First Results from the T_c Test-Stand for Superconducting Thin-Film Coatings

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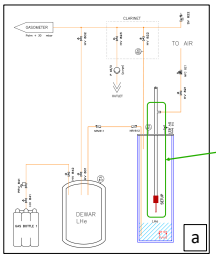
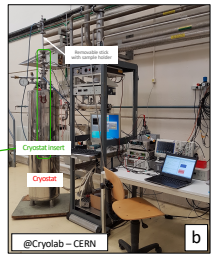
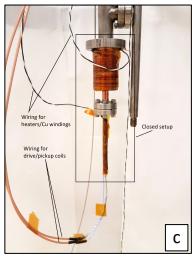
Introduction

The FCC Study is an international collaboration established, in the search for physics beyond the Standard Model, to investigate the feasibility of a new circular collider having LHC as main injector. To this end, one major challenge is represented by the development of ad-hoc SRF cavities, for which one of the possibilities is given by superconducting (SC) film coated copper cavities.
It is then important to study the properties of these films such as the critical temperature T_c to assess their superconducting performance. The achievement of the literature values of T_c still represents a non-trivial goal for films on copper. In this work, we present and discuss the results from the first measurements performed with a dedicated test stand that has been commissioned at the Central Cryogenic Laboratory at CERN for the contactless, inductive measurement of the T_c of SC thin-film samples deposited on copper.

Measurement set-up







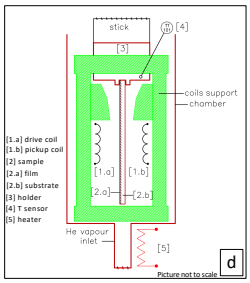
a. Test-stand PID

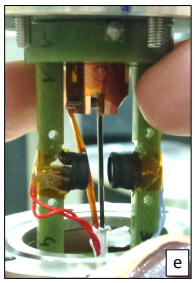
b. Test-stand at the Central Cryogenic Laboratory – CERN

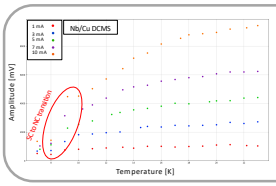
c. Experimental chamber (closed) at the bottom of the cryostat insert

d. Scheme of measurement setup

e. Measurement setup as mounted inside the experimental chamber







Parametric qualification:
- Temperature
- Drive coil current
- Sampling frequency
- Signal gain

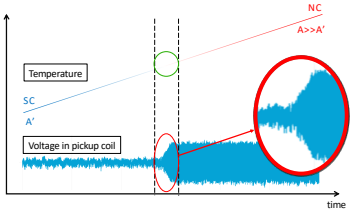
With: coils only, bare Cu, Nb/Cu and bulk Nb sample

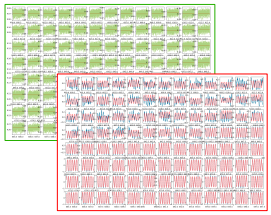
Measurement principle

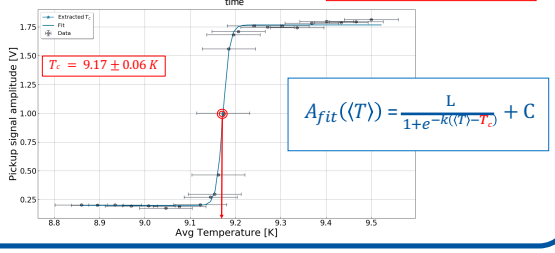
The sample is placed between the *drive* coil and *pickup* coils as in Fig. d[2]. He vapour enters the chamber at the bottom and flows through setup to cool down the sample:

1. T stable (within 0.1 K), film SC: the AC current is turned ON in the drive coil (Fig. d[1.a]);
2. AC magnetic field shielded: a voltage of amplitude A' is induced in the pickup coil (Fig. d[1.b]) by the leak field;
3. T is increased via electrical heater (Fig. d[5]);
4. $T > T_c$, film NC: the field induces a voltage of amplitude A>>A' in the pickup coil.

Off-line extraction of T_c:
1. V_{pickup} and T data are sampled into time sub-intervals long ~10 periods of the drive current signal;
2. each V_{pickup} sub-interval is fitted to extract the signal amplitude, <T> is extracted from the corresponding temperature sub-intervals;
3. the extracted amplitude is plotted vs <T> and fitted;
4. T_c is extracted as the half-height of the transition fit curve.



