Plačiajuostė $Ba_{0.17}Ca_{0.83}TiO_3$ keramikos dielektrinė spektroskopija

DIELECTRIC PROPERTIES OF OF BA0.17CA0.83TIO3 CERAMIC

Edita Palaimiene[1], Jan Macutkevic[1], Juras Banys[1], Antoni Winiarski[2], Irena Gruszka[2], Janusz Koperski[2], Andrzej Molak[2]
[1] Institute of Applied Electrodynamics and Telecommunications, Vilnius University,
LT-10257 Vilnius, Lithuania
[2]Institute of Physics, University of Silesia in Katowice, Ul. 75 Pułku Piechoty 1, PL-41-500, Chorz´ow, Poland
edita.palaimiene@ff.vu.lt

Perovskite barium titanate $BaTiO_3$ (BTO) possesses the high dielectric permittivity value, the large spontaneous polarization, good piezoelectric, and nonlinear optical properties at room temperature. It is ferroelectric at room temperature and it is paraelectric beyond the Curie temperature T_C close to 403 K [1]. $BaTiO_3$ ceramics doped with Ca (BCTO) exhibit improved piezoelectric properties in comparison with pure $BaTiO_3$. Moreover, the stabilization of BCTO is considered to result from the slight modification of Ba site with small Ca addition [2]. Barium calcium titanate is a very useful compound in the creation of electro-optical materials for holographic and photo-refractive applications [3] and show promising applications in advanced laser systems, optical interconnects and electronic or optical storage devices [4].

The aim of present work is to investigate the dielectric properties of barium calcium titanate ceramic, $Ba_{0.83}Ca_{0.17}TiO_3$. Dielectric properties of $Ba_{1-x}Ca_xTiO_3$ (x = 0.17) ceramics were studied in wide frequency range of 20 Hz - 53 GHz.

Figure 1 a and b shows the real part of dielectric permittivity temperature dependence, $\varepsilon'(T)$, obtained for BCT ceramics at ambient pressure conditions for different frequencies of electric field. The permittivity magnitude varies in 500–2500 range. The step-like anomaly (A label in Fig. 1a), occurs in ~200–250 K range, which presumably reflects the structural transition between the tetragonal and the orthorhombic phase. We also mention that at low temperatures, below ~220 K.

The $\varepsilon'(T)$ exhibits a diffused peak, which maximum at Tε'max, shifts in 334–337 K range with frequency. Fig. 1c and d shows the permittivity frequency dependence, $\varepsilon'(f)$, in FE and PE phase, respectively. The $\varepsilon'(f)$ spectra monotonically vary both below and above $T_{\varepsilon' max} \approx 337$ K. $T_{\varepsilon' max}$ can be attributed to the Curie temperature, T_C, of FE-PE phase transition. Hence, it occurred at temperature lowered by ~60 K, that is much different from those T_C~400 K reported in literature for BCT [5]. The permittivity peak position dependence on frequency allowed determining the shift of the FE-PE phase transition for frequency decade (Fig. 1b):

$$\Delta T_{\varepsilon' \max}/\Delta \log f = (337\,\mathrm{K}–335\,\mathrm{K})/5 = 0.4\,\mathrm{K/frequency\,decade}.$$

Moreover, we would like to point that dispersion in $\varepsilon'(T)$ dependence was more pronounced below T_C. Within non-centrosymmetric phases domain wall motion might be responsible for this dispersion. One can notice that the thermal generation of electric charge current contributed to the impedance measured at low frequencies in high temperature range, T>400 K (Fig. 1c).

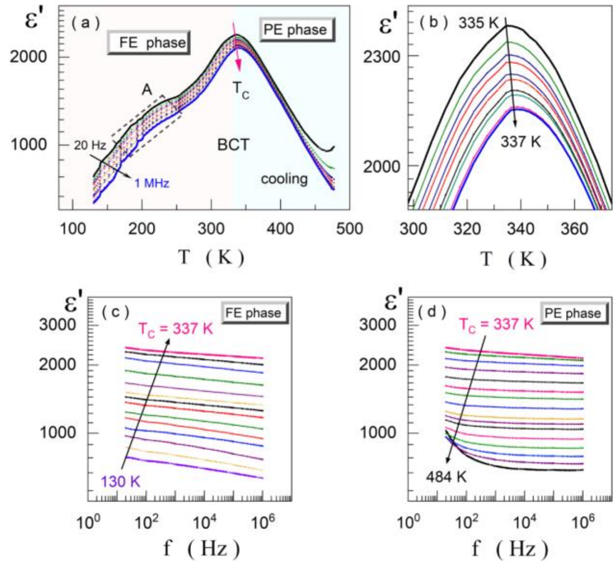

FIGURE 1. Real part of the dielectric permittivity dependences, $\varepsilon'(T,f)$, obtained on cooling for (Ba0.83Ca0.17)TiO3 ceramics at ambient air: (a) $\varepsilon'(T)$; (b) frequency shift of peak related to FE-PE phase transition; (c) $\varepsilon'(f)$ in low temperature ferroelectric phase; (d) $\varepsilon'(f)$, obtained in high temperature paraelectric phase. Chosen plots, with ΔT step from ~4–15 K, are shown for clarity of figures.

Keywords: dielectric, ceramic, Curie temperature.

References

[1] M.H. Khedhri, N. Abdelmoula, H. Khemakhem, R. Douali, F. Dubois, Structural, spectroscopic and dielectric properties of Ca-doped BaTiO3, Applied Physics A, 125:193, (2019).

[2] D. Fu, M. Itoh, S. Koshihara, Crystal growth and piezoelectricity of BaTiO3–CaTiO3 solid solution, Applied Physics Letters 93, 012904 (2008).

[3] F.V. Motta A.P.A. Marques, J.W.M. Espinosa, P.S. Pizani, E. Longo, J.A. Varela, Room temperature photoluminescence of BCT prepared by Complex Polymerization Method, Current Applied Physics 10, 16–20, (2010).

[4] H. Veenhuis, T. Börger, K. Peithmann, M. Flaspöhler, K. Buse, R. Pankrath, H. Hesse, E. Krätzig, Light-induced charge-transport properties of photorefractive barium-calcium-titanate crystals doped with rhodium, Applied Physics B 70, 797–801 (2000).

[5] E. Palaimiene, J. Macutkevic, J. Banys, A. Winiarski, I. Gruszka, J. Koperski, A. Molak, Crossover from ferroelectric to relaxor behavior in Ba1−xCaxTiO3 (x = 0.17) system, Materials 13, 2854 (2020).