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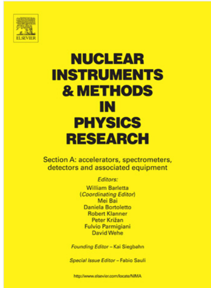

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Enhancement of effective linear RF surface resistance of superconducting surfaces by microscopic topography

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Abstract:

Minimization of Radio-Frequency *(RF)* dissipation on superconducting surfaces is of interest for many applications. A prominent one is the use of Superconducting RF *(SRF)* cavities for charged particle acceleration. In addition to our previous investigation which characterized the occurrence of high-field non-linear losses by microscopic surface topography, the topic of increased linear losses as a function of surface topographic character merits consideration. Surfaces with isotropic homogeneous surface topography may be well characterized by power spectral density *(PSD)* derived from systematic height measurements. PSD characterizations of representative niobium cavity surface treatments have been developed: Electro-Polishing *(EP)*, Nano-Mechanical Polishing *(NMP)*, and Centrifugal Barrel Polishing *(CBP)*. A perturbation model based on PSD statistical analysis is used to calculate additional RF loss on these surfaces when superconducting. The model assesses the penetration depth effects for a superconductor. We thus estimate the RF power dissipation ratio between these rough surfaces and an ideal smooth surface.

1. Introduction

It is known that surface roughness can play an important role in RF component performance. [1] Relative to the Hammerstad model, studies submit *(in unison)* that there is excessive RF loss found present in rough copper surface(s). [2] A rough surface increases the average surface resistance in resonators, thus leading to quality factor degradation of SRF cavities. Furthermore, the penetration depth of the superconducting materials can be comparable to the fine-scale surface roughness. [3] Therefore, such SRF surface roughness can alter the electromagnetic fields within the penetration depth, which may increase the RF loss. The RF electromagnetic fields infiltrate the surfaces and modify the distribution of the surface currents, which flow within the penetration depth.

In the RF wave view, the reflection of the incident wave is transformed by the rough surfaces. The local magnetic fields will conformably align with the rough surface(s) and locally determine the RF loss.[3,4] In a resonator, RF waves form resonating modes at certain frequencies. At a local surface point, the incident wave is a summation of a set of plane waves from multiple