Metallographic Polishing Pathway to the Future of Large Scale SRF Facilities

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Abstract

Optimization of SRF cavities mainly focuses on pushing the limits of bulk Niobium, cost reduction of cavity fabrication and development of new SRF materials for future accelerators (ILC, FCC). Nowadays chemical etching (BCP & EP) is the only surface treatment used to prepare SRF surface made from Nb. However the operational cost of chemical facilities is high and these present a very bad ecological footprint. The search of an alternative technique could make the construction of these future large scale facilities possible.

Metallographic polishing (MP) is a candidate not only for bulk Nb treatment, but could also provide the mirror-finished substrate for alternative SRF thin films deposition. Recent R&D studies, conducted at IPNO & IRFU, focused on the development of 2-steps MP procedure of Nb flat samples. Roughness of polished surface has been proven better than standard EP/BCP treatment and less polluted than CBP. MP provides on flat surfaces a high removal rate (above 1 µm/min) and high reproducibility. The paper will describe the optimized method and present all the surface analysis performed. The first RF characterization of a polished disk will be presented.

Motivations

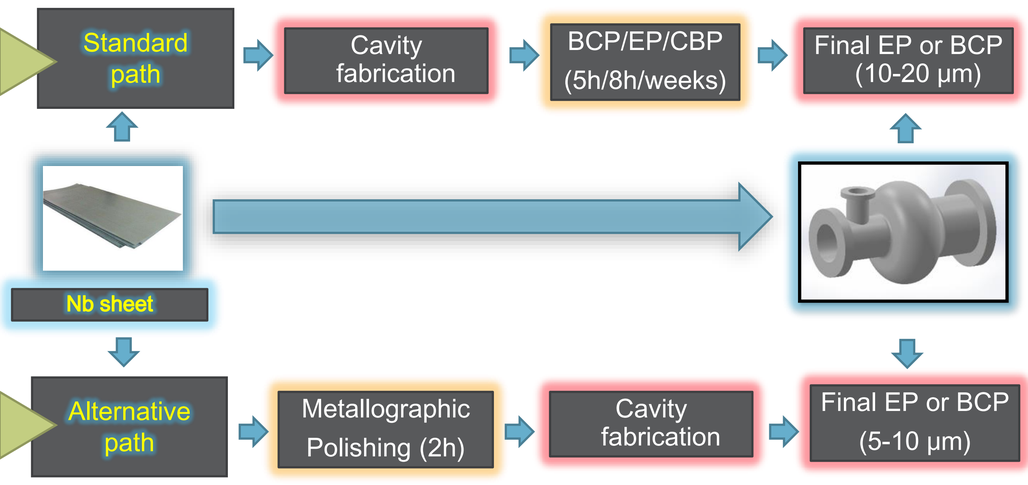
- Possible reduction of the cost of cavity processing
- Achieve better surface roughness
- Substrate preparation for thin films deposition
- Improve enviromental footprint and worker safety

Objectives for polishing

Niobium quality:
- Remove the polluted & damaged layer induced by Nb sheet fabrication
- Preserve superconducting properties

Industrialisation:
- Limit the number of steps to 2 or 3 (instread of typically 5-6 steps in the metallography)

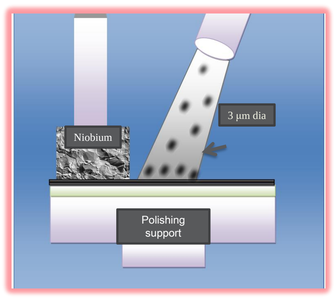
2 paths



Metallographic Polishing

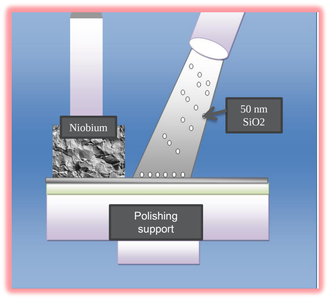
Two steps processing optimized for Niobium

Abrasion step:
Rigid composite disk (RCD)+ diamond suspension (3µm)

