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Microscopic Investigation of Materials Limitations of Superconducting RF Cavities

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Based on the needs of the SRF community to identify and evaluate defects on Nb surfaces, a novel near-field magnetic microwave microscope was successfully built using a magnetic writer from a conventional magnetic recording hard-disk drive [1]. This magnetic writer can create an RF magnetic field in the 100 mT range, localized and strong enough to drive Nb into the mixed state, and may have sub-micron resolution.
In our experiments on Nb surfaces we observed that the amplitude of 3rd harmonic response-V_3f(T,H_rf) is relatively small below a temperature dependent onset rf field amplitude H_0(T) (the DC field is nominally zero). For rf amplitudes H_rf > H_0(T) there exists measurable harmonic response signal with periodic dips at H_rf amplitudes= H_1(T), H_2(T), H_3(T)⋯Similar behavior is observed in both bulk Nb and thin film Nb samples. The periodic response is shown to arise from the sample and is only observed in the superconducting state. The origin of this response is most likely nonlinearity generated by a Josephson effect at or near the surface. Numerical calculations based on the rf-current-biased Resistively and Capacitively Shunted Junction (RCSJ) model can be fit very well to the data using reasonable parameters. Another possible model based on the paper by Gurvich and Ciovati [2] is being investigated, where interaction between the core of a vortex semi-loop and nearby pinning sites is modeled. COMSOL simulations are used to solve the Time-Dependent Ginzburg Landau equation and investigate the nonlinear response produced by such interaction.

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2 A. Gurevich and G. Ciovati, "Effect of vortex hotspots on the radio-frequency surface resistance of superconductors"Phys. Rev. B 87, 054502 (2013).

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