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Study of interstitial oxygen concentration near surface of Mid-T heat treated Nb SRF cavities: frequency shift analysis

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Mid-T heat treatment promotes the dissolution of surface native niobium oxide into bulk niobium and increases the interstitial oxygen concentration in the near surface layer of niobium, resulting in an improved quality factor for niobium SRF cavities at moderate accelerating fields. This study examines the average interstitial oxygen concentration within the effective magnetic field penetration depth by analyzing the total resonance frequency shift below the critical temperature and the surface resistance above it. The interstitial oxygen distribution along the depth for various heat treatment recipes is evaluated, revealing improved uniformity with increasing heat treatment temperature and conditions that cause oxygen diffusion to extend beyond the layers governing electromagnetic properties are identified. Furthermore, an anomalous frequency dip below the critical temperature is observed, with findings demonstrating a strong correlation between oxygen concentration and the dip features. This study confirms the known linear relationship between critical temperature reduction of niobium and increased interstitial oxygen concentration, yielding the same reported coefficient. Moreover, examining the effective diffusion length derived from the thermal profile of mid-T heat treatments and the estimated total oxygen content in the native pentoxide layer, with certain simplified assumptions, shows strong agreement with the oxygen concentration values obtained in this study.

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Footnotes

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