Resistivity Switching In Hafnium Dioxide Nanostructures

V. E. Borisenko

Belarusian State University of Informatics and Radioelectronics

P.Browka 6, 220013 Minsk, Belarus

e-mail:borisenko@bsuir.by

An origin and peculiarities of resistivity switching in nanodevices designed as a hafnium dioxide (HfO_2) nanolayer incorporated between conducting metal or silicon electrodes are considered. Atomic structure changes, thermal reversible breakdown and charge carrier traps are discussed to form conductive nanofilaments in HfO_2 under its reversible electrical breakdown. The formation and rupture of the nanofilaments result in up to three orders of magnitude change in the current flowing through the insulator during the switching event.

The model of atomic structure changes supposes that oxygen vacancies and foreign atoms from the electrodes form conductive nanofilaments in HfO_2 under its reversible electrical breakdown. It is confirmed by *ab initio* atomic structure simulation explaining recent *in situ* transmission electron microcopy observations.

The proposed "thermal" model is based on an assumption that the thermal reversible breakdown of the insulator is due to its Joule heating displaying an exponential dependence of conductivity on temperature. The temperature and corresponding current-voltage characteristics of conductive filaments have been calculated starting with the heat conduction equation with boundary conditions accounting for the heat dissipation via electrodes. These characteristics are found to be affected by the ambient temperature and nanostructure parameters.

The traps assisted model includes a capture of charge carriers in HfO_2 followed by their ionization via a multiphonon transition mechanism. The multiphonon transitions via the Poole-Frenkel effect or electron tunneling as well as a multiphonon tunneling ionization of neutral traps have been analyzed. The proposed models are concluded to be useful for understanding atomic and electrical phenomena in resistivity switching HfO_2 based nanostructures, which are promising candidates for nonvolatile data storage and reconfiguration electronic applications.