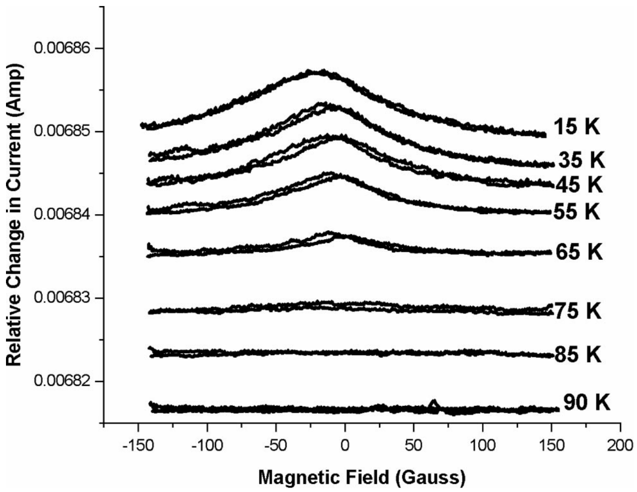

FIG. 12. Field dependence of current for the YBCO (Sample 2) above and below the critical temperature T_c. The magnetic field is scanned from −150 Gauss to +150 Gauss in 60 s.

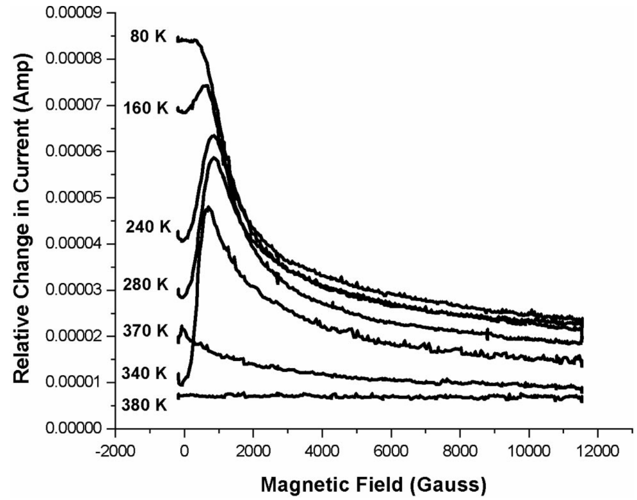

FIG. 14. Field dependence of current for the LSMO sample above and below the ferromagnetic transition temperature T_c. The magnetic field is scanned from −150 Gauss to +150 Gauss in 60 s.

mal state (Fig. 11). Detail interpretation of the result and a comparison of preparation techniques which leads to different type of power absorption are beyond the scope of this instrumentation article and will be discussed in the forthcoming publication.[7]

In our second experiment we investigated with manganites sample. The ICO based NRRA measurements on manganites sample, $La_{0.7}Sr_{0.3}MnO_3$ (LSMO), are presented in Figs. 13 and 14. This system was recently synthesized and its magnetic and magnetotransport characteristics were studied at our institute. The sample undergoes a paramagnetic to ferromagnetic transition as the temperature is lowered with the Curie temperature T_c around 362 K. In the ICO experiment, the LSMO material is pelletized to capsule form so that it fits snugly into the core of inductive coil. Figure 13 shows the temperature dependence of the power absorbed in zero field. Note that the change in current is much larger than the background shifts due to empty coil and this has been eliminated in the data presented in Figs. 13 and 14. The paramagnetic to ferromagnetic transition is distinctly seen (Fig. 13) and the data are consistent with the existing reports on this material.[8,9] In paramagnetic state the sample absorbs more energy than its ferromagnetic state. The field dependence for the same sample is plotted in Fig. 14 where we have shown the data for two cases where the temperature is held above and below T_c. The striking difference in the current variation in the paramagnetic and the ferromagnetic phase of the sample is quite obvious. For $T > T_c$, the current value smoothly and monotonically decreases with increasing applied field and shows a tendency to saturate at higher fields. We ascribe this change to being directly associated with the magneto impedance (MI) which is dominated by rapid change in the permeability. The shape of the curve for $T < T_c$ and the saturation field are different from that seen in the curve for $T > T_c$. For $T < T_c$, the magnetic field dependent power absorption goes through a peak and then saturates. Details interpretation of the results and a comparison of the power absorption for these systems are beyond the scope of this instrumentation article and will be discussed in a forthcoming publication.[10]

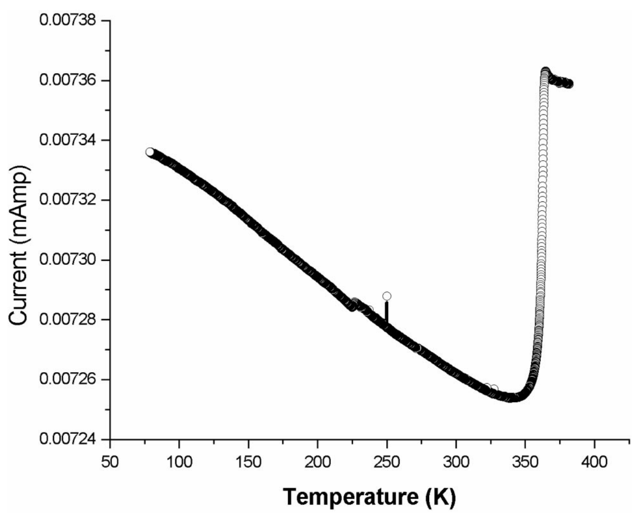

FIG. 13. Measured zero-field temperature dependence of the current for the LSMO sample. The paramagnetic to ferromagnetic transition at 362 K.

VII. DISCUSSION

We have demonstrated a contactless method for measuring conducting, magnetic and trasport properties of materials at different temperature and magnetic field by using this ICO based techniques. Many improvements will enhance this ICO method in future. Use of tunnel diode oscillator in place of IC oscillator may give better stability and resolution. The technique can be useful for the calculation of ac self-field loss in rf reason. Preliminary results on CMR and superconducting samples indicate that this instrument provides a novel way to study the spin and charge dynamics in CMR materials and Josephson junctions and vortex phenomena in superconducting materials.

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[1] S. V. Bhat, P. Ganguly, T. V. Ramakrishnan, and C. N. R. Rao, J. Phys. C **20**, L559 (1987).
[2] A. Rastogi, Y. S. Sudershan, S. V. Bhat, A. K. Grover, Y. Yamaguchi, K. Oka, and Y. Nishihara, Phys. Rev. B **53**, 9366 (1996).
[3] G. Blatter, M. V. Feigel'man, V. B. Geshkenbein, A. I. Larkin, and V. M. Vinokur, Rev. Mod. Phys. **66**, 1125 (1994).
[4] W. H. Hartwig and C. Passow, *Applied Superconductivity*, edited by V. L. Newhouse (Academic, New York, 1975), Vol. II.
[5] A. Dulcic, B. Rakvin, and M. Pozek, Europhys. Lett. **10**, 593 (1989).
[6] A. M. Portis, K. W. Blazey, K. A. Muller, and J. G. Bednorz, Europhys. Lett. **5**, 467 (1988).
[7] S. Sarangi, S. P. Chockalingam, and S. V. Bhat (unpublished, 2004).
[8] S. Y. Yang, W. L. Kuang, Y. Liou, W. S. Tse, S. F. Lee, and Y. D. Yao, J. Magn. Magn. Mater. **268**, 326 (2004).
[9] A. K. Debnath and J. G. Lin, Phys. Rev. B **67**, 064412 (2003).
[10] S. Sarangi, S. S. Rao, and S. V. Bhat (unpublished, 2004).