SUPERCONDUCTING THIN FILMS CHARACTERIZATION AT HZB WITH THE QUADRUPOLE RESONATOR

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ABSTRACT **Superconducting thin films have great potential as post-Nb material for use in SRF applications in future accelerators and industry. Deposition of thin films on real cavities scales in test facilities are challenging, in particular when curved surfaces have to be coated. In this contribution we report on the method we use to characterize small and flat thin film samples (Deposited onto both Nb and Cu substrates) in an actual cavity named the Quadrupole Resonator (QPR) [1,2]. We also summarize the latest measurement results of NbTiN thin films produced by J-Lab[2].**

METHOD

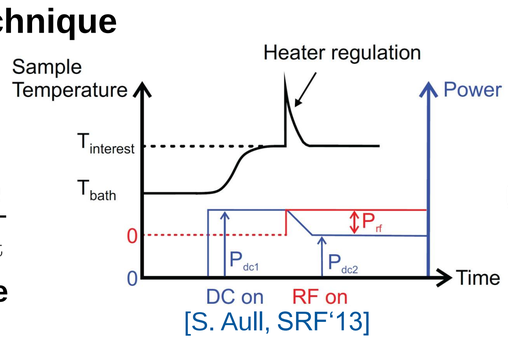
Calorimetric measurements:
RF-DC-compensation technique

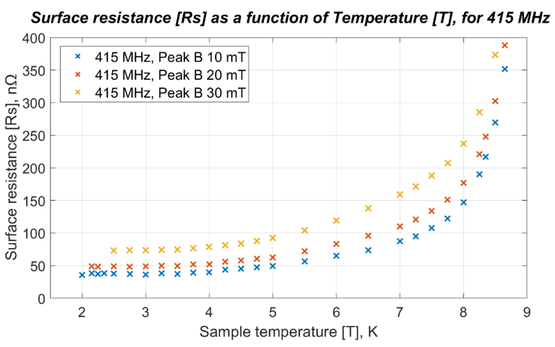
$$R_S = 2\mu_0^2 c_1 \frac{\Delta P_{DC}}{B^2_{sample}}$$

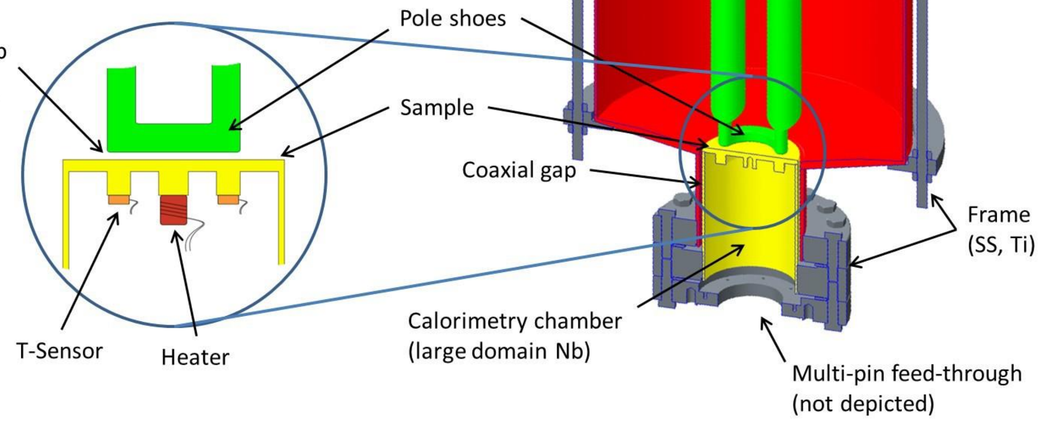
$$= 2\omega\mu_0^2 \cdot \frac{c_1}{c_2} \cdot \frac{\Delta P_{DC}}{P_t \cdot Q_t}$$

