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Investigation Of An Alternative Path For SRF Cavity Fabrication And Surface Processing

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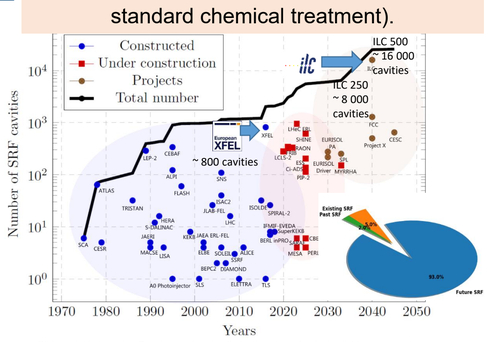
Abstract

The preparation of SRF cavities includes a lengthy, costly, and safety issued electrochemical polishing (EP or BCP) step to remove the damaged layer coming from the cavity fabrication. We have shown that most of the damage layer is originated from the rolling process during the preparation of the sheet material, while subsequent deep drawing tends to leave only µm thick damage layer. We propose a 2-steps mechanical process that allows us to easily get rid of the thick damage layer on the sheets before cavity forming. The process has been established on samples and extended to large disks ready for 1.3 GHz half-cell forming. The polished sheets will be then sent to KEK for half-cell forming and subsequent surface and material analysis before proceeding to half-cell welding. Former studies on the sample demonstrated that damages induced by forming can successfully be removed by recrystallization and less than 10 µm final chemistry.

Motivation

I. Possible reduction of the cost of cavity surface processing for future accelerators (replace standard chemical treatment).

II. Achieve better surface roughness to improve the performance (removal of all type of defects, substrate preparation for thin film deposition) => possible reduction of the cost of accelerator operation

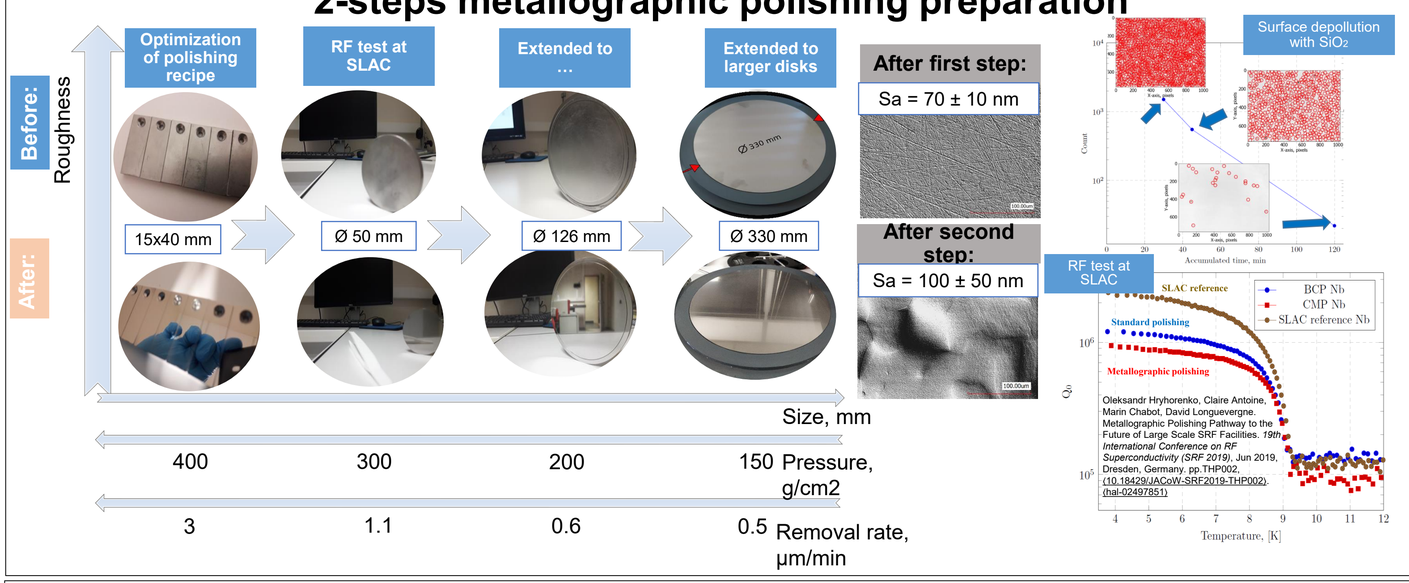


Oleksandr Hryhorenko. Development and optimization of mechanical polishing process for superconducting accelerating cavities. Accelerator Physics [physics.acc-ph]. Université Paris-Saclay, 2019. English. (NNT : 2019SACLS566). (tel-02455975)

