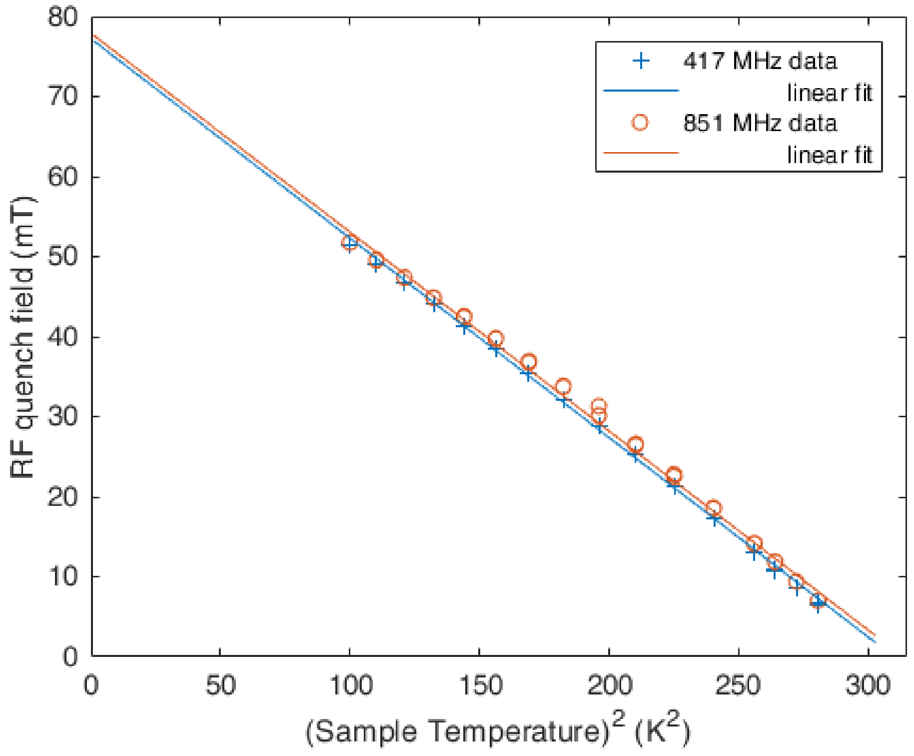


For comparison: Nb_3Sn QPR sample produced via vapor-tin diffusion by Cornell in 2017

Tc = 18.4 K

Room for improvement

Quench field extraction

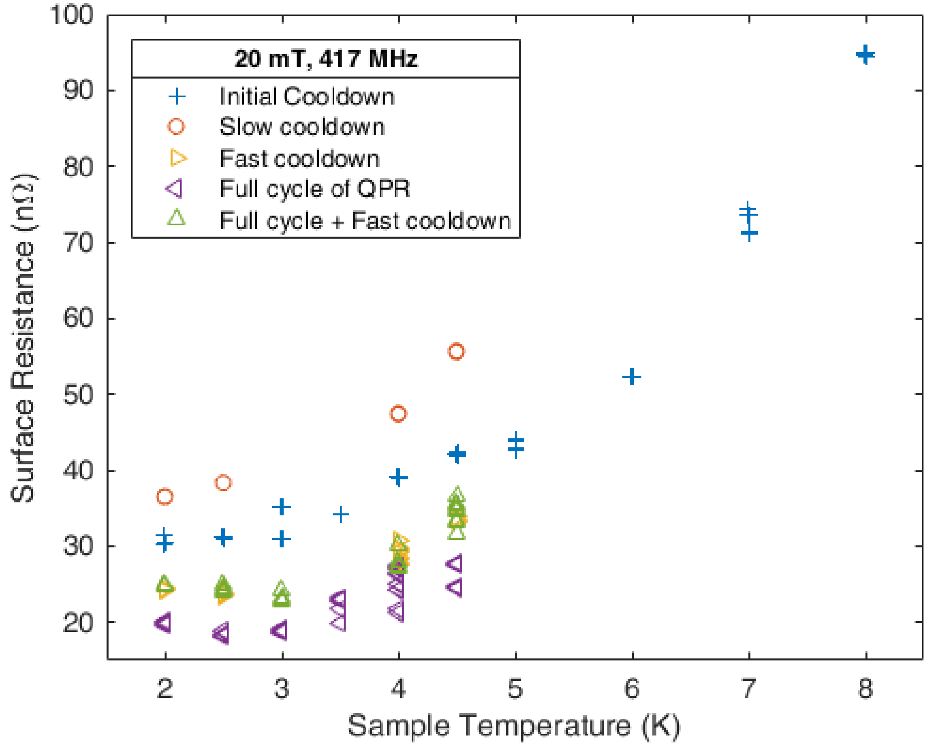


Extrapolated quench field at 0 K of 77 mT

Possibly due to reduced Tc

Room for improvement

R_s vs T



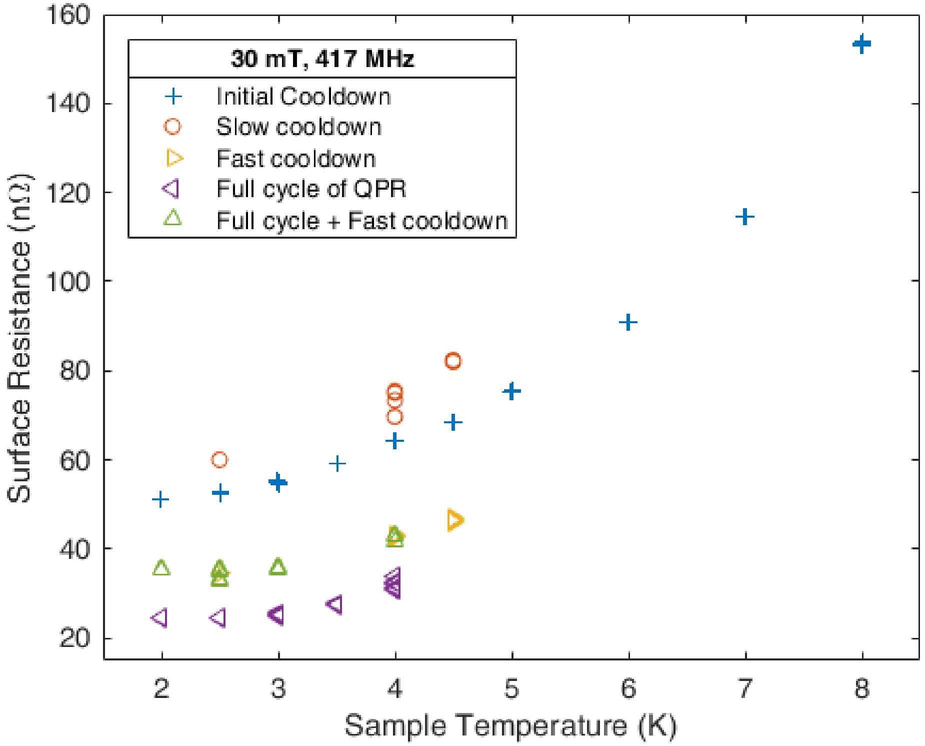
Residual resistance depends on cooling dynamics

