Electroforming mechanism of metal/oxide/metal memristive switches

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Abstract

Reversible switching (1) of oxide-based memristive switches (2) often requires an electroformation process involving the application of a high bias voltage across the device. In this talk, we describe a set of studies which elucidate the physical changes brought about by this electroformation and the role it plays in subsequent switching. Gas bubbles have been observed to form under the top metal contact of a Pt/50nm TiO_2/Pt switch with a micron size junction area. Conducting channels responsible for the low resistance state of the switches were found adjacent to the bubble regions. The electroforming process is bias polarity dependent with one voltage polarity forming the device to the OFF state and the other polarity forming the device to the ON state, but either polarity produces gas bubbles and reversible switching. In contrast, no detectable bubbles or physical deformations have been observed for the formed nano-sized switches that exhibit a superior switching behavior. Here we demonstrate that the electroformation in a metal/oxide/metal switch is an electroreduction process caused by electric field enhanced by Joule heating. During electroforming, oxygen vacancies drift towards the cathode forming localized conducting channels in the oxide film. Equivalently O^{2-} ions drift towards the anode and are discharged there, evolving O_2 gas and causing some physical deformation in the junction. The forming deformation is reduced to a undetectable level by shrinking the junction size to nanoscale. The forming process is essentially eliminated by using a thin oxide layer in the device.

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