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Investigation of Local Nonlinear Microwave Response of Nb_3Sn in the Superconducting State

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Superconducting Radio Frequency (SRF) cavities are being widely used in new generation particle accelerators, but their performance can be limited by surface defects which lead to cavity breakdown at high accelerating gradients. The microscopic origins of SRF cavity breakdown are still a matter of some debate. To study the electrodynamics of superconductors locally, 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, localized and strong enough to drive superconducting Nb into the mixed state, and may have sub-micron resolution. This probe enables us to evaluate the deleterious RF properties of surface defects under conditions experienced in the SRF cavity. We mainly study the 3rd harmonic response (P_{3f}) as a function of rf field amplitude (H_{rf}) and temperature (T). In previous experiments on bulk and thin film Nb surfaces we observed two different classes of nonlinearity, which we call Low-field and Periodic. The Low-field response is the intrinsic response of the sample due to dynamics of vortex semiloops [2] created by the magnetic writer [3]. In the Periodic case the response can be linked to the Josephson effect at or near the surface and is in good agreement with the nonlinear response expected from rf-current-biased Resistively and Capacitively Shunted Junction (RCSJ) model [4]. New results on a Nb_3Sn film show evidence for multiple superconducting transitions, including a phase with a transition temperature of about 5.5 K. The most prominent nonlinear response appears to be due to the intrinsic Low-field mechanism. We summarize our results in light of the materials properties of Nb_3Sn, and compare to those previously obtained on SRF-Nb materials.

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