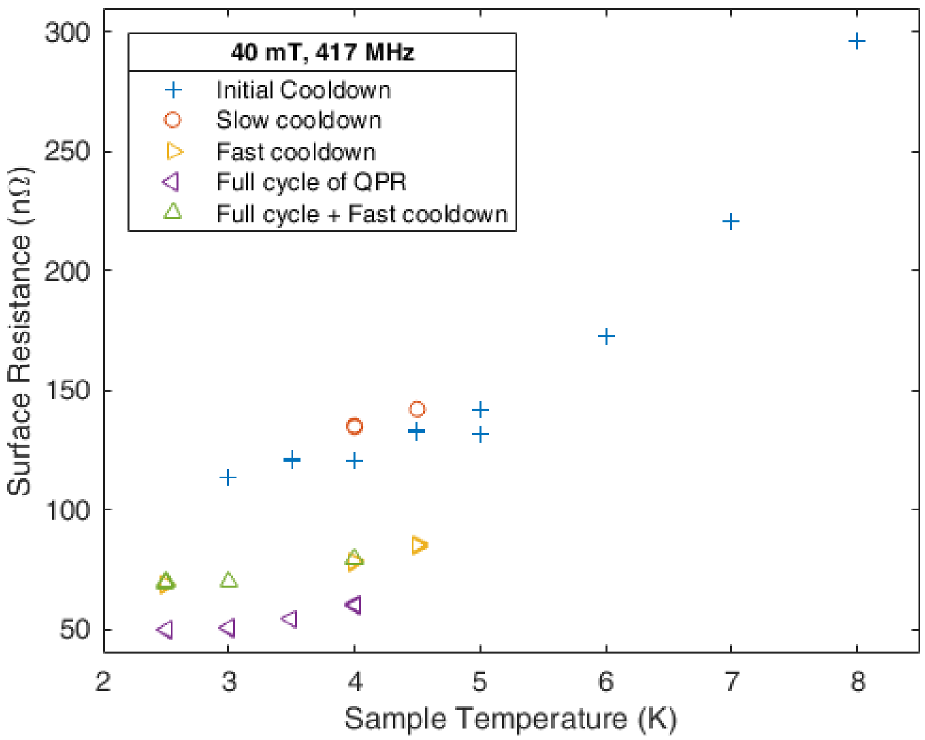
Residual resistance of 19 nOhm measured

True residual resistance at optimum cooling conditions might even be lower.

Fast cooldown better than slow cooling, but spatial temperature differences should be minimized. Effects of thermal cycling in QPR different as compared to a cavity.

R_s vs T (at higer fields)





