Effects of Bi$_2$O$_3$ Addition in Micro- and Nanoscale on the Structural and Electrical Properties of Zn$_{1-x}$Bi$_x$O varistors

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Abstract:

Two similar sets of Zn$_{1-x}$Bi$_x$O ceramic varistors with various $x$ values (0.00≤$x$≤0.20) have been prepared by using Bi$_2$O$_3$ additions with two different sizes. In the first set, Bi$_2$O$_3$ nanoparticles (≈200 nm) were used, while Bi$_2$O$_3$ microparticles (≈5 μm) were used in the second set. It was found that addition of Bi up to 5 % for both sets did not affect the wurtzite-type hexagonal structure of ZnO, but with increasing Bi above 5 %, some unknown lines were clearly observed in XRD spectra. The grain sizes are increased in both sets with increasing Bi content up to 2.5 %, followed by a decrease with further increase of Bi up to 20 %, and their values for microparticle additions were larger than that of the sets containing nanoparticle additions. Two nonlinear regions were formed in the I–V curves of ZnO due to Bi$_2$O$_3$ nanoparticle additions above 5 %. However, this behavior was completely absent in the samples containing Bi$_2$O$_3$ microparticles. Moreover, the breakdown field and nonlinear coefficient decreased with Bi$_2$O$_3$ addition up to 5 % for both sets, followed by an increase with further increase of Bi up to 20 %, and their values were higher for nanoparticle additions than that of microparticles. A reverse behavior was recorded for the electrical conductivity. The results have been discussed in terms of Bi$_2$O$_3$ nanosize grains which may be localized at the grain boundaries of ZnO ceramics.

Keywords:

Ceramics . Chemical synthesis . X-ray diffraction . Electrical properties . Transport properties

Published In:

Brazilian Journal of Physics