Wide and easy accessible parameter space

T_{sample} = 1.8 … >20 K
B_{RF} = 5 … 120 mT
f = 415, 850, 1285 MHz



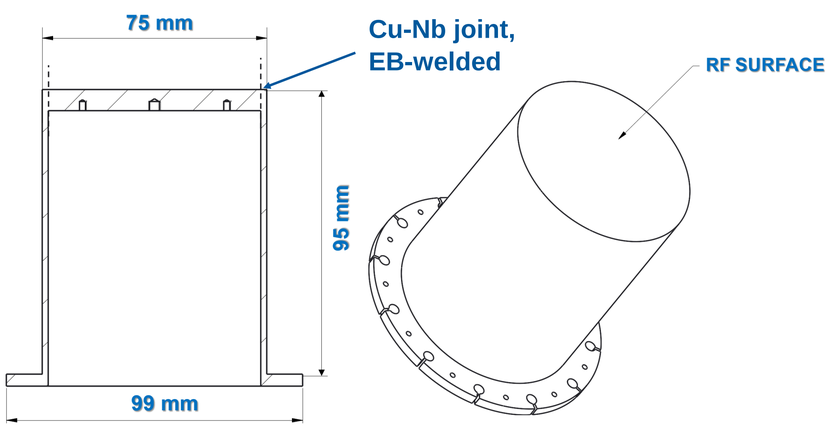




NEW SUBSTRATES FOR SUPERCONDUCTING FILMS RESEARCH

Those substrates were sponsored by the ARIES project [3] one of the goals of which is the systematic study of Cu surface preparation procedures for films deposition. The results of this research are important for future Cu-based coated cavities which might be used for the FCC and other next-generation accelerators.

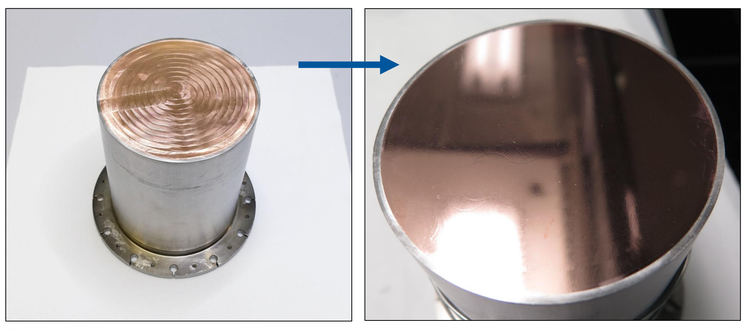
- 5 copper and 5 niobium substrates were produced at RI[3].
- For making coating process easier new (simplified) design has been developed.
- After fabrication Cu substrates will be mechanically treated to reduce roughness and chemically polished at INFN LNL[4].
- Cu-Nb joint was created with electron-beam 'welding' by RI.
- After SUBU done by INFN, first two substrates will be coated with NbN films at two facilities: University of Siegen and Daresbury Laboratory[5].
- Nb substrates were mechanically polished, chemically treated by BCP (~150 µm) and exposed to ~800°C annealing for 2 hours. Unfortunately after BCP they require further polishing.



Substrate dimensions

NEXT STEPS

- Finalizing SUBU polishing of Cu substrates at INFN LNL
- Coating of samples at University of Siegen and Daresbury Laboratory[5] with NbN films



One of the Cu substrates after fabrication and after SUBU .

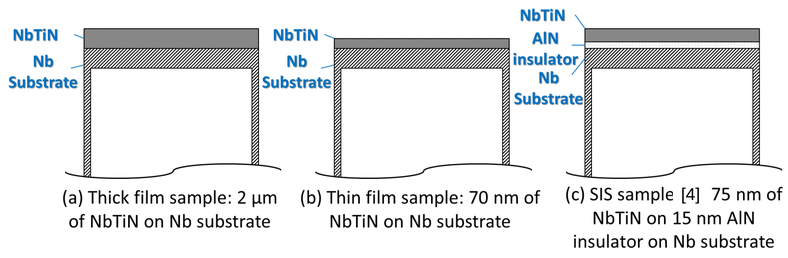
*[*Credits: Cristian Pira, INFN LNL]*

5 mechanically polished Nb substrates (before BCP)

NB-TI-N FILMS MEASUREMENTS

NbTiN films on Nb were prepared by J-lab[2]. Three NbTIN samples with different film thickness and layer structure were measured at HZB with the QPR:

- NbTiN 2 µm bulk film on Nb
- NbTiN 70 nm film on Nb
- NbTiN SIS (SC-insulator-SC) structure (see also pres. by S. Keckert for more detailed analyses of this structure [4])



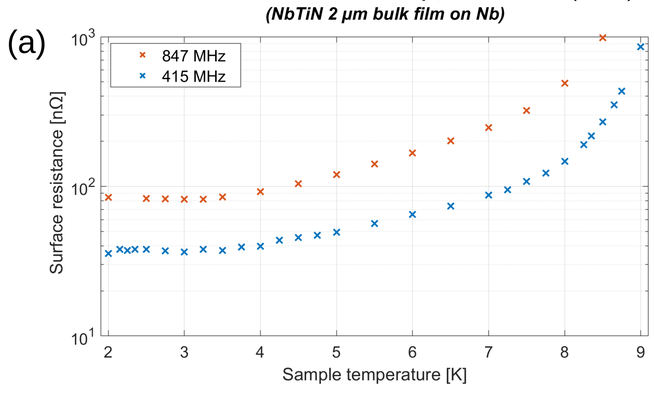
(a) Thick film sample: 2 µm of NbTiN on Nb substrate

