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Addressing the Medium-Field Q-Slope Challenge in Nb Thin Film Cavities

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In this study, we addressed the persistent medium-field Q-slope issue in Nb thin film cavities, which, despite their high Q at low RF fields, exhibit a significant Q-slope at medium RF fields compared to bulk Nb cavities. Traditional heat treatments, effective in reducing surface resistance and mitigating the Q-slope in bulk Nb SRF cavities, are challenging for Nb thin film cavities. We employed DC bias HiPIMS to deposit Nb film onto a 1.3 GHz single-cell elliptical bulk Nb cavity, followed by annealing treatments. Annealing at 340 ℃ increased the quench field from 10 to 12.5 MV/m. Annealing at 600 ℃ and 800 ℃ for 3 hours resulted in a quench field increase of 13.5 and 15.3 MV/m respectively. A 6-hour anneal at 800 ℃ boosted the quench field to 17.2 MV/m. Analysis of RF results and material characterization before and after annealing provided valuable insights into the effect of Nb film's microstructure and impurity levels on the evolution of the Q-slope in Nb film cavities. Our results demonstrate a promising strategy to overcome the medium-field Q-slope by optimizing the film properties and impurity levels in Nb film cavities, potentially paving the way for more efficient superconducting RF technologies.

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