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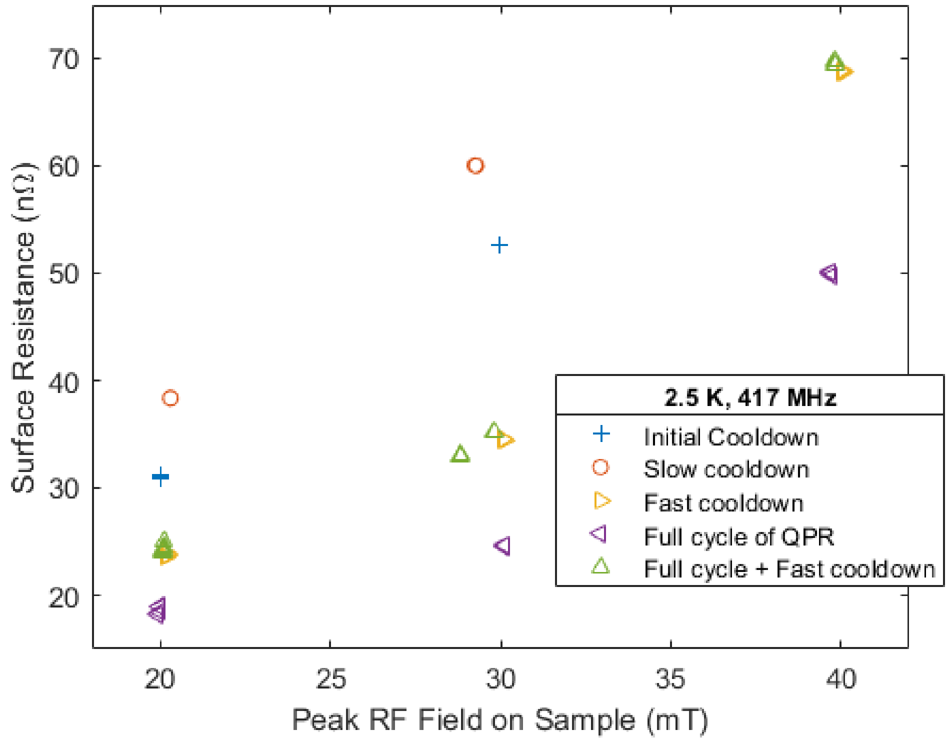
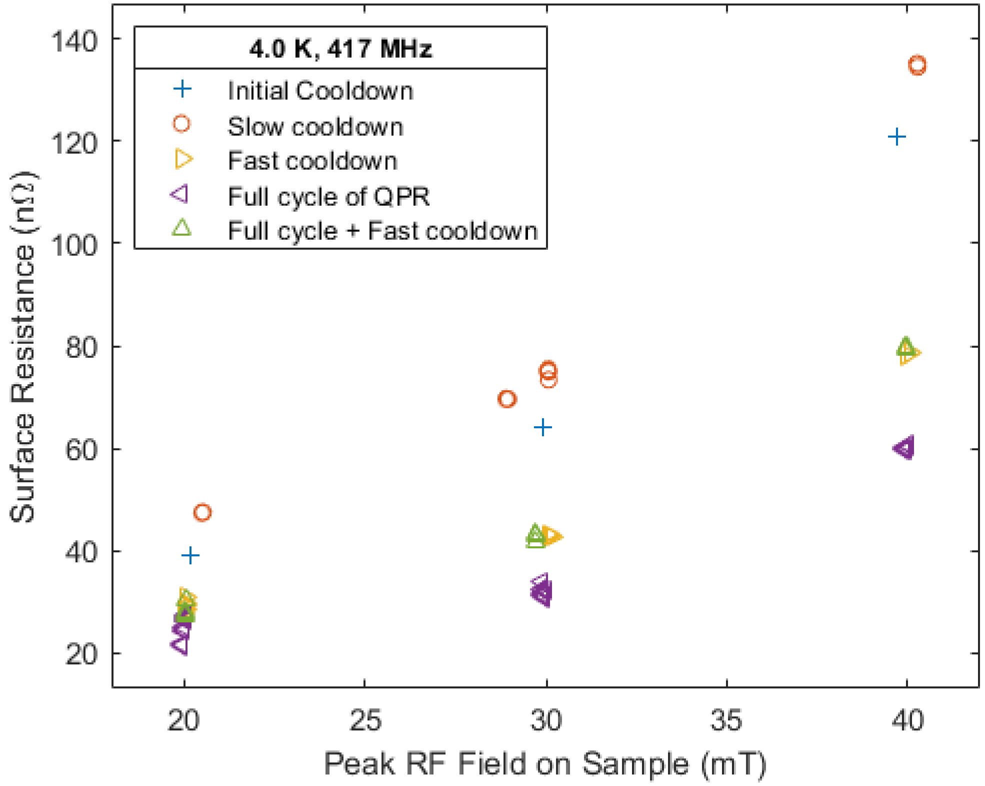
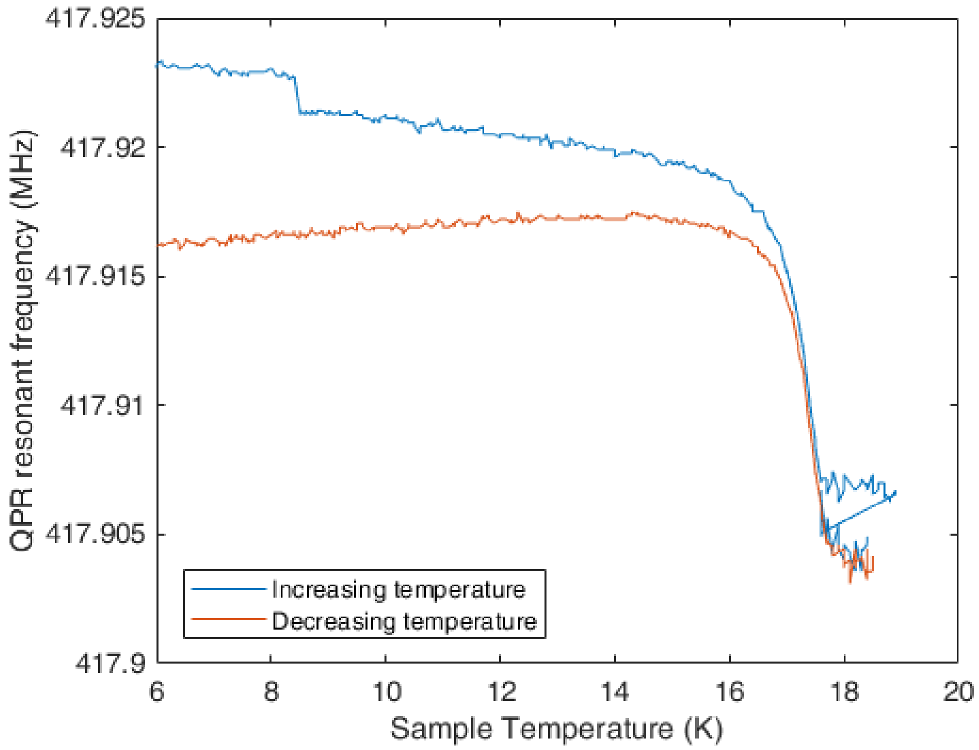
Rs vs B


2.5 K, 417 MHz
Initial Cooldown
Slow cooldown
Fast cooldown
Full cycle of QPR
Full cycle + Fast cooldown
Surface Resistance (nΩ)
Peak RF Field on Sample (mT)
20
30
40
50
60
70
20
25
30
35
40


4.0 K, 417 MHz
Initial Cooldown
Slow cooldown
Fast cooldown
Full cycle of QPR
Full cycle + Fast cooldown
Surface Resistance (nΩ)
Peak RF Field on Sample (mT)
20
40
60
80
100
120
140
20
25
30
35
40