(b) Thin film sample: 70 nm of NbTiN on Nb substrate

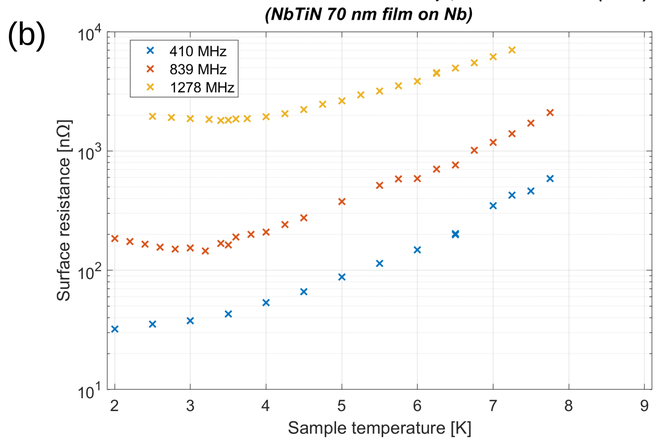
(c) SIS sample [4] 75 nm of NbTiN on 15 nm AlN insulator on Nb substrate

Schematic structure of three samples a), b) and c)

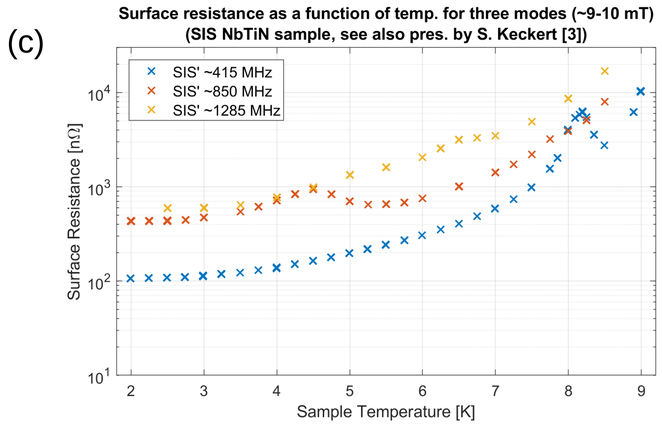
Surface resistance as a function of Temp., for two modes (10 mT) (NbTiN 2 µm bulk film on Nb)



Surface resistance as a function of Temp., for three modes (5 mT) (NbTiN 70 nm film on Nb)



Surface resistance as a function of temp. for three modes (~9-10 mT) (SIS NbTiN sample, see also pres. by S. Keckert [3])



NN	Film	Tc, K	B_{quench}, mT (3 K)
(a)	Bulk (2 µm)	17.0±0.1	55±1
(b)	Thin (70 nm)	16.5±0.1	10±1
(c)	SIS [5]	14.3±0.1	20-25

RF quench B field and critical temperature measurements for samples

CONCLUSIONS

- Films show low surface resistance, however they all have far too low critical RF field (especially thin films) as compared to present Nb cavities
- SIS structure presents the most interesting behavior and shows the 'reversed' temperature vs surface resistance at some regions (see [4])

[3] RI Research Instruments GmbH https://research-instruments.de
[4] Laboratori Nazionali di Legnaro LNL https://www.lnl.infn.it/
[5] Daresbury Laboratory https://stfc.ukri.org/about-us/contact-us/

REFERENCES

(1) R. Kleindienst, O. Kugeler, and J. Knobloch, "Development of an optimized quadrupole resonator at hzb," *in Proc. of the 16th International Conference on RF Superconductivity (SRF'13), Paris, France, 2013*, pp. 614–616. http://accelconf.web.cern.ch/AccelConf/SRF2013/papers/tup074.pdf
(2) R. Kleindienst, A. Burrill, S. Keckert, J. Knobloch, and O. Kugeler, "Commissioning Results of the HZB Quadrupole Resonator," in *Proc. of International Conference on RF Su- perconductivity (SRF'15), Whistler, BC, Canada, 2015*, pp. 930–936, isbn: 978-3-95450-178-6. doi: 10 .18429 / JACoW-SRF2015-WEA1A04.
(3) European Union's ARIES collaboration H2020 Research and Innovation Programme under Grant Agreement no. 730871. https://aries.web.cern.ch/
(4) S. Keckert, J. Knobloch, and other., "RF CHARACTERIZATION OF AN S-I-S MULTILAYER SAMPLE" *Also in proc. of the 19th International Conference on RF Superconductivity* (SRF'19), 2019, Dresden, Germany, THFUA1

ACKNOWLEDGEMENTS & SPONSORSHIP

EASITrain – European Advanced Superconductivity Innovation and Training. This Marie Sklodowska-Curie Action (MSCA) Innovative Training Networks (ITN) has received funding from the European Union's H2020 Framework Programme under Grant Agreement no. 764879

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