Magnetic Field Penetration of Niobium Thin Films Produced by the ARIES Collaboration

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1. Introduction

A new local magnetometer has designed, built and commissioned at Daresbury laboratory which applies a local, parallel DC field from one side of the sample to the other. The facility is built directly onto a cold head and operates in a cryogen free environment, with the sample being able to reach temperatures as low as 2.6K. The H2020 ARIES collaboration studied the effect of polishing Cu substrates on Nb thin film growth. The effect of polishing on the SC properties of sputtered Nb films has been investigated using the new facility. It has been shown that EP and SUBU5 are preferred as a polishing technique based on producing a larger field of full flux penetration, B_{fp}. These results have also been compared to previous results produced in a VSM in both parallel and perpendicular field.

2. Method

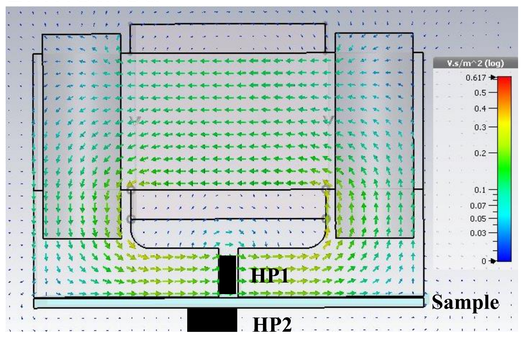


Figure 1 – A simulation of the C shaped dipole magnet, with the positions of the Hall probes shown

A ferrite C shaped dipole magnet is used to apply a DC field parallel to the sample. The applied and penetrated fields are measured by Hall probe sensors, HP1 and HP2 respectively. Initially whilst the superconductor is in the Meissner state, the applied field is screened, such that HP2 will read 0 mT. As the magnetic field is increased further, the field will penetrate through the sample at the field of full flux penetration, B_{fp}.

References

[1] C. Piraet al., "Impact of the cu substrate surface preparationon the morphological, superconductive and rf properties of thenb superconductive coatings,"in Proceedings of SRF, 2019.

[2] C. Piraet al., "Evaluation of cleaning process, Aries delivery report d15.1,"Horizon 2020 Research Infrastructures GAn°730871, 2018.

3. Field penetration facility

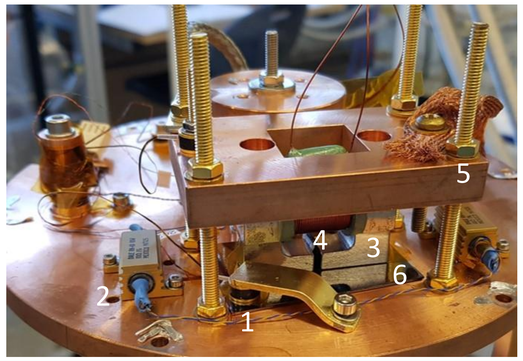


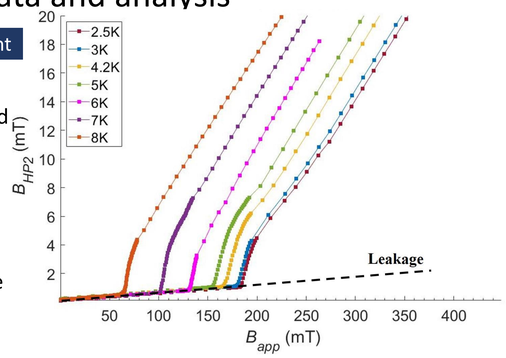
Figure. 2 – The magnetic field penetration experiment set up.

1. Thermometer held onto the sample by a brass pin
2. Resistors to control temperature
3. C sahped dipole magnet
4. Hall probe sensor
5. Brass pins to align magnet
6. Sample (Aries Nb on Cu

4.Raw data and analysis

Figure 3 - Right

The applied magnetic field is slowly increased. It can be seen from Fig 3 (Right) that some leakage is produced.



