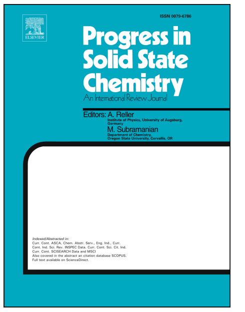

Proton Exchange Reactions in SiO_X-Based Resistive Switching Memory: Review and Insights from Impedance Spectroscopy

Yao-Feng Chang, Burt Fowler, Ying-Chen Chen, Jack C. Lee

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Proton Exchange Reactions in SiO_x-Based Resistive Switching Memory: Review and Insights from Impedance Spectroscopy

Yao-Feng Chang*, Burt Fowler, Ying-Chen Chen, and Jack C. Lee

Microelectronics Research Center, the University of Texas at Austin, Austin TX 78758, USA.

Abstract: In this work, the AC admittance and conductance of non-polar SiO_x-based resistive switching memory devices is measured as a function of temperature to investigate charge transport and potential switching mechanisms. After electroforming using a forward/backward voltage scan, devices were measured over the frequency range of 1k-1MHz and the temperature range of 200-400K. For temperature (T) > 300K, AC conductance follows $\sigma(\omega) = A\omega^s$, where s is linearly dependent on temperature and close to, but less than, unity. For T < 300K, $\sigma(\omega)$ is almost temperature-independent with s ~ 1. A classical hopping model and AC impedance spectroscopy measurements are found to provide reasonable explanations of the experimental data. Defect concentration is estimated to be 1-5 x $10^{19}cm^{-3}$ and independent of device resistive state when modeling charge transport using a polaron hopping characteristic. The energy barrier to electron hopping is estimated to change from 0.1 eV to 0.6 eV and the average hopping distance varies from 1 nm to 6 nm when the device is switched between low- and high-resistance states, respectively. Device switching mechanisms are modeled by simple proton exchange reactions that both activate and deactivate the defects involved in change transport. The impedance spectroscopy results supporting hole-like polaron hopping and the values obtained for the physical parameters provide additional insights into the fundamental mechanisms of SiO_x-based resistive memory. Uniform switching performance with robust high temperature reliability and fast operating speed demonstrate good potential for future nonvolatile memory applications.

Keywords: Proton exchange, Resistive switching, Silicon oxide, Non-polar, RRAM.

* Corresponding Author

Email: yfchang@utexas.edu; Phone: 512-221-6910; FAX: 512-471-5625