Penetration depth



London penetration extracted from frequency change using Slater theory

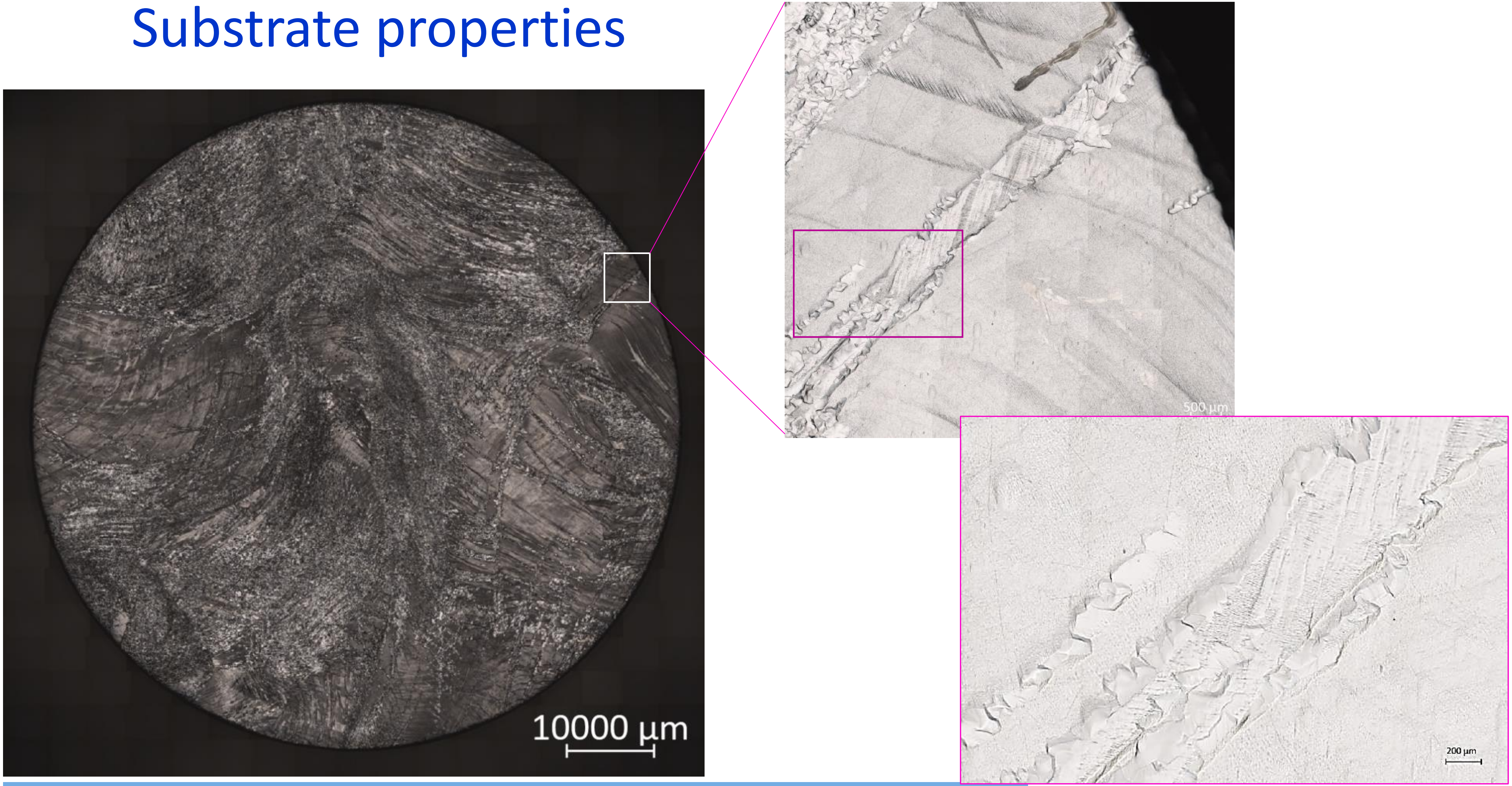
We obtain values of 350 nm (Literature value = 90 nm Cornell sample had 160 nm)

Possibly geometry factor is sensitive to surface roughness.

Need to integrate over real surface, not assumed flat surface?

$$G \sim \frac{\iiint_V |\boldsymbol{H}(r)|^2 dV}{\oint_A |\boldsymbol{H}(r)|^2 dA}$$

