PROBE FOR AC MAGNETIC SUSCEPTIBILITY IN $YBa_2Cu_3O_{7-x}$ [1]

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It was projected and built a probe for AC (3KHz) differential measurements of the magnetic susceptibility of high Tc superconductors. Samples of $YBa_2Cu_3O_{7-x}$ were tested in the 77 - 110K interval. It was measured the real (χ') and imaginary part (χ'') of the magnetic susceptibility and these results were correlated with X rays difratograms. The ceramic samples were then transformed into powder form and the real and imaginary part of the magnetic susceptibility again measured. These results will be discussed.

1- Supported by FINEP

2- On a fellowship from FAPESP

PACS number: 74.30.Ci, 74.60.W

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International Conference on Transport Properties of Superconductors, Rio de Janeiro, April 29 - May 4, 1990

INTRODUCTION

The magnetic susceptibility χ in $YBa_2Cu_3O_{7-X}$ has a real (dispersion) part χ' and an imaginary (dissipation) part χ''. Goldfarb *et al*[1] reported that the real and imaginary parts of the AC susceptibility from 10 to 1000Hz, in the superconducting state, are virtually independent from the frequency, but strongly dependent on the magnetic field H_o. The real and imaginary behavior in AC susceptibility measured at the frequencies 10, 100 and 1000 Hz, in an applied field of 1mT (rms), were also studied from Rao *et al*[2] and the same results were obtained. D.X.Chen *et al*[3] showed that denser samples have stronger diamagnetic effects. These results point out the important roles played by flux pinning on the surface, flux trapping due to inhomogeneities, and the porous nature of the materials.

SAMPLE PREPARATION

Single-phase $YBa_2Cu_3O_{7-X}$ compounds were prepared by thoroughly mixing Y_2O_3 , $BaCO_3$, CuO in a 1.000 : 3.496 : 2.114 mass ratio. The mixture was then grounded and heated for 12h at 950°C under a constant flow of O_2 at atmospheric pressure. The mixture was then slowly cooled to room temperature at a ratio of 25°C per hour. After this procedure, a standard powder metallurgical method followed, i.e., grinding, pressing, and sintering tablets of the compound at 950°C, under O_2, for 12h and again slowly cooled to room temperature at a ratio of 25°C per hour.

AC PROBE

L. Gomes *et al*[4] made a very simple probe that checked the Meissner effect of $YBa_2Cu_3O_{7-X}$ samples. Our experimental probe was projected to allow AC magnetic susceptibility measurements of samples under inductive almost uniform magnetic field as low as 0.034 A/m (rms). This probe (fig.1) consists of a central inductor solenoid, F, that has a cylindrical shape and two coil sensors (A and B) collinearly placed with F but in opposite sides.

