Relationships between dielectric breakdown resistance and charge transport in alumina materials

M. Touzin (a), D. Goeuriot (a), X. Meyza (a), C. Guerret-Piécourt (b), D. Juve (c), D. Treheux (c), H.-J. Fitting (d)

(a) Centre Sciences des Matériaux et des Structures,UMR-CNRS 5146, Ecole Nationale Supérieure des Mines de Saint-Etienne, 158 cours Fauriel, F-42023 Saint-Etienne cedex 2, France

(b) Laboratoire de Physico-Chimie des polymères, UMR-CNRS 5067, Université de Pau, BP 1157, F-64013 Pau cedex, France

(c) Laboratoire de Tribologie et Dynamique des Systèmes, UMR-CNRS 5513, Ecole Centrale de Lyon, 36 avenue Guy de Collongue, F-69134 Ecully cedex, France

(d) Physics Department, University of Rostock, Universitätsplatz 3, D-18051 Rostock, Germany

Keywords : Al_2O_3, Dielectric breakdown

Abstract

Dielectric breakdown is the main cause of insulator degradation. Breakdown strength strongly depends on materials microstructure (grain size, grain boundaries nature…)[1]. The experimental study of these materials behaviour towards charges injection was performed by Scanning Electron Microscopy Mirror Effect (SEMME) method. It allows to know, during the injection, the amount of injected charges and those which are trapped in the insulator. In order to explain the experimental results, we have developed an iterative computer simulation of the self-consistent charge transport in bulk alumina samples during electron beam irradiation, based on the H.-J. Fitting's Flight Drift Model (FDM). Ballistic and drift electron and hole transport as well as their recombination, trapping and detrapping (due to the temperature) are taken in account. As a main result the time dependent secondary electron emission rate and the spatial distributions of currents, charges, the field and the potential slope are obtained. The analysis of these two kinds of results allowed us to identify the effect of the microstructure on the behaviour of the injected charges in the insulator and then to propose, depending on the temperature, some mechanisms leading to a good dielectric breakdown resistance. Indeed, at room temperature a huge localisation of charges limits their injection into the sample which permit to delay breakdown. On the other hand, when the temperature increases, the efficiency of the charges spreading behaviour is improved. In this case, the good breakdown resistance depends on the ability of the charges to diffuse in the materials.

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[1] J. Liebault, J. Vallayer, D. Goeuriot, D. Tréheux, F. Thévenot, "How the trapping of charges can explain the dielectrics breakdown performance of alumina ceramics", J. Eur. Ceram. Soc., 2001, **21**, pp. 389-397