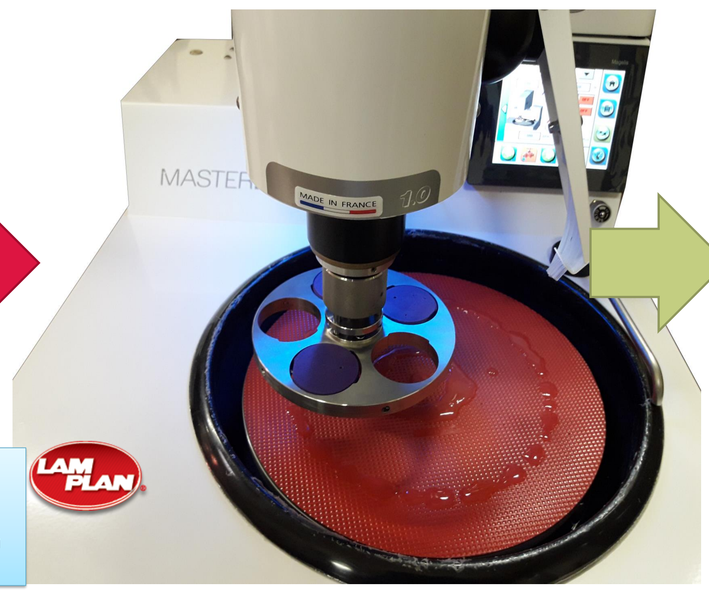


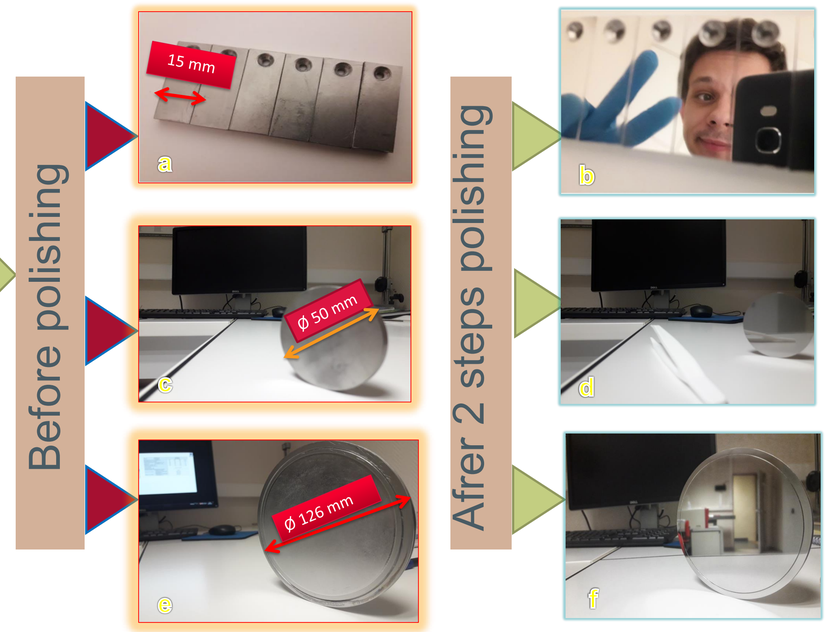
- Planarization of the surface
- Removal of existing damaged layer from sheet manufacturing (typically 100-200 µm)

