Optimisation Of Copper Electroforming For Manufacturing Superconducting-radiofrequency Cavities

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Abstract

In the framework of the Future Circular Collider (FCC) study, SRF (Superconducting Radio Frequency) cavities will be produced by applying niobium superconducting thin films onto copper substrate cavities. The copper cavities are traditionally produced by mechanical forming of two half-cells, which are assembled together by electron beam welding along the cavity equator. However, the process requires welding, leading to the formation of defects along the junction interfaces. Therefore, a seamless process, which guarantees a high quality Cu substrate and very smooth surface finishing, would be an advantage. In the present innovative approach, seamless cavities are produced by copper electroforming on a sacrificial aluminium mandrel. The bottleneck of the process is the heterogeneous distribution of the plated copper layer along the cavity and the resulting thinner section at the cavity iris. COMSOL Multiphysics® simulations exploiting COMSOL Multiphysics® Electrochemistry Module were performed in order to optimise the copper thickness uniformity. A combination of secondary anodes and masking was proposed to achieve a minimum thickness of 2 mm everywhere and to decrease the total plating time. The simulations were run with a moving mesh in order to simulate the boundary displacement resulting from the plated thickness on the cathode and the consumption of the secondary anodes. Finally, an optimised geometry of anode and masking was defined that highly improves the copper layer thickness distribution along the cavity.

Figures used in the abstract

Figure 1 : Electroformed copper thickness distribution (in mm) along the cavity after electroplating for 160 hours at 1.6A/dm2. In a) simple anode; b) additional optimised anode.