DIELECTRIC PROPERTIES OF THE PEROVSKITE-LIKE OXIDES $CaCu_3Ti_{4-X}M_XO_{12}$ (M = Zr, V, NB) PREPARED BY HIGH TEMPERATURE – HIGH PRESSURE SYNTHESIS [1]

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The perovskite-like CaCu3Ti4O12 (CCTO) is attracting considerable attention due to the unique physical properties including the most known such as giant permittivity effect the origin of that is still being discussed. In earlier papers we showed that high temperature – high pressure synthesis leads to an increase in the permittivity (as compared with the permittivity of materials synthesized by solid-state reaction) for CCTO and for a number of perovskite-like phases with the structure K_2NiF_4 [1-3]. As a result of the high temperature – high pressure effects, the grain size in CCTO significantly increases too [1, 2]. The ame of this work is to reveal the effect of the composition, morphology, microstructure and external influences on the dielectric constant of the synthesized materials based on CCTO. For this purpose the dielectric properties of materials synthesized by various methods, including high temperature – high pressure method, and materials obtained as a result of partial substitution of titanium atoms in the CCTO for atoms of zirconium, vanadium and niobium, have been studied.

The samples $CaCu_3Ti_{4-x}M_xO_{12}$ (M = Zr, x = 0.3; M = V, x = 0–0.5; M = Nb, x = 0.5) have been synthesized at high pressures (2.5 GPa – 10 GPa) and temperatures (900º C-1100º C) in a toroid-type high-pressure chamber. For comparative studies, the samples CCTO and $CaCu_3Ti_{4-x}Nb_xO_{12}$ were also synthesized by solid-state reaction [2]. Series of samples CCTO were preparated using solution combustion method for the synthesis of powders using the different fuels (citric acid and diammonium citrate) and their subsequent sintering. All synthesized phases crystallize in a cubic symmetry (space group Im-3, Z = 2) and have a perovskite-like structure.

The electrical properties were studied in a wide range of temperatures (10–600 K) at atmospheric pressure and pressures (10 GPa to 50 GPa) at room temperature, on DC and AC (1 Hz-32 MHz) (Solartron 1260A and the ModuLab Materials Test System). For the topography and the electrical current profile studies in some samples the scanning probe microscopy (SPM) technique was implemented in the contact spreading resistance mode (SPM Asylum MFP3D).

The studied compounds are characterized by a high dielectric constant (~ 10^3-10^5). The high temperature – high pressure processing increases the dielectric permittivity of the materials. By analyzing the influence of the morphology features, the grain characteristics, of temperature and pressure effects on the dielectric properties of materials, it was concluded that not only the Maxwell-Wagner polarization processes (or internal barrier layer capacitors (IBLC) model [4]) is responsible for the high values of the dielectric constant. But, in the main, the Nano Barrier Layer Capacitance (NBLC) model [5] and the small polaron hopping conduction mechanism, which take into account the intragranular effects, can explain the high dielectric properties of studied materials.

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