Nonlinear full-coupled dynamic RRAM switching model

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Implementation of the memristor (RRAM element) suitable for computing is one of the rising recent research trends. Indeed, having a new reliable non-volatile two-levels (one-bit) storage unit with a long storage time can commence the latest stride in RAM technology. Also, many applications are to be implemented in a multi-levels RRAM. It can be used to drastically increase the information capacity of RAM elements, as well as for neuromorphic (cognitive) computational systems that can help in simulations of human brain.

Although it is simple enough to implement the memristor using macrostructures (such as ordinary electronic components), it is not applicable for the computing purposes. So, the aim is to produce a simple enough and small enough unit able to change its resistance in response to some governing force. Research on thin transition metals oxide films shows the applicability of such an object for the objective – creating the memristor with desirable characteristics. Many specialists tend to connect the memristive switch with the filament formation that occurs when a current pulse passes over a dielectric. That is why we devote this study to the analysis of charge transport in high-κ affected by the presence of defects and heat release. The final aim of the work is obtaining the model of dynamic memristor switching possessing the predictive capabilities for developing recommendations to optimize the memristor technology.

A thermodynamical filament growth model is formulated. The model is the boundary value problem, which includes a nonstationary heat conduction equation with a nonlinear Joule heat source, Poisson equation, and Shockley-Read-Hall equations considering strong electron-phonon interactions in trap ionization and charge transport processes. The results of computer simulations of the model are the subject of discussion in this work.

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