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M1Or1A-03: Comparative Analysis on Recrystallization and Recovery of High and Low RRR Niobium

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Transition niobium (Nb) metal has been widely accepted in superconducting technology due to its strong isotropic superconductivity. Its high mechanical formability allows the application of the radio frequency (RF) resonator (cavity) by fabricating a complex device form. The residual resistivity ratio (RRR: 300K/10K) is used to define the purity of superconducting Nb. To date, high RRR Nb (> 250) is known to exhibit ultimate low electrical surface resistance in the RF regime, which enables obtaining a high-quality factor, defined as the stored energy in terms of power dissipation. A high RRR Nb cavity significantly expels magnetic flux with post-treatment at 900℃ for 3 hours, which promises acceptable RF performance. However, the flux expulsion ratio of a low RRR Nb cavity remains unsatisfactory even with 1000℃ treatment. We suppose that a lack of understanding of the engineering process for the grain growth and recovery of the strained structure likely abandons the feasibility of lower RRR Nb application. In this study, we compare recrystallization and recovery between low and high RRR Nb regarding abnormal and normal grain growth in terms of annealing temperature and time. The comparison is based on evaluating grains and sub-grains coarsening and dislocation annihilation. Dislocation propagation associated with deformation is also investigated by nano-indentation. The same fashion of annealing is applied to both low and high RRR Nb materials in a high vacuum environment to minimize foreign element effects on the pinning of the grain boundary. Based on the evaluated trend on the recovery and recrystallization of high RRR Nb, we estimate the thermal treatment threshold for low RRR Nb, in which an optimal RF performance with sufficient magnetic flux expulsion can be achieved.

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