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
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

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SRF cavity fabrication
Requirements for alternative fabrication
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 forming
- 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 material
- Conventional forming: Nb, Nb/Al, Nb/Al/Dis
- Alternative forming: Nb/urethane sheet (~50 µm/die)

2-steps metallographic polishing preparation

- Conventional forming: Nb/Al/Dis
- Pressure: 6.5 MPa ~ 10 MPa
- Removal rate, µm/min: 3 – 0.5

Forming activities on samples
- Conditions compatible with cavity half-cells forming:
  - Pressure: 6.5 MPa ~ 10 MPa
  - Magnetic field: ~ 0.5 T

Roughness characterization

- Before forming
  - Sa = 0.15 µm (EP)
  - Sa = 0.12 µm (BCP)
  - Conventional forming: Nb/Al/Dis
- After forming
  - Sa = 0.06 µm

Damage evaluation (face)

- Mechanical polishing at UCLab
  - Conventional forming: Nb/Al/Dis
  - Sa = 0.13 µm
  - Alternative forming: Nb/urethane sheet (~50 µm/die)

Conclusion and Perspectives

- 2 steps metallographic polishing recipe has been developed compatible with SRF applications (at UCLab)
  - Surface characteristics show smooth, non-polluted, and minor crystallographic defects
  - Polishing procedure extended 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)
  - Done by 2021

- Perform the EBSS 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 stats

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