Polishing step (CMP):
Microporous polyurethane cloth + 50 nm SiO_2 solution



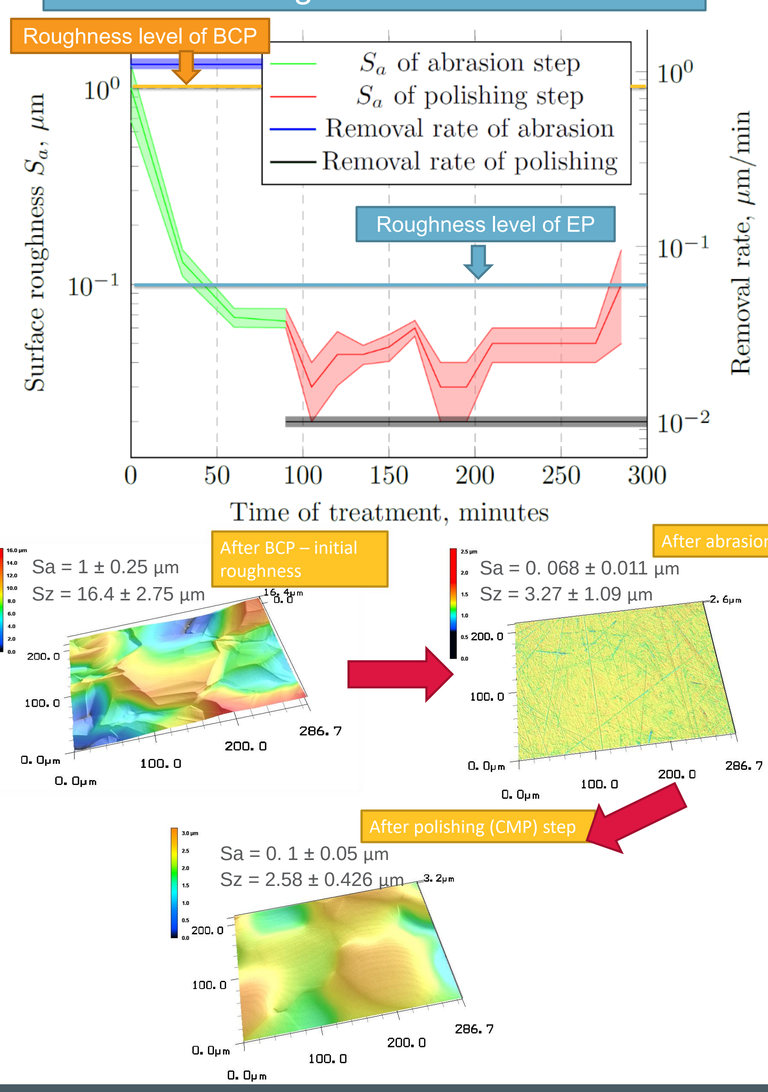
- Remove damages and pollution from abrasion step
- Achieve surface average roughness Sa < 0.1 µm
- Preserve superconducting properties over few 100 nm