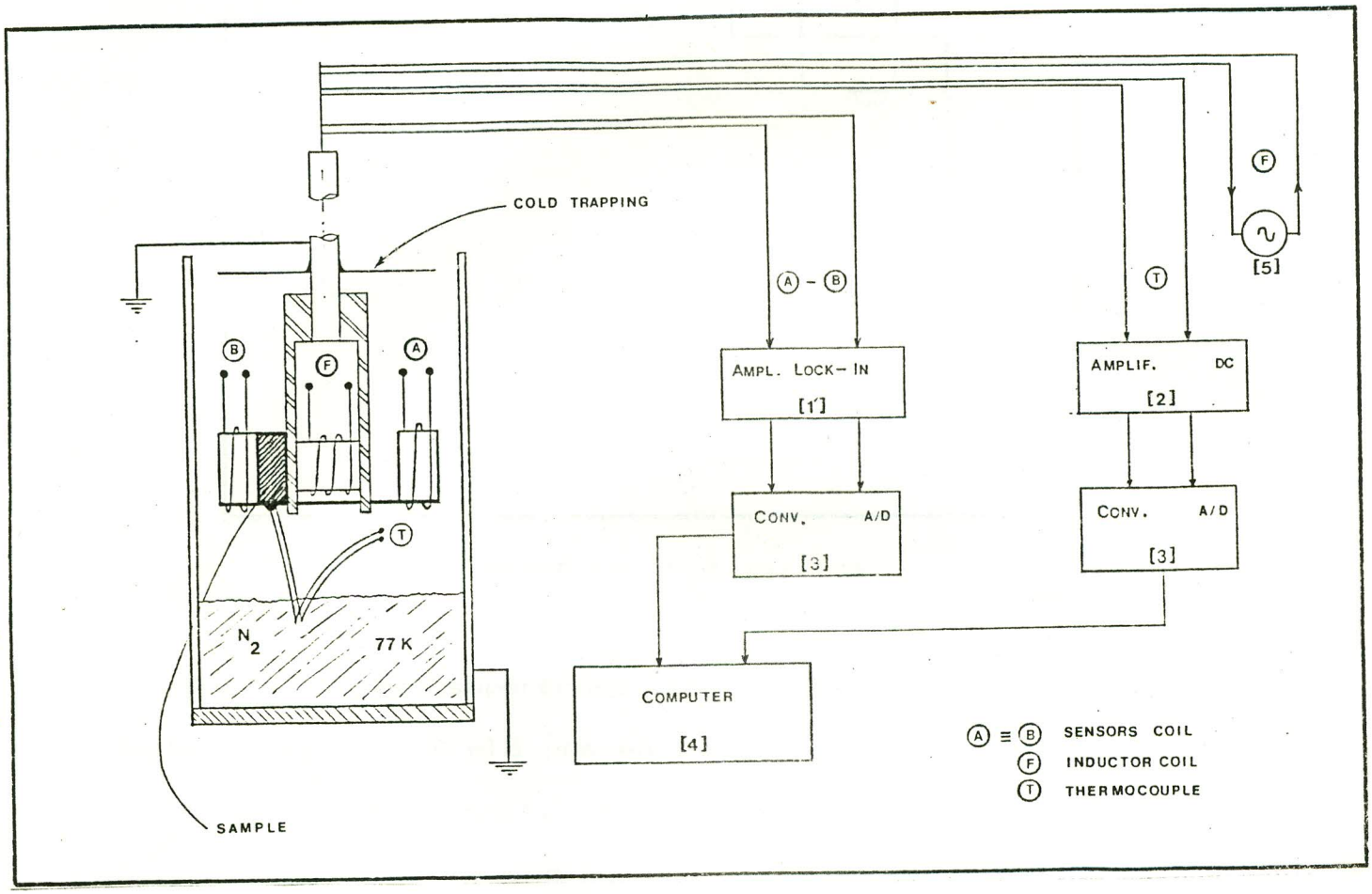

Fig.1 - *Experimental set-up used on AC susceptibility measures in the 77K - 130K temperature range.*

The sample in a tablet form is then placed between A e F. This probe allows a balance of the differential (A - B) signal by fine adjusting the position of the sensor B, using a non-magnetic micrometric screw (fig.2).