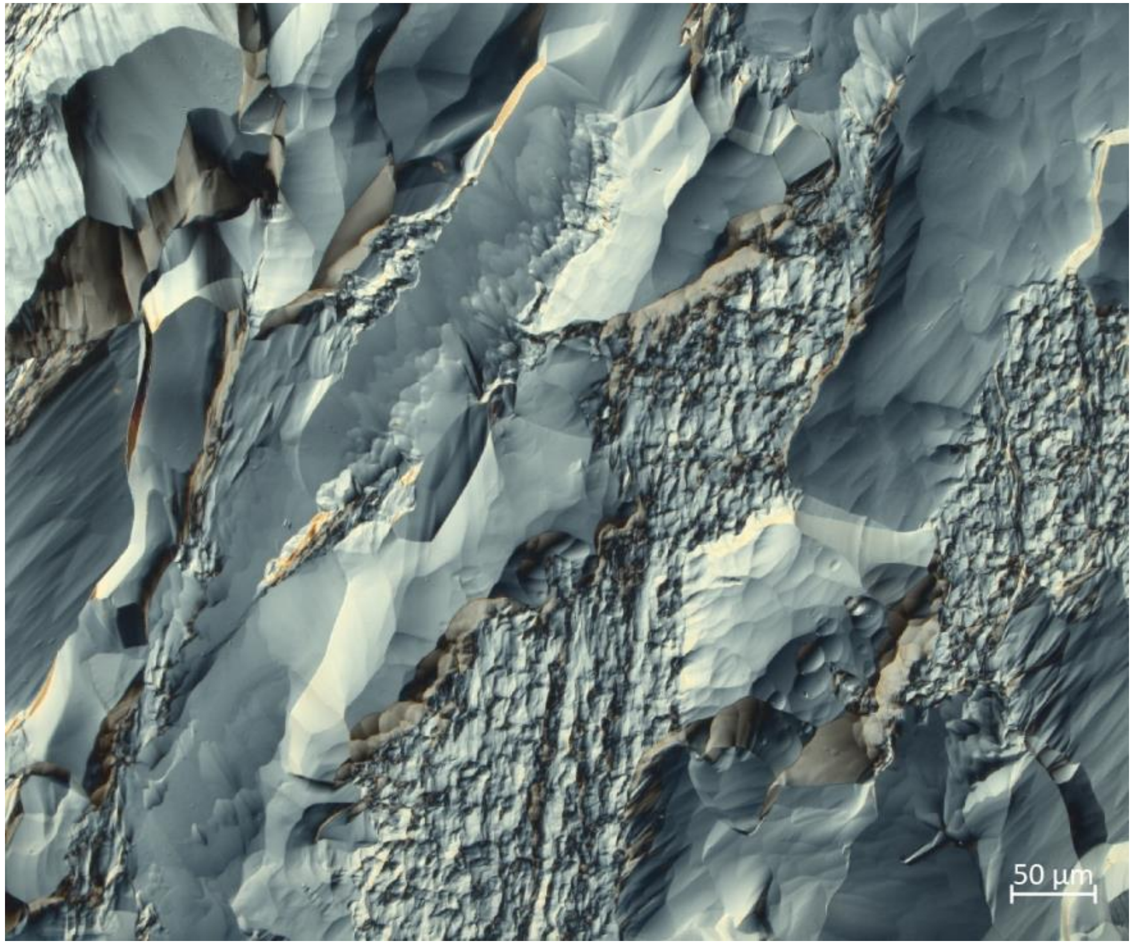
Substrate properties

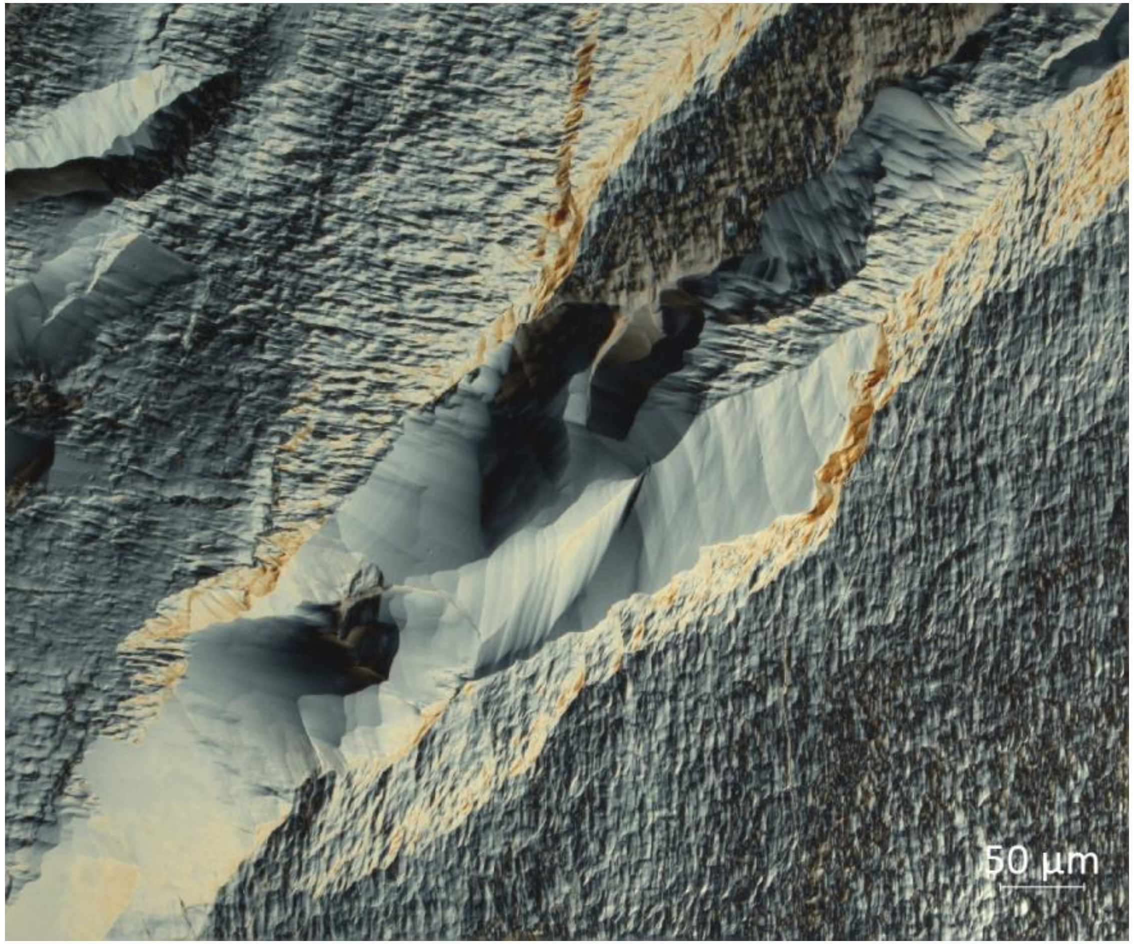


Niobium QPR Sample (baseline treated at Uni Hamburg/DESY)

