Resistive Switching Random Access Memory - Materials, Device, Interconnects, and Scaling Considerations

Yi Wu, Jiale Liang, Shimeng Yu, Ximeng Guan, H. –S. Philip Wong

In this paper, we review recent progresses on metal oxide resistive switching memory (RRAM). It is well-known by now that the electrode materials play an important role in the switching mode of the metal oxide RRAM. Even with the same resistive switching oxide but different electrode materials, the switching mode can be drastically different [3]. It was demonstrated that AlOx-based RRAM can switches as low as 1μA [4]. Both unipolar and bipolar switching behaviors co-existed within the same AlOx-based RRAM device depending on the SET process triggering electrode [5]. Recent work by introducing nitrogen doping into AlOx showed that the switching current can be even lower than 100nA and the RRAM devices required no forming at pristine state [6]. Alternatively, by stacking AlOx with HfOx, the device switching uniformity was improved compared to the single layer HfOx-based RRAM device [7]. Understanding the physics of switching is required for a proper prediction of reliability (endurance, retention) for RRAM operation. Starting from a filamentary conduction model based on the generation and annihilation of oxygen vacancies, we developed a kinetic Monte Carlo modeling tool to explore the switching mechanism of RRAM. A 2-D analytical solver was established to explain the switching parameter variations in HfOx-based RRAM. A numerical simulator was developed to reproduce the experimental I-V characteristics and pulse transient current during switching [1-2] including the stochastic nature of the switching event. In a forward-looking analysis, we investigated the impact of wordline/bitline metal wire scaling on the read/write performance, energy consumption, speed and reliability in the cross-point memory array architecture. Possible solutions were provided to incorporate and mitigate the scaling effects of metal wire interconnect for the next-generation non-volatile memory (NVM) [8].