A.D. Palczewski et al. "R&D Progress in SRF Surface Preparation With Centrifugal Barrel Polishing (CBP) for both Nb and Cu", in *Proc. 16th Int. Conf. RF Superconductivity (SRF'13)*, Paris, France, Sep. 2013, paper TUIOB01, pp. 398-403.

III. Improve environmental footprint and worker safety (remove or at least reduce the amount of used acids)

2-steps metallographic polishing preparation

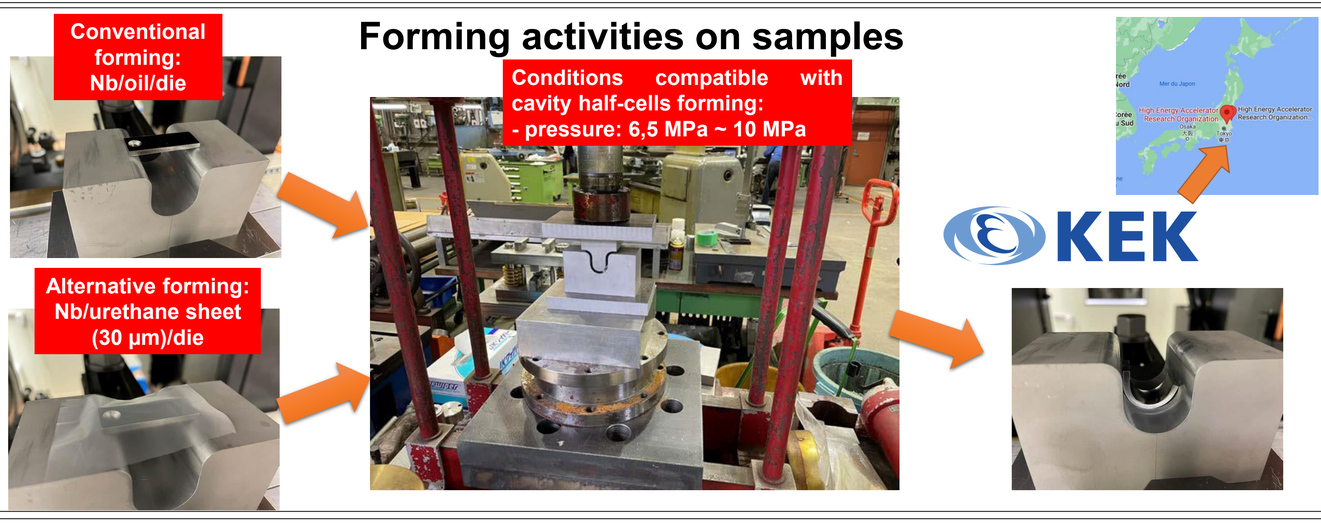


SRF cavity fabrication

Standard path:

Alternative path:

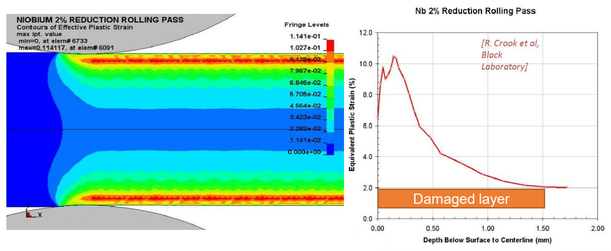
Forming activities on samples



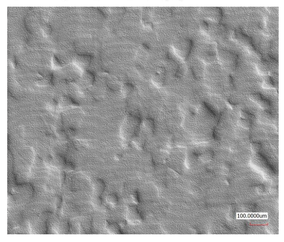
Requirements for alternative fabrication

