Electro-Thermal Simulation Studies for Pulsed Voltage Energy Absorption and Potential Failure in Microstructured ZnO Varistors

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ABSTRACT: Zinc oxide varistors are ceramic devices made by sintering ZnO powder together with small amounts of other additives such as Bi2O3, MnO2, Co3O4 etc... The presence of Biions trapped at the grain-boundaries are thought to be responsible for a highly nonlinear behavior. The nonlinear current–voltage (I-V) characteristics and excellent energy absorption capabilities, make ZnO varistors very useful as electrical surge arresters. We present a coupled electro-thermal analyses to determine the voltage driven temperature increases and possible impact on material failure in a ZnO varistor. A two-dimensional, random Voronoi network model has been used. The inherently non-linear internal I-V characteristics have been included. A stochastic distribution of grains with varying sizes and barrier breakdown voltages has also been taken into account. The model is timedependent and includes two-dimensional heat generation and flow. Issues relating to internal heating analyses, time-dependent localized melting, cracking due to thermal stresses, and dynamical evolution towards failure, are addressed. Our results show that application of high voltage pulses can lead to internal ZnO melting. Such phase change is known to permanently damage the non-linear GB chracter associated with the Bi2O3 present in such material. Comparisons between uniform and normally distributed barrier voltages were made. Physically, it was shown that differences would be associated would depend on grain size and the applied bias regime. It has also been shown that reduction in grain size would help lower the maximum internal stress. This is thus a desirable feature, and would also work to enhance the hold-off voltage for a given sample size.

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