A. Prudnikava, BE-IAS/HZB

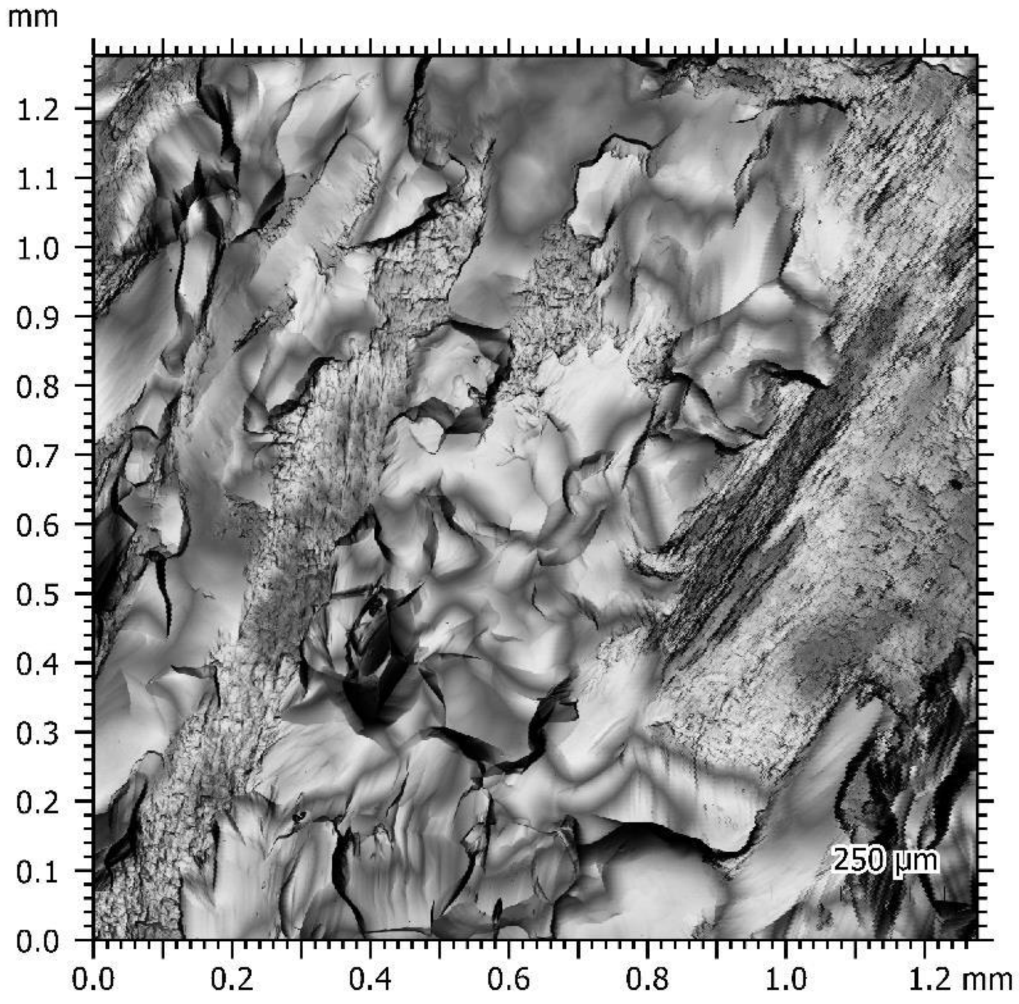
Optical (Polarized Light) Images

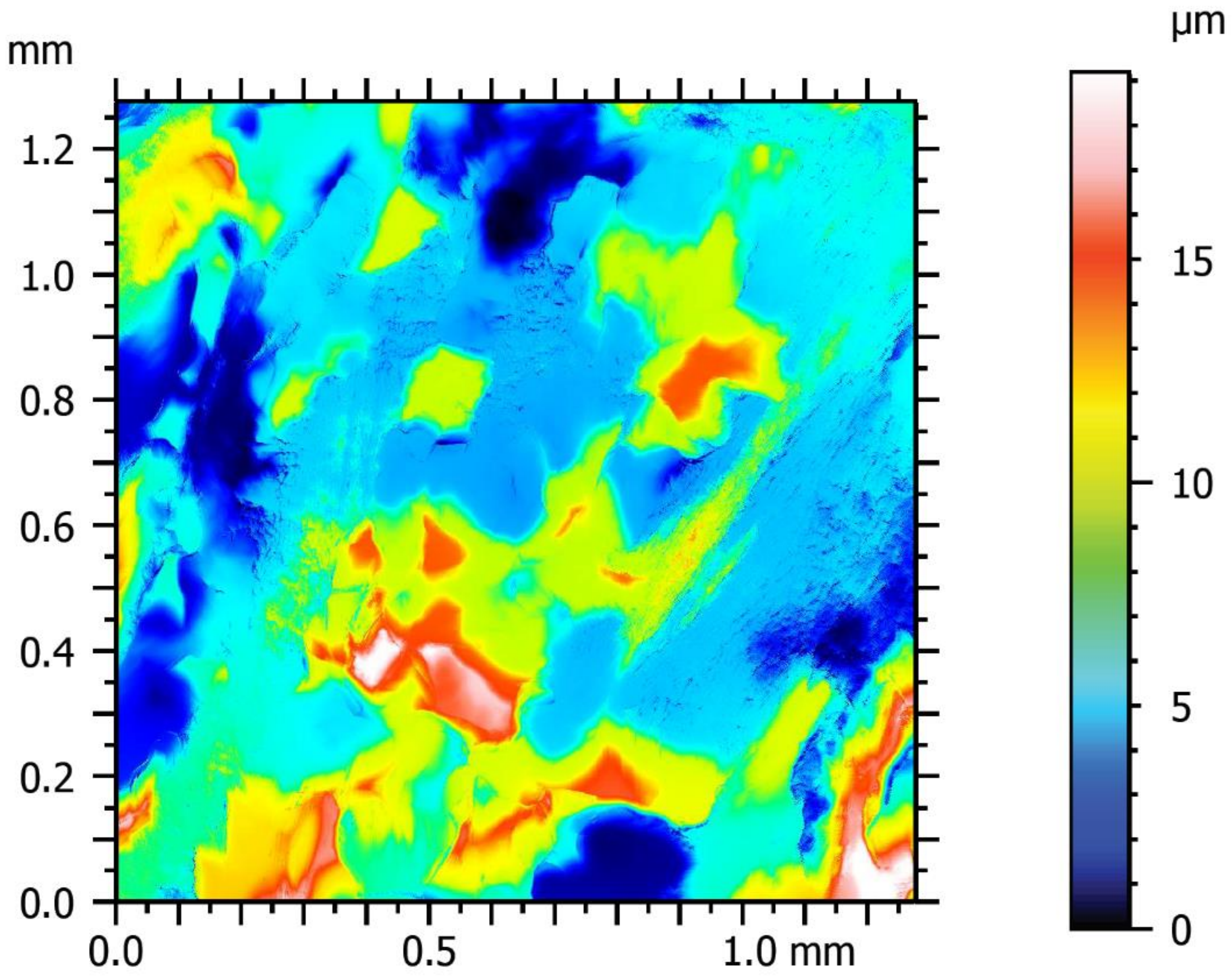




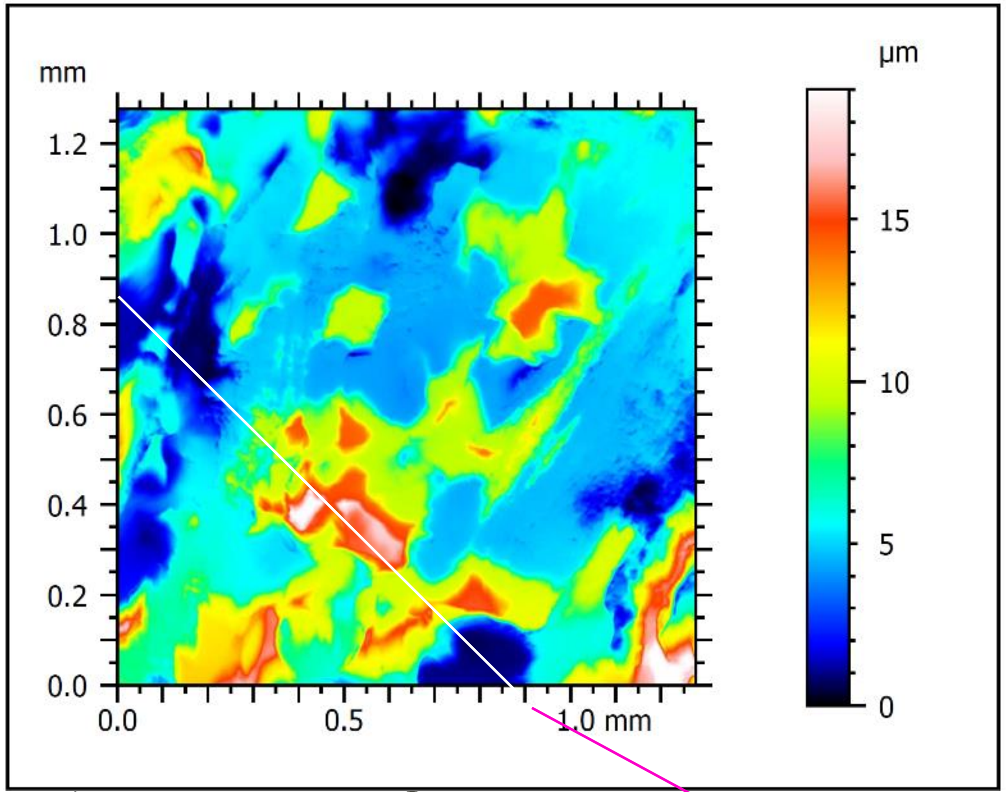
Optical (Polarized Light) Images