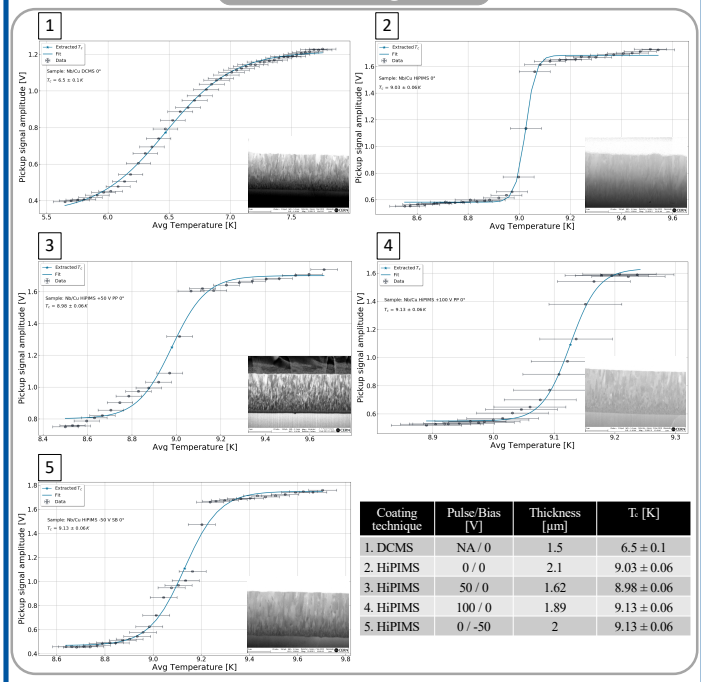




Measured samples

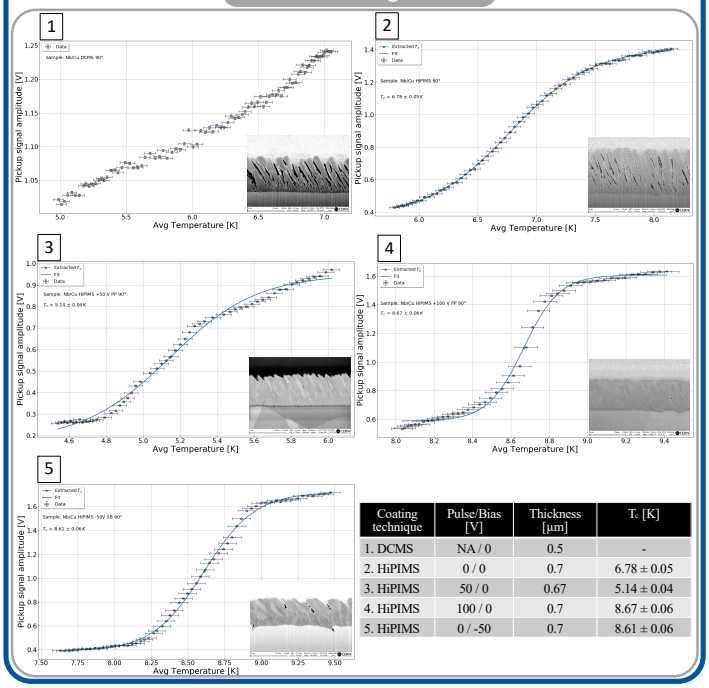
The transition curves from the SC to the NC state are shown below for Nb thin-films deposited on copper, along with the FIB pictures of the samples. The films analyzed here were deposited via DCMS or HiPIMS under different coating parameters. The tables summarize the results, provided together with the applied coating technique and the film thickness extracted via XRF analysis.

Incidence angle 0°



Coating technique	Pulse/Bias [V]	Thickness [µm]	T_c [K]
1. DCMS	NA / 0	1.5	6.5 ± 0.1
2. HiPIMS	0 / 0	2.1	9.03 ± 0.06
3. HiPIMS	50 / 0	1.62	8.98 ± 0.06
4. HiPIMS	100 / 0	1.89	9.13 ± 0.06
5. HiPIMS	0 / -50	2	9.13 ± 0.06

Incidence angle 90°



Coating technique	Pulse/Bias [V]	Thickness [µm]	T_c [K]
1. DCMS	NA / 0	0.5	-
2. HiPIMS	0 / 0	0.7	6.78 ± 0.05
3. HiPIMS	50 / 0	0.67	5.14 ± 0.04
4. HiPIMS	100 / 0	0.7	8.67 ± 0.06
5. HiPIMS	0 / -50	0.7	8.61 ± 0.06

Acknowledgements

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