Requirements for material

Remove damaged layer



- ✓ Smooth and compatible roughness with EP & BCP (Sa ≤ 0.1 µm)
- ✓ Chemically pure
- ✓ Minor crystallographic damages (stress as low as possible)



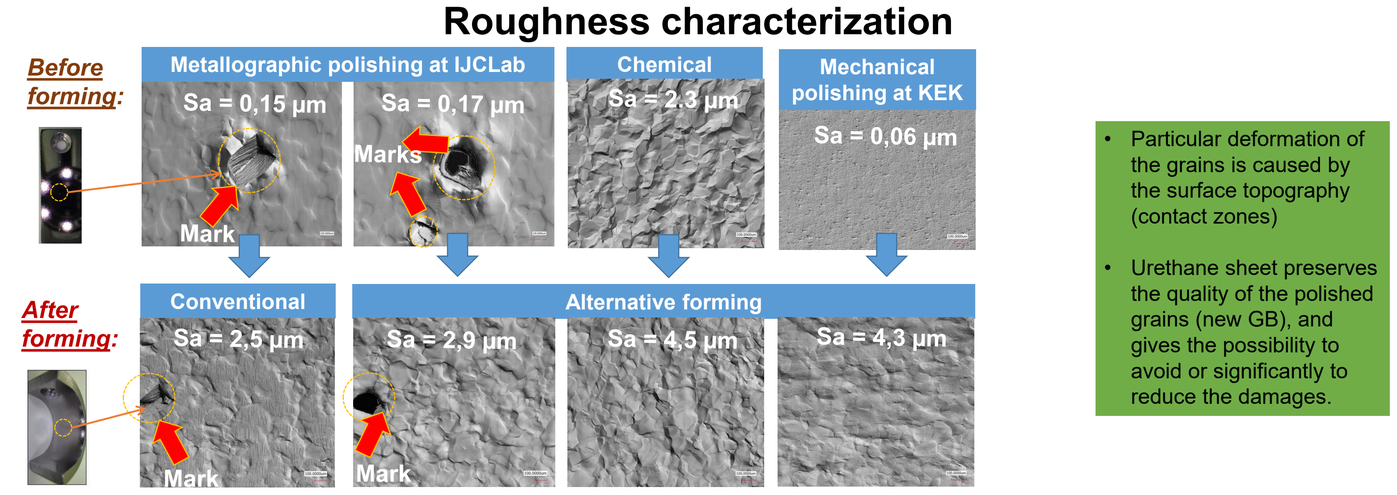
Requirements for polishing

- Time of treatment should be shorter than conventional polishing (~5 hours BCP, ~8 hours EP)
- High removal rate ~µm/min.
- Limit manipulations and process to 2 steps:
  1. Coarse planarization/damaged layer removal (~150 µm)
  2. Achieve the required surface quality

