Simultaneous Measurement of the Resistance and Inductance Transition Characteristics of the HTc Superconductors

A. Koňakovský, A. Cigáň, J. Maňka, Š. Buchta

Institute of Measurement Science, Slovak Academy of Sciences, Bratislava, Slovakia
E-mail: anton.konakovsky@savba.sk

Abstract. *The cryogenic probe and the automatic apparatus for study of transition properties of* HT_c *superconductors using the contacting measurement method and the inductive measurement method based on the Meissner-Ochsenfeld effect were developed. It is shown, that these two methods can lead to consistent results in Tc measurements, however, in general they yield complementary information.*

Keywords: *high-temperature superconductors, measurement of transition characteristics, contacting method, inductive method, critical temperature*

1. Introduction

The conventional four-point technique of the *R* vs. *T* dependence measurement, where *R* is the electrical resistance and *T* is the temperature, is the standard method for determination of the critical temperature T_c of the HT_c sample. Also another two contactless measuring methods - using the change of the self inductance of the coil located in the vicinity of measured sample [1] and using the change of mutual inductance of two coils separated by the sample [2] - have been developed. The synchronized scanning of the transition process by the resistance and inductance methods gives a new opportunity for analyzing the measured data. For this purpose a new apparatus has been developed.

This paper describes the automatic laboratory apparatus for measurement of transition characteristics of high-temperature superconductors by the synchronized scanning of mutual inductance of the pair of coils separated by the sample, electrical resistance of this sample and pertinent temperature.

2. Apparatus description

The measured sample is sandwiched between the primary and secondary coils wound as spiral coils. The electrical contacts on the sample surface are made by soldering. Two Pt100 sensors fabricated as spiral bifilar winding are attached outside of primary and secondary coils and used as the temperature sensor.

Cryogenic probe

The cryogenic probe consists of the coils and the temperature sensor. The sample is being inserted into the fixed chamber. Its walls are the coils and the holders. The sample's temperature control is made with the help of the power control of heating spiral. The probe with the primary and secondary coils, the sample, the temperature sensor and the heating wire are closed in thermally insulated vessel.

Measuring apparatus

The measuring apparatus consists of the thermally insulated vessel with cryogenic probe immersed in the vapor or liquid nitrogen, the electronic switch, digital voltmeter, personal computer, the source of the AC current for primary coil, three sources of DC current for the temperature sensor, for the conventional four-point measurement technique and for the heating the probe. The arrangement of this apparatus is shown in Figure 1.

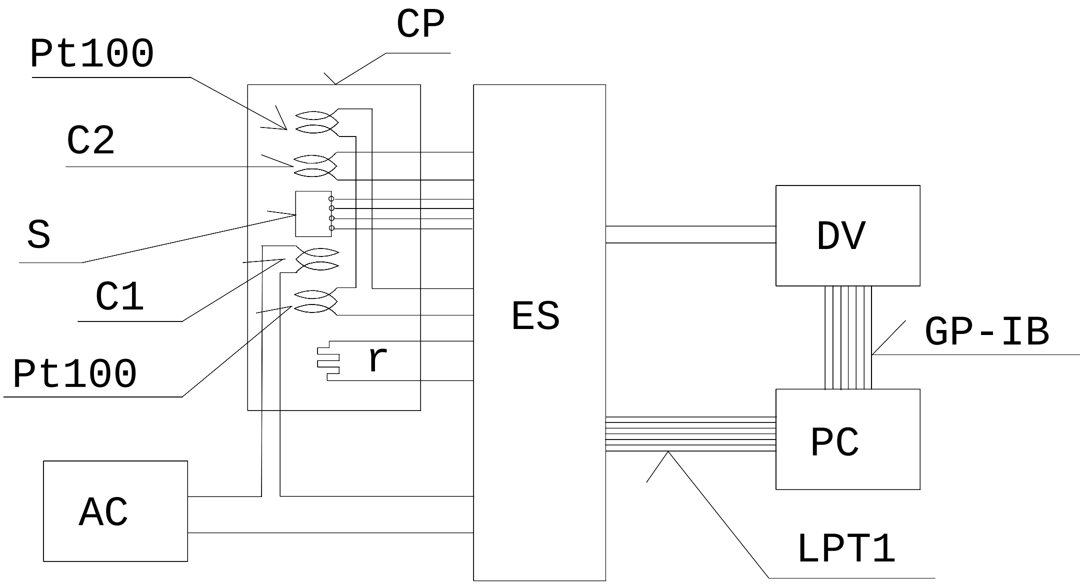

Fig. 1. The block diagram of the apparatus for measurement of the transition characteristics. (AC) is the AC current source for the primary coil, (CP) is the cryogenic probe, (Pt100) are the temperature sensors, (S) is the sample, (C2) is the secondary coil, (C1) is the primary coil, (r) is the heating resistor, (ES) is the electronic switch with heating source, (PC) is the personal computer, (DV) is the digital voltmeter with GPIB bus.

