EBSD study of the damage induced during forming of superconducting radiofrequency copper cavities

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Abstract

The Future Circular Collider (FCC), an on-going study at CERN, will require the use of superconducting radiofrequency (SRF) niobium-coated copper cavities. Alternatives to the traditional shaping methods (i.e. spinning) are being nowadays developed. Electrohydro forming (EHF) is a promising alternative since it ensures high reproducibility and shape accuracy while reducing the forming time. However, the use of this approach has some drawbacks, which can jeopardize the performance of the cavity. As an example, the copper (Cu) sheets can contain defects (not easily detected by non-destructive techniques) which might have an impact on the quality of the niobium (Nb) coating. Moreover, the need of welding in this technique introduces an additional risk of porosities along the junction between each cavity's elements. In this respect, an innovative alternative technique has recently been investigates at CERN. In this process, the cavity is formed by electrodeposition of copper on a sacrificial aluminum (Al) mandrel whose surface state will determine the inner cavity's surface quality. This technology relies on the absence of welding in the region relevant for the radiofrequency operation and performance.

The mechanical stability of the cavities is a key aspect since it plays an important role on the final performance in operation. It is known that forming processes induce plastic deformation in the material. In order to accommodate this plastic deformation, the material can generate Geometrically Necessary Dislocations (GND), which disturb the structure of the lattice and lead to local misorientations. Electron Backscatter Diffraction (EBSD) is used as a material characterization technique to study local variations via the Kernel Average Misorientation. Small orientation gradients may be displayed, highlighting areas of high GND densities. Accordingly, EBSD will be used to identify which of the above mentioned shaping methods induce lower damage on the material during forming of the cavities (Figure 1 and Figure 2).

Images

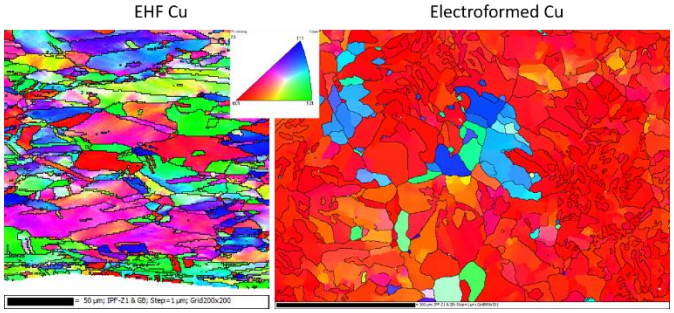


Figure 1- Comparison of IPF Z0 of copper cavities formed by EHF (left) and electroformed (right).

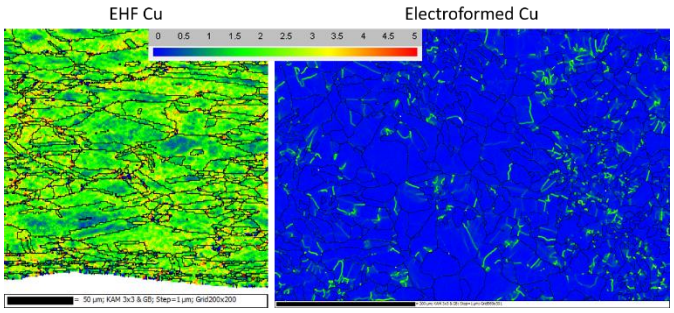


Figure 2- Comparison of KAM criteria maps of copper cavities formed by EHF (left) and electroformed (right) in rainbow-scale from 0º to 5º.

Recent Publications

E. García-Tabarés et al, Characterization of electroplated copper for superconducting radiofrequency cavities. Euromat Conference. Stockholm, September 2019

E. García-Tabarés et al, EBSD study of the damage induced during forming of copper cavities, Electron Backscatter Diffraction meeting. Plymouth, April 2018.

C. Benvenuti et al, IEEE transactions on applied superconductivity, vol. 9, No. 2, June 1999 DOI: 10.1109/77.783442

G. Rosaz et al, FCC week. Berlin, 2018

E. Cantergiani et al, SRF2015, THAA05 DOI: 10.18429/JACoW-SRF2015-THAA05

L. Lain Amador et al, Journal of Vacuum Science & Technology A 36, 021601 (2018) DOI: 10.1116/1.4999539



Biography

Elisa García-Tabarés Valdivieso holds a PhD on Material Science and Engineering. She did her PhD research on the development of a new generation of solar cells (i.e. III-V on silicon multijunction solar cells). She continued developing her professional career doing a postdoc at CERN based on material characterization by means of different techniques, including Optical, and Electron Microscopy (SEM, FIB), Energy Dispersive X-ray Spectroscopy (EDS), X-ray Diffraction (XRD), X-ray Photoelectron Spectroscopy (XPS) and Electron Backscattered Diffraction (EBSD). Her fields of expertise includes, among others, quality control of superconducting cables, characterization of radiofrequency cavities or high-resolution analysis of coatings and thin films for particle accelerator applications.

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