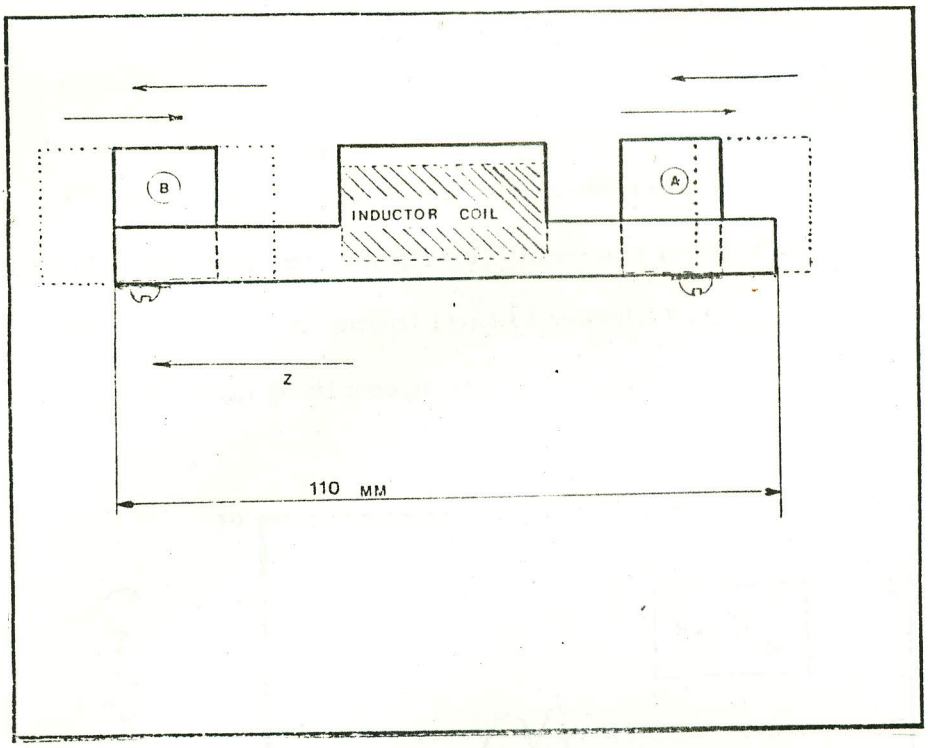

Fig.2 - *Sensor coils adjusting*

Once in the superconducting state, the sample repels the inductive magnetic field preventing it from reaching the sensor A. The differential signal, A - B, now deviates from zero to approximately -B, depending on the strength of the diamagnetic shielding. This signal is processed by a Stanford's dual phase lock-in amplifier and read by an Apple computer with an A/D interface simultaneously with the temperature signal.

The thermocouple was fixed on the sample with a G.C.Electronics' silver print. The signal was increased 6000 times by using a DC amplifier which was made by our electronic lab.

RESULTS

In fig.3 we show the imaginary and real magnetic susceptibility of tablet samples, for a fixed frequency of 3kHz. The imaginary part of the susceptibility exhibits a cusp where the real part undergoes a sharp diamagnetic change.