Laser Images



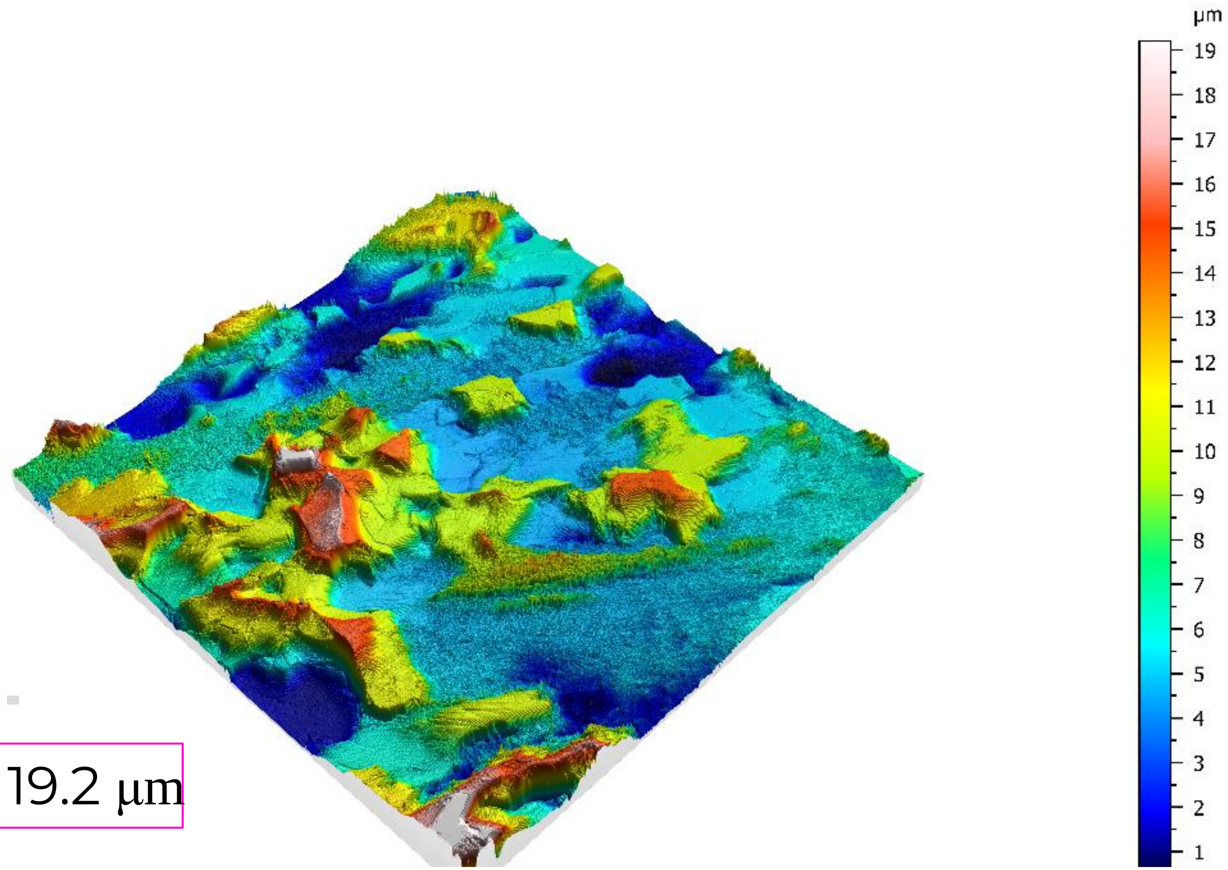


Surface Roughness

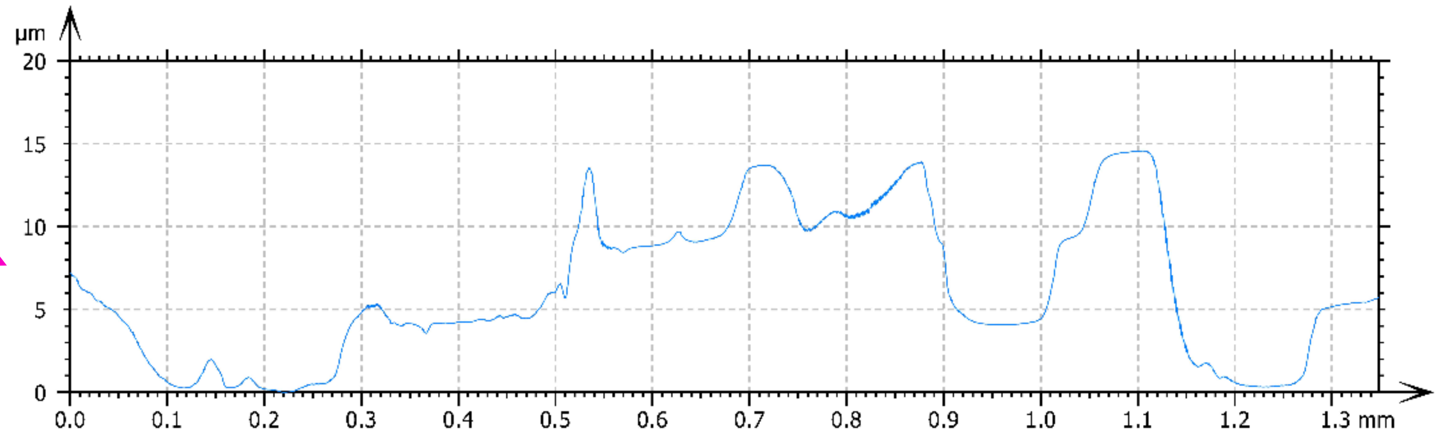


Height parameters		
Sq	3.508	µm
Ssk	0.8253	
Sku	3.602	
Sp	12.44	µm
Sv	6.598	µm
Sz	19.04	µm
Sa	2.784	µm