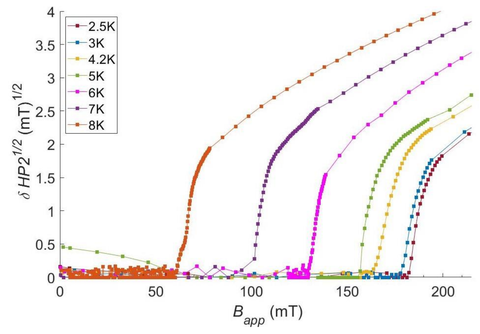


Figure 5 - Left

To accurately determine B_{fp}, the square root of the standard deviation of B_{HP2} from the linear dependence of the leakage field ($\delta HP2^{1/2}$) is used.

6. Conclusion

STFC	Siegen	INFN with laser treatment
SUBU CERN	SUBU INFN	SUBU INFN
EP	EP	
SUBU INFN	SUBU CERN	Tumbling
	Tumbling	SUBU CERN
EP + SUBU	EP + SUBU	EP + SUBU

Table 1 - The polishing technique that produced the largest B_{fp} (top) to lowest B_{fp} for each institute which deposited the Nb thin film.

Each institution that deposited the Nb thin film had a varying parameter such as thickness, or further polishing. It can be seen EP + SUBU had the lowest B_{fp}, where as SUBU and EP individually produced the largest B_{fp}.

5. The effect of polishing Cu substrates on B_{fp} of Nb thin films

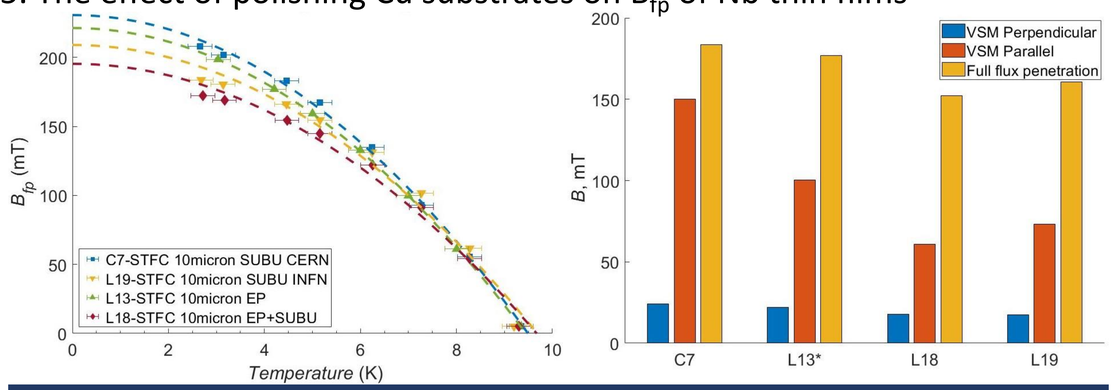


Figure 6a (left) – The B_{fp} as a function of T for samples deposited at STFC, and 6b (right) a comparison between the field of first flux penetration in a VSM and B_{fp} in the magnetic field penetration facility at 4.2K