Requirements for forming

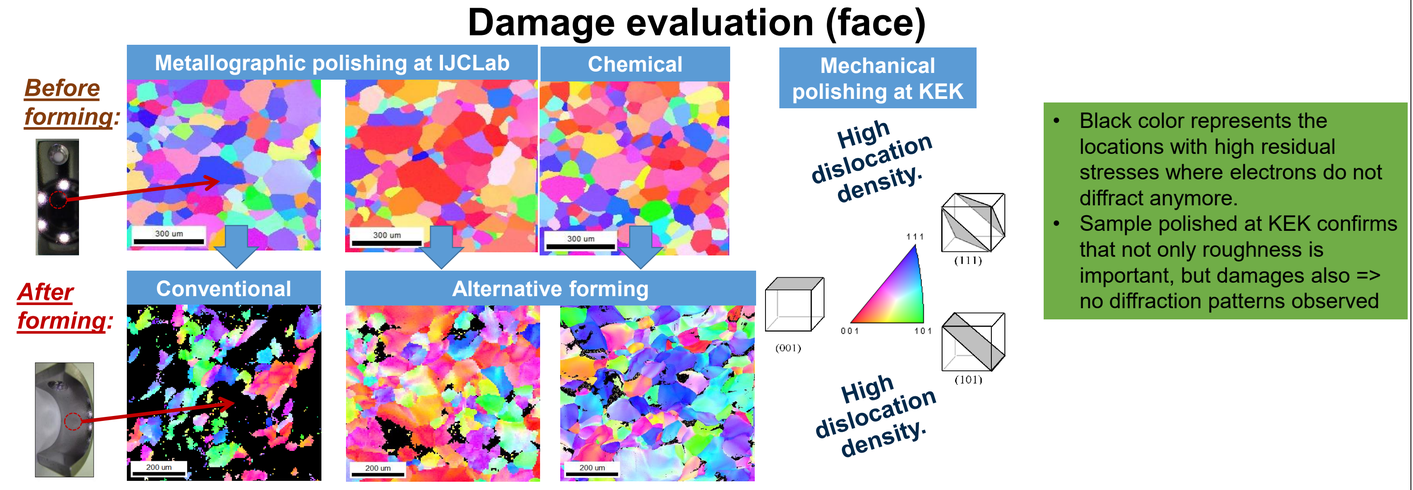
- Preserve the polished surface quality
- Avoid or significantly reduce the damaged layer
- Easily integrated in the preparation process

Roughness characterization



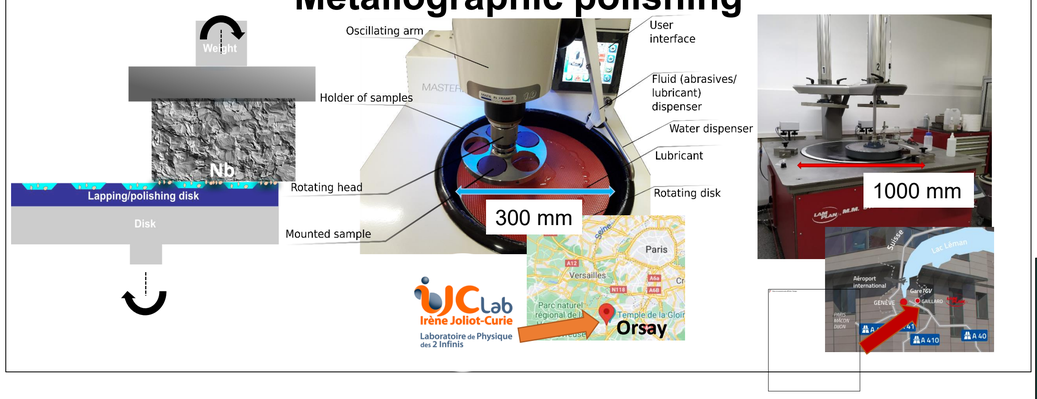
- Particular deformation of the grains is caused by the surface topography (contact zones)
- Urethane sheet preserves the quality of the polished grains (new GB), and gives the possibility to avoid or significantly to reduce the damages.

Damage evaluation (face)



- Black color represents the locations with high residual stresses where electrons do not diffract anymore.
- Sample polished at KEK confirms that not only roughness is important, but damages also => no diffraction patterns observed

Metallographic polishing



Conclusion and Perspectives

- 2 steps metallographic polishing recipe has been developed compatible with SRF applications (at IJCLab)
- Surface characterizations show smooth, non-polluted, and minor crystallographic defects
- Polishing procedure extented to the large sheets (at LAM PLAN)
- Alternative cavity forming technique has been applied to samples polished by different techniques (metallographic, chemical, mechanical)
- Increased roughness due to creation of the new grain boundaries
- Evaluated the damages of the surface (face)

To be done in 2021:

- Perform the EBSD analysis of the cross-sections (evaluate thickness of damaged layer) : June-July 2021
- Apply the heat treatment at medium temperatures (recrystallisation)
- Forming of 1.3 GHz half-cells with the following cavity fabrication using the polished disks (KEK – FJPPL program)
- Cut the welded half-cells and analyze the surface state

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