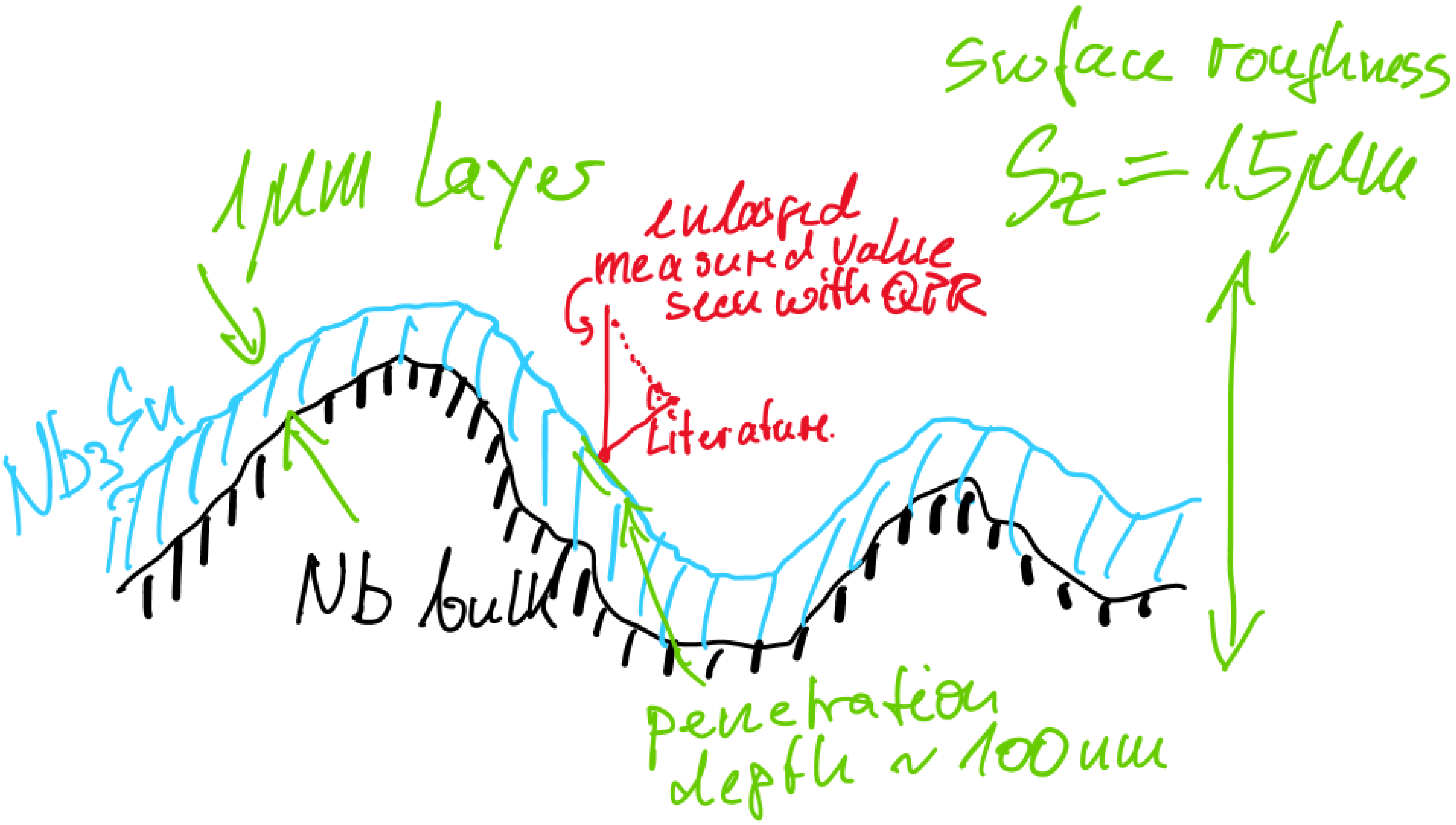
profile



S_Z = 19.2 µm



Parameters	Value	Unit
Length	1.348	mm



surface roughness
Sz = 1,5μm
1μm layer
Nb3Sn
Nb bulk
enlarged
measured value
seen with QPR
Literature.
penetration
depth ~ 100nm