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PHYSICA C

Measurements of Self-field AC losses in PbBi-2223 Ag-sheathed Tapes

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A technique for measurement of self field AC losses of PbBi-2223 Ag sheathed tapes is presented and preliminary results shown.

Self-field AC losses in PbBi-2223 Ag sheathed tapes are important in the development of industrial applications but little work has been conducted in this area[1,2,3]. The technique presented here is intended for systematic studies of such losses in a wide frequency range (5Hz to 2kHz). The loss component (E') of the surface electric field, between 10nV/cm and 1mV/cm, was measured as a function of transport current (I). A lockin amplifier was used to make the measurement with the phase of the transport current being determined by using a Rogowski coil. Although this device is insensitive to phase shifts caused by eddy currents and external fields there is a small phase shift due to capacitance effects of the coil windings (<0.001° for our coil). The experimental schematic is shown in Figure 1.

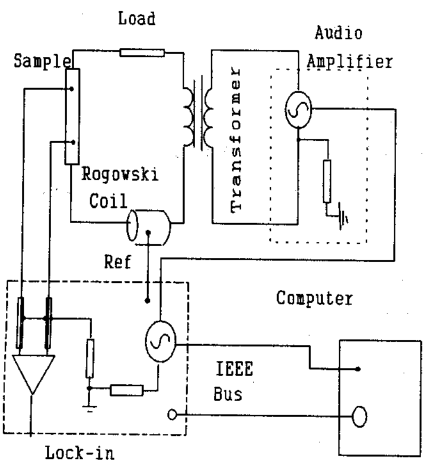

Figure 1. Experimental Schematic.

The narrow band width and high phase resolution (0.001°) of the lockin amplifier, coupled with the high phase accuracy of the Rogowski coil, allow low level voltage measurements without filtering and inductive compensation. In contrast to those measurements using conventional differential amplifiers [1], where filtering and compensation are necessary, this method has two important advantages. (1) The problem of phase corruption in the preamplifier stage of the measurement circuitry is reduced and the phase sensitivity of the system is increased through phase lock-in. (2) It eliminates the error introduced during compensation, caused by the non linear current dependence of the inductive pickup (E'') from the loop involving the silver sheath and voltage leads. Since part of the pick up loop is the Ag sheath, this non linearity (ie. a current dependant inductance) is inevitable due to a changing current distribution in the tape with increasing transport current. This non-linear behaviour was observed in our measurements as shown in Figure 2.

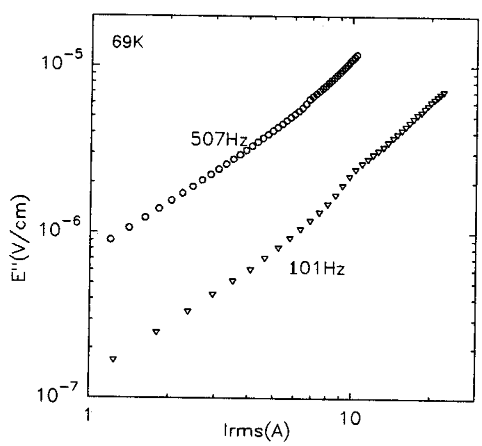

Figure 2. Current Dependence of E''

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Before measurement of the 2223 tapes the system was calibrated by measuring eddy current losses in a silver wire (ϕ2mm) at $J<1A/cm$, at frequencies between 5Hz and 10kHz and at temperatures of 300K and 77K. This data was then compared to theoretically derived results indicating an accuracy better than 10%.

The dependence of E' against Irms for 101Hz and 1507Hz are presented in Figures 3 and 4, along with the DC characteristics.

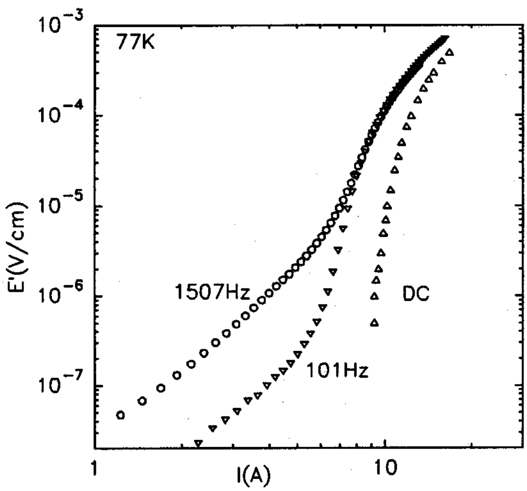

Figure 3. Current dependence of E' at 77K

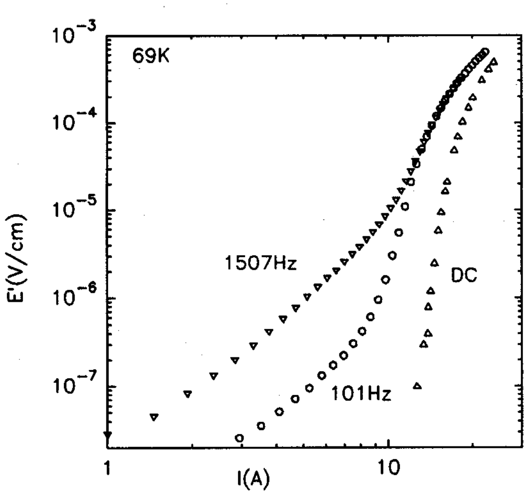

Figure 4. Current dependence of E' at 69K

The loss component E', for low current values shows an I^2 dependence ie. power losses are proportional to I^3. In this region E' also shows a frequency dependence as shown in Figure 5.

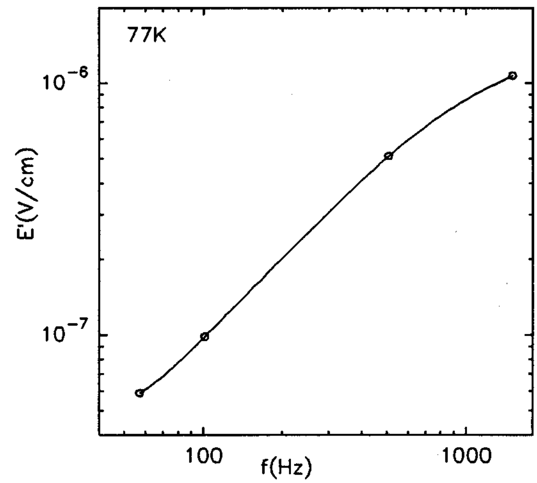

Figure 5. Frequency response of E' at I=0.4Ic (Ic defined using DC 1μV/cm criteria)

These trends indicate that the losses in this region are due to to magnetic hysteretic losses described by the critical state model [4]. As the current is increased the losses become frequency independent indicating that the total losses become dominated by the resistive flux flow losses. The DC value of the Jc, for this particular tape, was $10^4 Acm^{-2}$ at 1μV/cm. The AC_{rms} values do not join the DC curve because of the highly non linear behaviour of the resisitivity. Because of the attention spent to ensure phase accuracy this method is an accurate and flexible means of conducting systematic studies of AC self field losses.

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