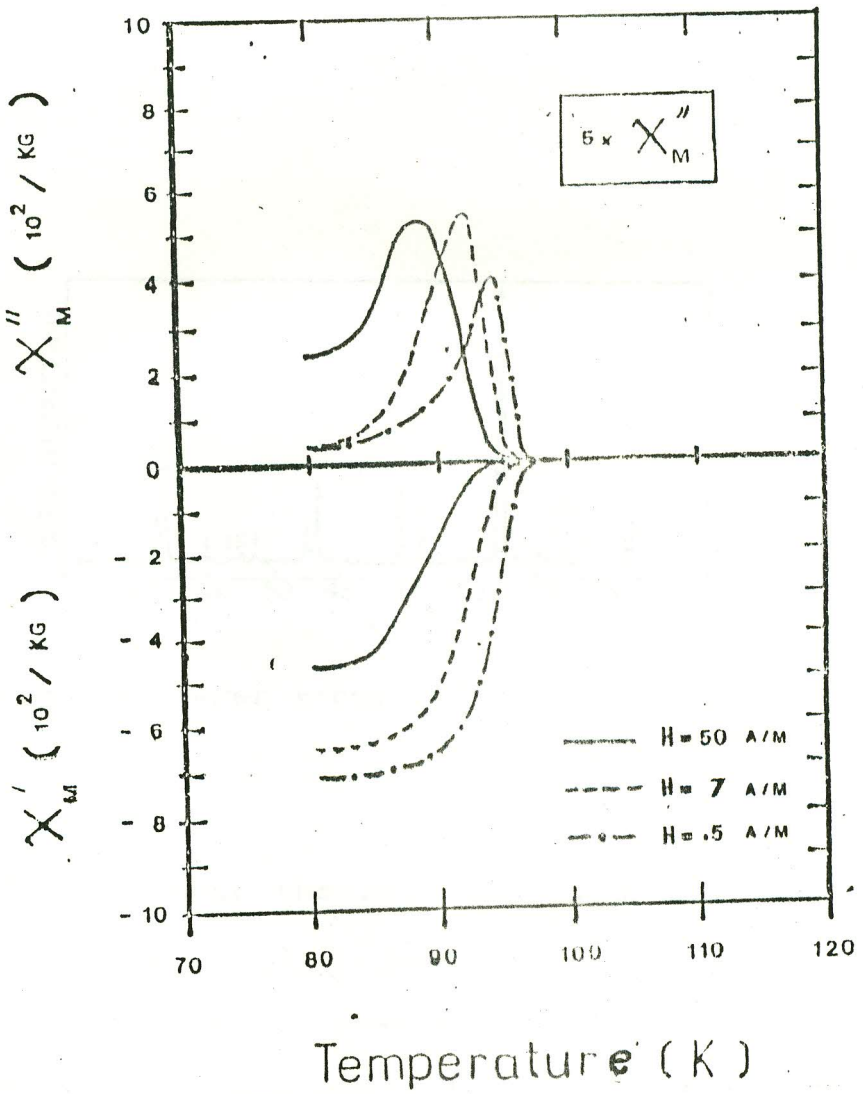

Fig. 3 - $YBa_2Cu_3O_{7-X}$ *susceptibility with* f = 3 kHz.

It is seen the cusp shifts to lower temperatures when the magnetic field is increased. The experimental error on the field amplitude is about 2%.

Powder x-ray diffraction pattern (fig.4) taken by commercial x-ray equipment showed the presence of the $YBa_2Cu_3O_{7-x}$ superconducting phase, as the dominant composition of the material.[5]

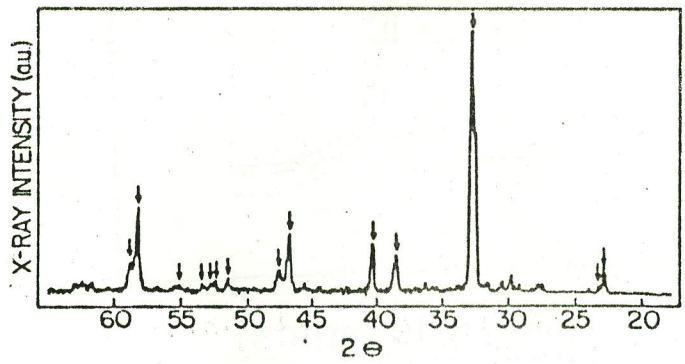

Fig 4 - *Powder x-ray diffraction pattern*

Figure 5 shows that the real and imaginary parts of the AC susceptibility of $YBa_2Cu_3O_{7-x}$ samples are virtually frequency independent. The dissipation peak of χ'' shifts slightly to lower temperatures when the frequency increase up to 30 kHz.

