Contribution of polarization mechanisms in colossal permittivity of doped $BaTiO_3$ ceramics

V'yunov O.I., Reshytko B.A., Belous A.G.

Vernadskii Institute of General and Inorganic Chemistry, Natl. Acad. of Sci. of Ukraine.
Palladina ave. 32/34, Kiev, 03680, Ukraine
E-mail: vyunov@ionc.kiev.ua

Ferroelectrics with very large (“colossal”) magnitudes of permittivity ($\varepsilon > 1000$) are demanded for modern applications: capacitance-based energy-storage and microwave devices, memory elements, etc [1]**.** Colossal values of the permittivity (CMP) can arise due to different phenomena, including ferroelectricity, charge-density waves, metal-dielectric interface, hopping charge transport and grains interface effects [2]. The CMP in $BaTiO_3$-based ceramics can be explained by the internal barrier layer, hopping polarization [3], and external barrier between electrode and ceramics [4].

The present work is devoted to a deeper understanding the nature of colossal permittivity of $BaTiO_3$-based ceramics and the contribution of different polarization mechanisms in the total value of permittivity.

Polycrystalline Y-doped $BaTiO_3$-based solid solutions with different amount of Mn additives were synthesized via a solid-state reaction technique. All samples were single-phased and crystallized in the tetragonal symmetry. It was experimentally established that ferroelectric semiconductors based on barium titanate had colossal values of the permittivity ($\sim 10^4$). The dielectric losses of the materials with CMP values are high enough to limit their potential applications. Impedance spectroscopy showed that the contribution of various polarization mechanisms to the permittivity decreased in the sequence: “internal barrier layer → external barrier between electrode and ceramic → hopping polarization → spontaneous ferroelectric polarization”., In contrast to samples with ohmic (aluminum) contacts, samples with flap (silver) contacts had stable values of permittivity and low values of dielectric losses over a wide frequency range (up to 10^4 Hz), which is important for practical use.

This research was supported by the Program on Fundamental Studies of the National Academy of Science of Ukraine “Fine Chemicals”.

1. Wu Y., Miao J., Liu Z., Li Y. Colossal permittivity and dielectric relaxations in $BaTi_{0.99}(Nb_{0.5}Ga_{0.5})_{0.02}O_3$ ceramics // Ceram Int.-2015.-V.41.-P.S846-S850.
2. Lunkenheimer P., Krohns S., Riegg S., Ebbinghaus S. G., Reller A., Loidl A. Colossal dielectric constants in transition-metal oxides // Eur Phys J.-Special Topics.-2009.-V. 180. -№ 1.-P. 61-89.
3. Guillemet-Fritsch S., Valdez-Nava Z., Tenailleau C., Lebey T., Durand B., Chane-Ching J. Y. Colossal permittivity in ultrafine grain size $BaTiO_{3-x}$ and $Ba_{0.95}La_{0.05}TiO_{3-x}$ materials //Adv Mater.-2008.-V. 20.- № 3.-P. 551-555.
4. Hess Harald F., DeConde K., Rosenbaum T. F., Thomas G. A. Giant dielectric constants at the approach to the insulator-metal transition //Phys Rev B.-1982.-V. 25.-№ 8.-P. 5578.