Effect of CaO and BaO Additions on the Electrical Parameters of SnO_2 Based Varistor Ceramics with Nano-Sized Intergranular Phase

Gaponov O.V., Vorobiov O.V., Vasyliev A.M.

Oles' Gonchar Dnipropetrovs'k National University, Dnipropetrovs'k, Ukraine

The high nonlinear SnO_2 based ceramics which can be used as a varistor material has intensively been investigated for the last two decades. Along with the widespread ZnO based ceramics SnO_2 based ceramics can be used for producing the overvoltage-protective devices. In this article SnO_2-Co_3O_4-Nb_2O_5-Cr_2O_3-CuO ceramics baked at 1520 and 1620 K with CaO or BaO additions is studied. The structure of the investigated material consists of SnO_2 grains divided by the layers of Cu-rich intergranular phase. The width of this phase is the same as for the ZnO based ceramics and equals to several nanometers.

In ceramics obtained at both burning temperatures the electrical conductivity in the low electric field decreases with CaO addition and even more decreases with BaO. It correlates with the increase of potential barrier height at the grain boundaries from 0.6 to 0.8 eV. The nonlinear coefficient $\beta = 36$ is the highest in the ceramics with 0.5 mol. % BaO addition baked at 1620 K. The electric field E_1 of samples obtained at 1520 and 1620 K is increasing with CaO and BaO additions. This process is caused by decreasing of the average grain size. It explains the obtained parameters of the dielectric permittivity which decreases in the samples with alkaline-earth metal oxide additions. The normalized nonlinear coefficient $\beta_E = \beta/E_1$ decreases with adding CaO and BaO. The SnO_2-Co_3O_4-Nb_2O_5-Cr_2O_3-CuO ceramics baked at 1620 K has the highest $\beta_E = 0.016$.

The specific resistance of SnO_2 grains estimated from high-current pulse measurements [1] differs greatly for different SnO_2 based ceramics and amounts to from 5 to several tens Ohm·cm. The estimated average size of SnO_2 grains is 2-7 μm which correlates with the data of scanning electron microscopy.

In the studied SnO_2-Co_3O_4-Nb_2O_5-Cr_2O_3-CuO system with CaO and BaO additions the rise of burning temperature leads to the increase of linear shrinkage, grain size, electrical conductivity in the low field, normalized nonlinear coefficient and dielectric permittivity and the decrease of the electric field E_1. The coordinated changes of these parameters uphold the barrier mechanism of conductivity in the SnO_2 based ceramics. The nonlinear coefficients and normalized nonlinear coefficients are higher for the samples baked at higher temperatures. The addition of alkaline-earth metal oxides allows to increase the potential barrier height at the grain boundaries and produce the varistors with the lower values of leakage current.

1. Glot A.B. Electrical properties of SnO_2 ceramic varistors withstanding high current pulses / A.B. Glot, Z.Y. Lu, Z.Y. Zhou, A.I. Ivon // Superficies y Vacio. – 2011. – 24(2). – P. 61-67.