11th International Conference on Advanced Materials
Rio de Janeiro Brazil
September 20 - 25
ICAM2009

Capacitance Spectroscopy Analysis of Polaronic Relaxation in $CaCu_3Ti_4O_{12}$ Polycrystalline Systems

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Abstract – Capacitance spectroscopy as function of temperature was conducted in $CaCu_3Ti_4O_{12}$ (CCTO) polycrystalline with the main goal to study the relaxation phenomenon at high frequency region, where there is a relaxation process which was attributed to the existence of polarons. The calculated activation energy was of 33 meV, a value which is typical of polaronic behavior. The result corroborates the recent Nanosized Barrier Layer Capacitor (NBLC) model presented in literature.

The CCTO is a material that presents a giant permittivity behavior, whose values are around ~10^4 without ferroelectric behavior. Currently, there are two acceptable models that describes this high dielectric constant in CCTO ceramic system: IBLC [1] and domains [2]. Recently published, the NBLC model use planar defects associated to polaron phenomena to explain the anomalous permittivity and elevated conductivity [3]. Some papers related polaron phenomena in stoichiometric CCTO [4], but none of them connected this kind of phenomenon with dielectric properties. To verify the existence of polaron relaxation in CCTO polycrystalline it was calculated the activation energy at high frequency region of complex capacitive plots.

The impedance and capacitance spectroscopy measurements were carried out employing a frequency response analyzer (Solartron model SI 1260) with dielectric interface (Solartron model 1296) in the frequency range from 320 KHz to 3.2 MHz. The system was chilled with liquid nitrogen and with temperature range from 0°C to -130°C.

Frequency dependence of imaginary part of complex capacitance is presented in Fig. 1. It shows a relaxation peak that shifts to higher frequencies as temperature increases. This relaxation is related to a bulk relaxation process [5] and now can be attributed to polaronic relaxation. Arrhenius analysis (see Fig. 2) was performed based on the characteristic frequency of the process. According to the results of Bidault et al. [6] that studied several perovskite structures, the activation energy of similar processes have values around 75 meV, which is of the same magnitude to the value found herein. The increase of the permittivity in *C' vs* frequency plot (not shown) occurs at the same frequency region so that reinforces that the polaron relaxation in CCTO system are associated with dielectric properties.

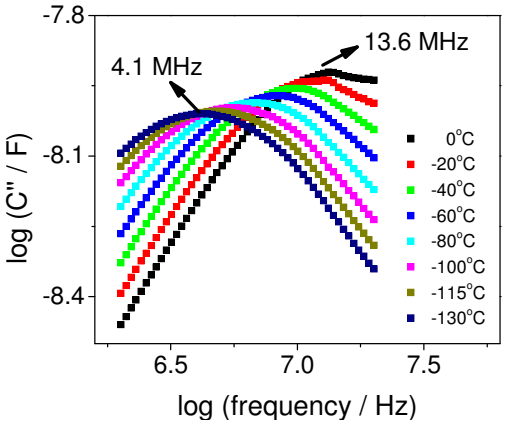

Figure 1. Frequency dependence imaginary capacitance exhibit the peak related of bulk permittivity.

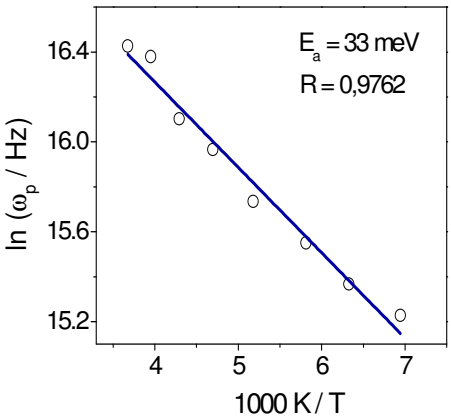

Figure 2. Arrhenius plot of *C''* peak frequency.

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