Software

By the electronic switch the software enables to connect the voltmeter terminal with the terminals of: the temperature sensors Pt100, resistance standard for measuring the DC current of the temperature sensor, the secondary coil and terminals of sample contacts. The comparison of measured and calculated values with the specified values allow to initiate the appropriate subroutine, e.g. the data recording, the control of the electrical heating of the probe, etc.
The digital voltmeter SOLATRON SCHLUMBERGER 7081 was used for measurement of the voltage. The communication between PC and the voltmeter is performed by GPIB bus. The communication between PC and the electronic switch is performed via parallel port LPT1.

3. Results and discussion

To compare the efficiency of the mutual inductance and standard resistance methods of measuring the transition characteristics, namely T_c, we have used the sample of YBCO. This comparison is in Figure 2.

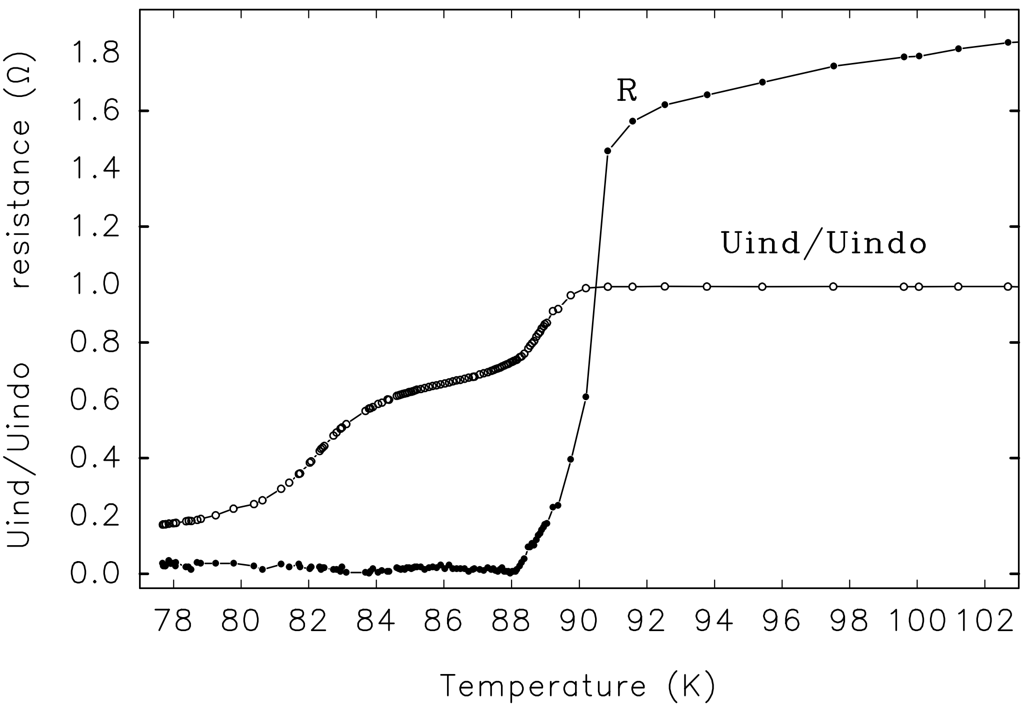

Fig. 2. Measurement of the transition for YBCO sample. [*R*] - the resistance of the sample measured by four-point technique, [Uind/Uind0] - the induced voltage in the secondary coil corrected for influence of the probe without the sample.

4. Conclusions

We presented the apparatus for simultaneous measurement of the transition characteristics of the HT_c superconductors by the conventional four-point technique and by the inductive method. The temperature of sample is controlled by means of energy balance between moderate electrical heating and moderate cooling by vapor nitrogen without the moving the sample in the cryostat. The accuracy of the determination of the transition parameters is significantly affected by the rate of temperature change. In our measuring system this can be kept on required value by the energy balance. The inductive method of the transition characteristics measurement reflects the volume properties and the transport method dominantly reflects the surface properties.

Acknowledgement

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References

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