PLASMA MODIFICATION OF BULK NIOBIUM SURFACE FOR SRF CAVITIES*

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Particle accelerator performance, in particular the average accelerating field and the cavity quality factor, depends on the physical and chemical characteristics of the superconducting radio-frequency (SRF) cavity surface. Plasma based surface modification provides an excellent opportunity to eliminate non-superconductive pollutants in the penetration depth region and to remove the mechanically damaged surface layer, which improves the surface roughness. Here we show that the non-equilibrium plasma treatment of bulk polycrystalline Nb presents a viable surface preparation method due to possibility to use plasma-generated radicals and due to the inherent anisotropy of the etching action. We have optimized the experimental conditions in the microwave glow discharge system and their influence on the Nb removal rate on the flat samples and achieved etching rate of 1.7 μm/min using up to 3% Cl_2 in the reactive Ar/Cl_2 mixture. Combining a fast etching step with a moderate one, we have improved the surface roughness without exposing the fresh sample surface to the environment.

The geometry of SRF cavities made of bulk polycrystalline Nb requires the use of asymmetric RF discharge configuration for plasma etching. The asymmetry in the surface area of a driven and grounded electrode creates a difference in the voltage drop over the plasma sheath attached to the driven electrode and the sheath attached to the cavity surface. The driven electrode geometry is optimized to achieve homogeneous sheath conditions at the surface. Specially designed single cell cavity is used to study these asymmetric discharges which contain 20 sample holder holes symmetrically placed over the cell. These sample holder holes can be used for both diagnostics and sample etching purposes. The approach is to combine radially and spectrally resolved profiles of optical intensity of the discharge with direct etched surface diagnostics to obtain an optimum combination of etching rates, roughness and homogeneity in a variety of discharge types, conditions and sequences.

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