Functional Materials 10, No.2 (2003)

A novel tin dioxide based semiconductor ceramics: a material for high nonlinearity varistors

I.A.Skuratovsky, A.B.Glot

Dnipropetrovsk National University,
13 Nauchnaya St., 49050 Dnipropetrovsk, Ukraine

A tin dioxide based varistor ceramics has been obtained exhibiting a considerable deviation from Ohm law. The nonlinearity coefficient of current-voltage characteristic ($\beta = (E/J)(dJ/dE)$) for this ceramics varies from 55 to 80 depending on the composition and the additive percentage. The additive concentration effect on the material electrical properties have been studied. The high nonlinearity of current-voltage characteristics of the obtained tin dioxide based ceramics is due to processes at the grain boundaries forming during the sintering.

Получена варисторная керамика на основе диоксида олова со значительным отклонением от закона Ома. Коэффициент нелинейности вольт-амперной характеристики ($\beta = (E/J)(dJ/dE)$) полученной керамики варьируется от 55 до 80 в зависимости от состава и процентного содержания добавок. Исследовано влияние концентрации добавок на электрические свойства полученного материала. Высокая нелинейность вольт-амперных характеристик полученной керамики на основе диоксида олова обусловлена процессами на границах зерен керамики, которые образуются при спекании.

Zinc oxide with small additives of other oxides such as Bi_2O_3, Sb_2O_5, Co_2O_3 and others is traditionally the main material in the production of oxide semiconductor varistors [1]. Such ceramics exhibit high nonlinearity coefficients of current-voltage characteristics (CVC) ($\beta > 50$ where ($\beta = (E/J)(dJ/dE)$; E is the electric field strength; J, the current density) and rather high economical characteristics. Tin dioxide [2, 3], titanium dioxide [4] and some other compounds are also used as basis for varistor ceramics.

In [2], SnO_2 based ceramics without zinc oxide additive was studied and it was found that the SnO_2–Bi_2O_3–Co_3O_4–BaO–Nb_2O_5 system ceramics has the CVC nonlinearity coefficient $\beta = 20$ and the specified electric field strength (that is, the field strength at the current density 1 mA/cm^2) $E_1 = 3500$ V/cm.

At present, a tin dioxide based material with Co_3O_4, Nb_2O_5 and Cr_2O_3 additives is known having the CVC nonlinearity coefficient $\beta = 41$ with the specified electric field strength $E_1 = 3990$ V/cm [3]. A material with even higher CVC nonlinearity coefficient $\beta = 72$ was obtained, the E_1 value for that material was, however, 19200 V/cm. Thus, to date, the tin dioxide based materials were unable to compete with zinc oxide varistor ceramics in their electric properties, therefore, their practical application field was limited. The unique character of zinc oxide as the main material in production of semiconductor oxide varistors is also open to discussion. Thus, it would be of interest to prepare a tin dioxide ceramics that would have a high CVC nonlinearity coefficient combined with low specified electric field strength. One way to solve this task would consist in the use of glass-forming additives that favor the potential barrier increase at grain boundaries in the zinc oxide ceramics.