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Artikel: New method for Hc2 measurement in high Tc superconductors

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NEW METHOD FOR Hc2 MEASUREMENT IN HIGH Tc SUPERCONDUCTORS.

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Abstract: A new method for upper critical field measurement in high pulsed fields, is presented. A special pick-up is used to measure the induced dM/dt while, simultaneously, an operational amplifier gives the derivative of the differential susceptibility (DDS). The obtained double peak signal decreases with increasing field and temperature and disappears at H=Hc2 or T=Tc. The magnetic Hc2 measurements have been carried out both on bulk $YBa_2Cu_3O_7$ samples and on in-glue-dispersed powders.

1. Introduction

Since the recent discovery of a new class of high Tc superconductors tremendous efforts have been devoted to the study of the materials in order to understand the mechanism of superconductivity and to find new superconductors. Despite recent efforts, the macroscopic nature of superconductivity in these high Tc ceramic superconductors is not yet well understood. Many Hc2 tests, on single crystals, polycrystalline samples and on epitaxial films have been carried out. The results were obtained by the resistive measurement method in both continuous and pulsed fields. Radio frequency Hc2 measurements are also reported. A new contact-free method for Hc measurements, developed by the authors, is presented.

2. Experimental

The upper critical field (Hc2) is measured by a new method using a pulsed field apparatus /1/. Its principle is simple: the magnetization curve of a superconducting sample is detected by means of a specially compensated pick-up and then studied by successive derivatives. The pick-up coil must be less sensitive to the modulation of the main field due to mechanical vibrations and electric stray fields. If we develop the field in a series of Legendre at the centre of the magnet we obtain: $H = H_o + c(2z^2 - r^2)$.
The pick-up is designed so as to give indipendent cancellation of these two terms. According to Bean's model /2/ we see that at high fields the sample reaches a critical state, that is the critical current depends only on the magnetic field in that region. By using the Ginzburg-Landau theory /3/ at the inversion point of the magnetic field the magnetization jump turns out to be:

$$\Delta(dM/dH) \leq (-1-1/(2k^2(t)-1)\beta_A))$$

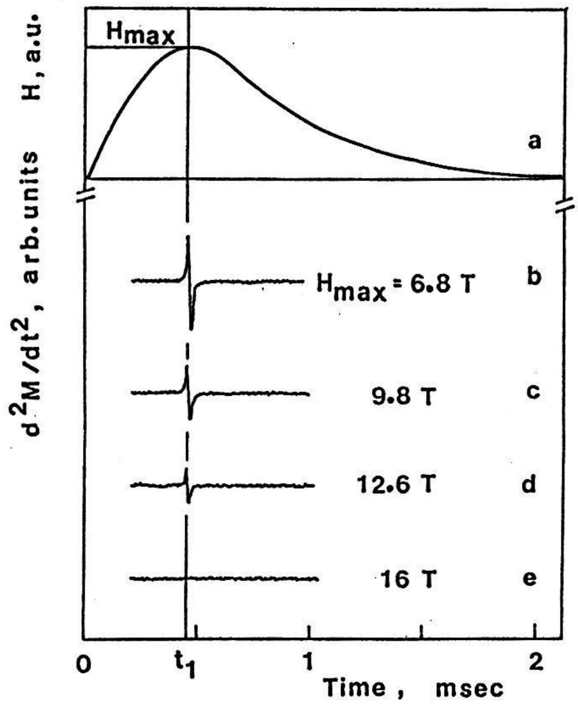

Figure 1. Experimental results: a) variation of the magnetic field with respect to time; b-e) d^2M/dt^2 versus time at different maximum applied fields at 78 K.

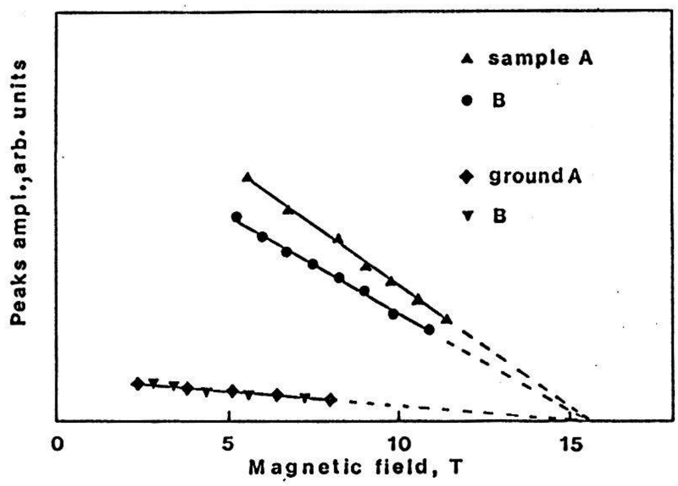

Figure 2. Variation of peak amplitude at $H=H_{max}$ with increasing field ▲ sample A, ● sample B, △ ground A, ○ ground B.

The experiments were carried out in a pulsed magnetic field with a 0.45 ms rise time and esponential decay; in the first approximation the variation of the field is very close to its maximum where dM/dt changes sign and can be considered linear. The experiments reveal that, due to increasing noise with increasing field, it is very difficult to detect dM/dt versus time, but it is relatively easy to detect d^2M/dt^2 against time. Some examples are shown in Figure 1 for samples A at various magnetic fields at 78K. It can be seen that the amplitude of d M/dt decreases by increasing the maximum field. In particular at H= 16 T the double peak is not present, this also happens as temperature approaches Tc. Figure 1 also shows an example of the evolution of magnetic field with respect to time (Hmax =16T). The variations of the peak amplitude at H=Hmax with increasing field for sample A and B are reported in Figure 2. In all cases the extrapolation of the results of each measurement and its intercept with the field axis gives the same value for Hc2, that is Hc2 = 15.6 T at 78K. This confirms that the presence of different pinning centres and defects, due to the different sample preparation, does not affect the Hc2 values obtained.

3. Reference

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