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ENERGY LOSSES IN HIGH-T_C SUPERCONDUCTORS IN AC AND DC-BIAS LOW MAGNETIC FIELDS

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Energy losses occuring in cylindrical high-T_C samples, subjected to AC, with a superimposed, parallel to it, DC-bias magnetic field, at temperature 77 K, have been examined. Critical current densities for both terms, inter- and intragranular were calculated, and their dependences on magnetic induction were determined. The losses at a fixed AC amplitude exhibits deep minima with increasing DC-bias magnetic field.

As it is already known, AC losses in ceramic superconductors can be separated into the two terms, namely one connected with irreversible flux motion in the intergranular region, and the second, within the individual grains (1-3).
In this work we present results of measurements of low frequency energy losses occuring in cylindrical YBaCuO and GdBaCuO samples subjected to sinusoidally varying AC magnetic field (87 Hz) with coaxially superimposed on it DC-bias one . The loss voltage signal taken from a pick-up coil wound directly onto the surface of the sample was measured by a lock-in amplifier.

For very small amplitudes b_0, up to about 1.7 mT, losses increase with approximately the fourth power of b_0, (see inset in Fig.1), what can be explained by a strong field dependence of the intergrain critical current density. For amplitudes sufficiently higher, the losses remain nearly constant ('loss plateau'). This is the range where the magnetic field fully penetrates the weak-linked regions and drives them into the normal state. With the further increase of b_0 losses are connected mainly with the properties of the suoerconducting material inside individual grains. For this region the losses fulfill the proportionality $W \sim b_0^3$, what is in accordance with the critical state model of Bean-London (B-L). Finally, for the highest available in our experiments values of the field amplitudes, the losses are linearly dependent on b_0. It can be attributed to the full penetration of the magnetic induction into grains.

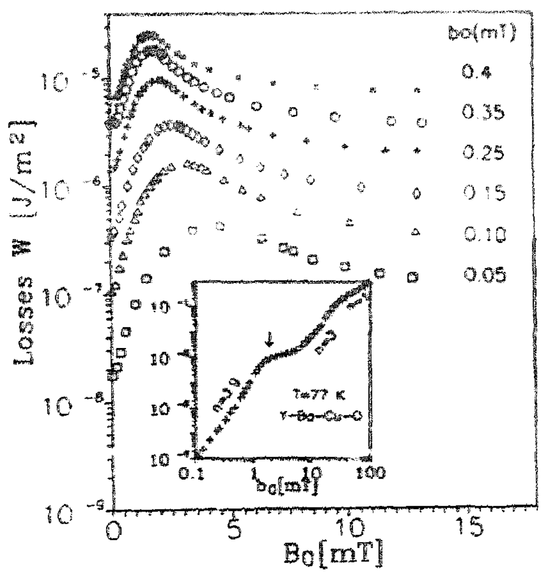

FIG.1. AC losses versus DC-bias magnetic field B_0 for different fixed amplitudes b_0. Inset shows the b_0 dependence of losses for $B_0 = 0$.

When, apart from the AC, also a DC magnetic field B_0 is additionally applied, losses commonly exhibit some minima. In the case of granular high-T_C materials the effect of loss reduction is different than this observed in classical

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superconductors (4). In Figs.1 and 2 losses vs. DC-bias magnetic induction B_0 are plotted, for various values of fixed amplitudes b_0. For very low amplitudes, in the vicinity of the first penetration field, which for investigated samples is of the order of 0.3 mT at 77 K, pronounced maxima in losses are observed. The maxima shift to the lower values of B_0 as b_0 increases. The maxima points correspond to the peak in a loss voltage signal, i.e. in the imaginary part μ'' of the complex permeability, which in turn appears when magnetic flux front reaches the center of the sample.

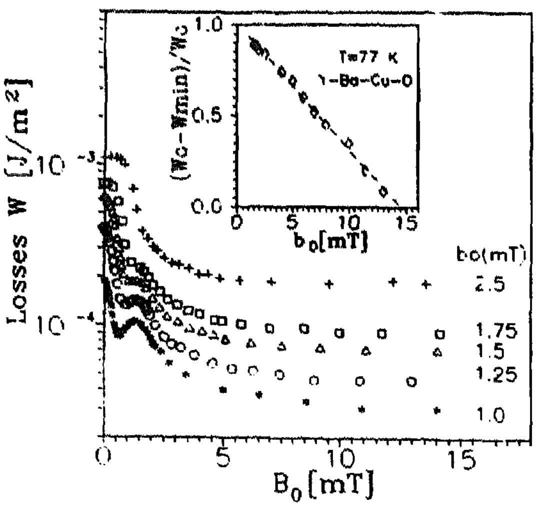

FIG.2. AC losses vs. DC-bias magnetic induction B_0 for different fixed amplitudes b_0 (range 1 to 5 mT).

For higher amplitudes b_0, in the region of 'loss plateau', the losses are significantly reduced by the DC-bias magnetic field (see Fig.2) The relative decrease of losses (see inset) depends on the b_0 and is greater that those observed in classical type-II superconductors, where minima are caused mainly by disappearance of the annihilation term of energy dissipation (4).

Assuming relation $b_0=B_p=\mu_0 J_C R$, where B_p denotes the value of the external magnetic induction, when flux fully penetrates the sample of radius R, we can estimate the values of the intergranular critical current density J_{CI}. Such determined values of J_{CI} versus applied DC magnetic induction B_0 are shown in Fig.3. The fitting to the experimental obtained points leads to the dependence of the form of $J_{CI} \sim B^{-n}$, where $n \simeq 2.3$ and $n \simeq 2.2$ for Gd and Y samples, respectively. Very similar results, i.e. steeper field dependence of the intergranular critical current density, measured by the direct four-point methods, were reported in papers (5-7).

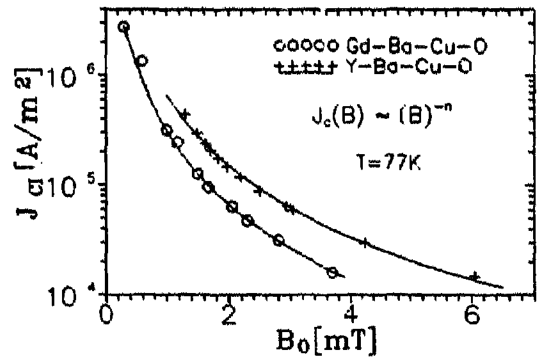

FIG.3. Intergrain critical current density dependence on the external magnetic induction, detemined from loss results for small amplitudes.

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