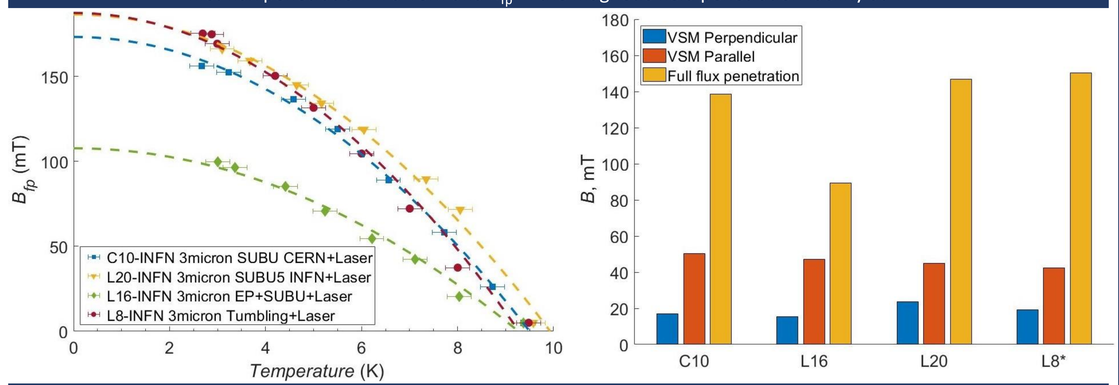


Figure 7a (left) – The B_{fp} as a function of T for samples deposited at INFN followed by laser polishing, and 7b (right) a comparison between the field of first flux penetration in a VSM and B_{fp} in the magnetic field penetration facility at 4.2K.

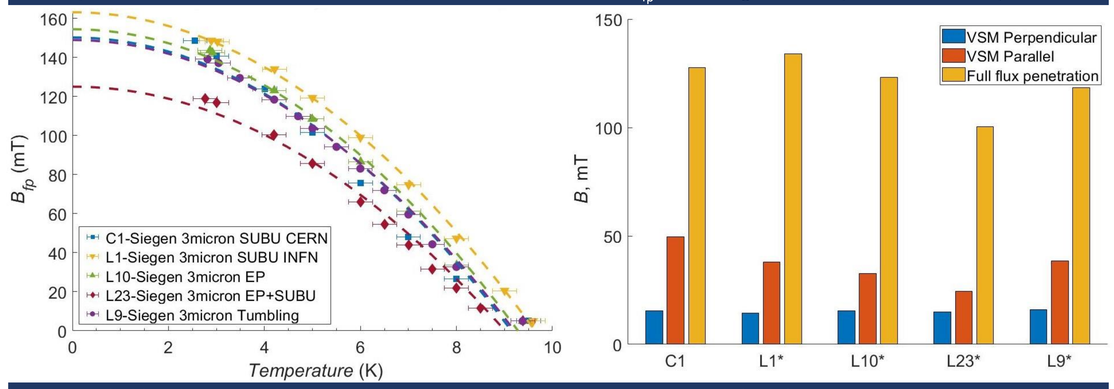


Figure 8a (left) – The B_{fp} as a function of T for samples deposited at Siegen, and 8b (right) a comparison between the field of first flux penetration in a VSM and B_{fp} in the magnetic field penetration facility at 4.2K.

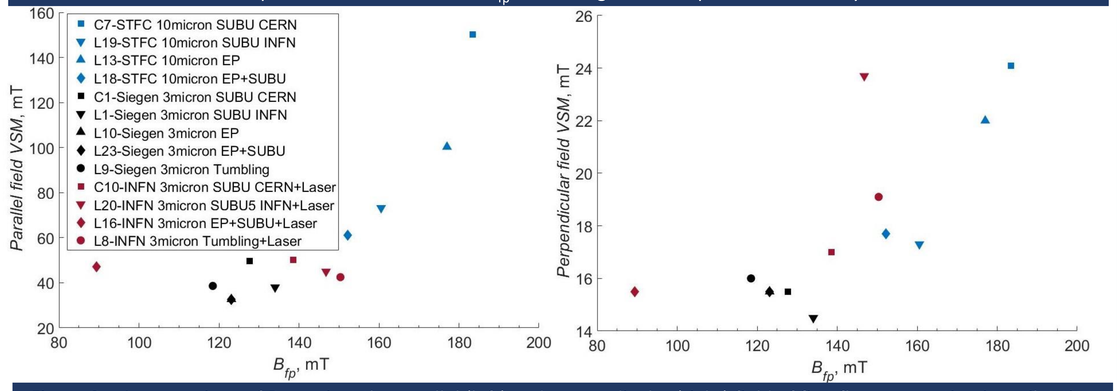


Figure 9 – A comparison of B_{fp} against the parallel (left) and perpendicular (right) field of first flux penetration in a vibrating sample magnetometer