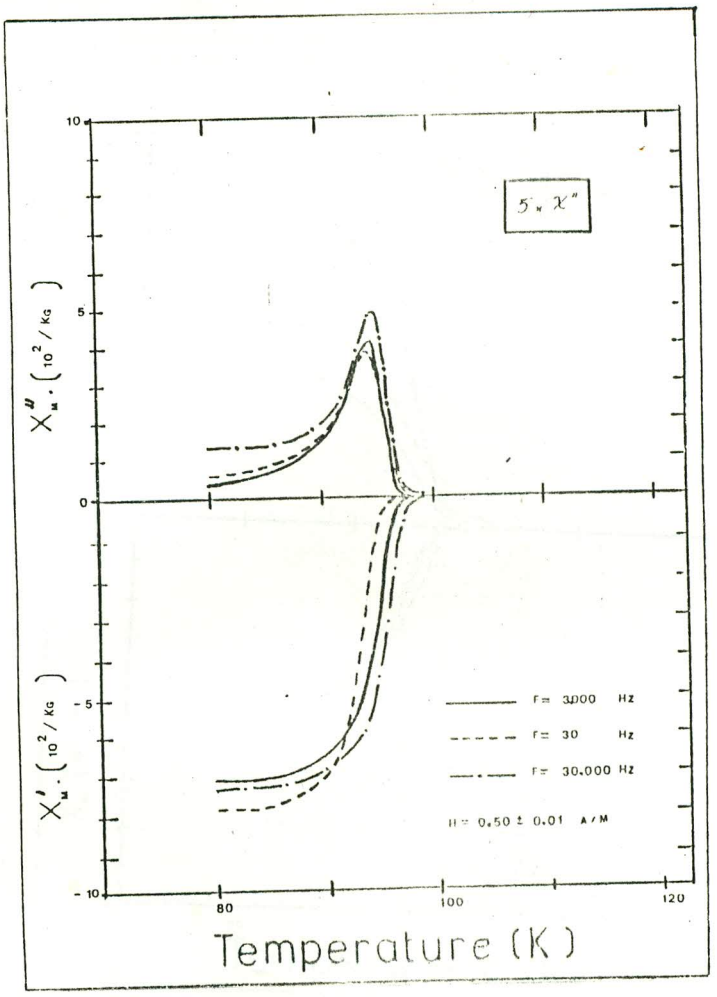

Fig 5 - $YBa_2Cu_3O_{7-X}$ *susceptibility with* H = 0.50 A/m (rms).

The samples were coarsely crushed with a hammer to particle sizes ranging from 44μm to 74μm. After that, the powder was loosely packed into a cylindrical plastic holder of roughly the same shape and dimensions as the original sinterized sample. Susceptibility results after the crushing are shown in fig.6 .

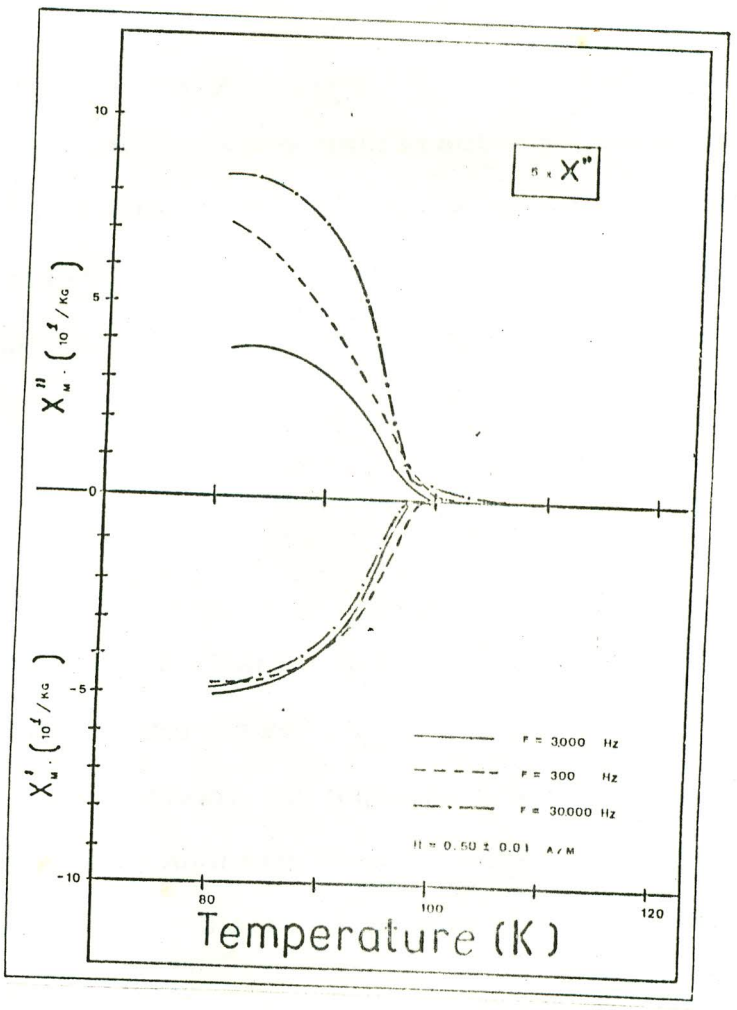

fIG. 6 *Particle sizes ranging from 44 μm to 74 μm.*

CONCLUSION

This AC probe is easy to build. The probe performance was checked out and the results were satisfactory, considering we could reproduce the early results obtained by other authors[1,2]. As we can see, the susceptibility is very sensitive on field amplitude (H_o), what indicates that small field amplitudes should be used ($H_o \leq 5$ A/m).

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