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AC LOSSES IN Nb-Ti MEASURED BY MAGNETIZATION AND COMPLEX SUSCEPTIBILITY

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ABSTRACT

DC magnetization and complex ac susceptibility were measured at 4 K as functions of longitudinal dc field for a multifilamentary Nb-Ti superconductor with no transport current. Minor hysteresis loops were obtained in the dc measurements. The full-penetration field, H_p, a function of applied field, H, was deduced directly for each minor loop. The values for H_p were fit to the Kim-type equation, $H_p(H) = H_p(0)/(1+H/H_k)$, where $H_p(0)$ and H_k are constants. The minor hysteresis-loop areas gave losses that were in excellent agreement with Carr's theoretical critical-state equation, $W = (4\mu_0 H_0 H_p/3)(1-H_p/2H_0)$, where H_0 is the maximum applied field for each loop.

An expression was obtained for the ideal reversible differential susceptibility: $\chi_{rev} = \phi_0/8\pi\mu_0(H-H_{c1})\lambda^2$, where ϕ_0 is the flux quantum, H_{c1} is the lower critical field, and λ is the penetration depth. H_{c1} and λ for the sample were deduced from the shape of the major hysteresis loop. Clem's theoretical expressions for the real (χ') and imaginary (χ'') components of ac susceptibility are functions of χ_{rev}, H_p, and ac field amplitude, h. The predicted susceptibilities based on these expressions were in good agreement with measured curves of χ' and χ'' as functions of h and H. The measured χ' and χ'' were independent of frequency up to 1 kHz, as expected when bulk hysteresis is the primary loss mechanism.

INTRODUCTION

In an earlier work[1] we discussed the relationship between dc magnetization and ac susceptibility in a type-II superconductor. That work described how magnetic measurements provide information on hysteresis losses. In this paper, as in Ref. 1, we examine magnetization and susceptibility for longitudinal fields and no transport current. Here, however, we obtain the full-penetration fields, H_p, directly from the hysteresis loops rather than estimate H_p from measurements of critical current density, J_c. Also, we derive an expression for the reversible susceptibility, χ_{rev}, rather than using the experimental susceptibility, χ_{dc}, as an approximation. A superconducting wire whose low-field magnetization approached a reversible curve was selected for study.[2] Several minor hysteresis loops were obtained in addition to the major loop. The susceptibility curves were more nearly reversible and virtually independent of frequency, as expected from theory.