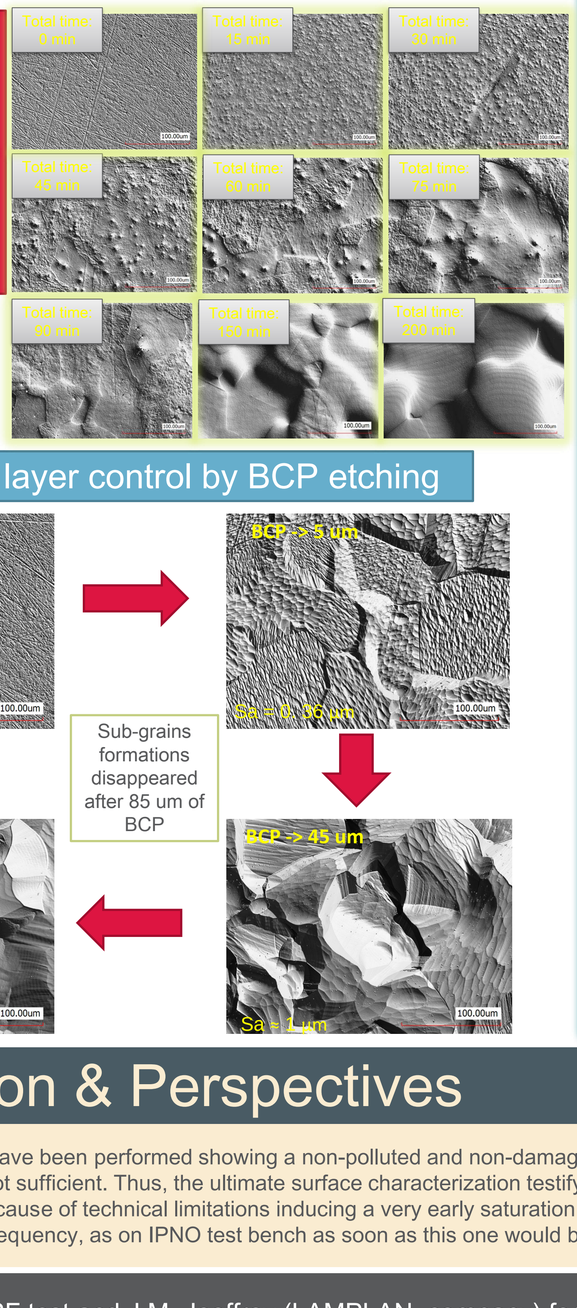
Surface Characterization

Roughness control



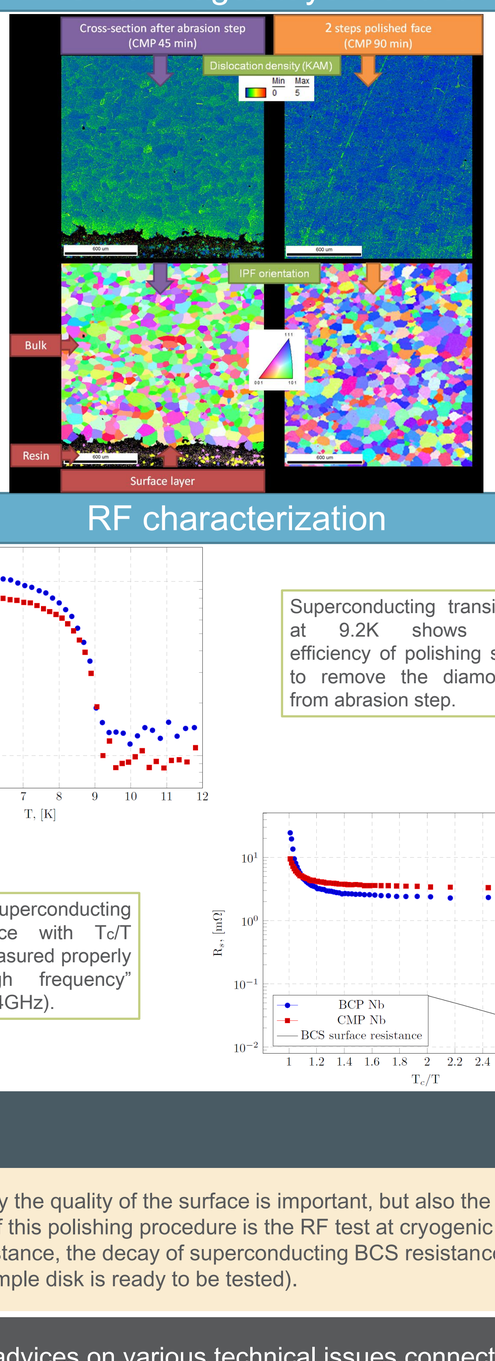
Depollution control during CMP step

- Contamination is observed after abrasion (*diamond particles*)
- Polishing step removes diamonds, however some roughness reappears (*chemical mechanical polishing*)



Damaged layer control by BCP etching

EBSD damaged layer control



RF characterization

Superconducting transition at 9.2K shows the efficiency of polishing step to remove the diamonds from abrasion step.

The decay of superconducting BCS resistance with Tc/T couldn't be measured properly due to "high frequency" limitations (11.4GHz).

Conclusion & Perspectives

A two-steps polishing procedure was successfully developed at IPNO and applied on RF disk. Optical characterizations have been performed showing a non-polluted and non-damaged surface. Not only the quality of the surface is important, but also the material quality underneath over a depth of several hundreds of nanometers. As a consequence, optical quality is necessary but not sufficient. Thus, the ultimate surface characterization testifying of the quality of this polishing procedure is the RF test at cryogenic temperature. This test performed at SLAC showed very promising results (visible superconducting transition at 9.2K). Unfortunately, because of technical limitations inducing a very early saturation of the surface resistance, the decay of superconducting BCS resistance with Tc/T couldn't be measured properly. A way to mitigate these "high frequency" limitations would be to test a sample at a lower frequency, as on IPNO test bench as soon as this one would be available (the sample disk is ready to be tested).

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