Microsc. Microanal. 25 (Suppl 1), 2019
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doi:10.1017/S1431927618016082

Resistive Switching Studies of ReRAM Devices by *In-Situ* TEM

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Resistive random access memory (ReRAM) devices have been extensively researched in recent years to address scaling issues in nonvolatile flash memories, which are based in charge-trapping. The most critical problem for the development of ReRAM technology is the detailed understanding of both the mechanisms of conductive filament (CF) formation and switching mechanism. The nanometric nature of the switching region and its random location in the device make it extremely difficult to characterize.

In this sense, *in-situ* TEM has been demonstrated as a valuable tool to explore ReRAMs switching mechanisms. D.H. Kwon et al. [1] demonstrate with *in-situ* current–voltage and HRTEM studies that switching occurs by the formation and disruption of Ti_nO_{2n-1} filaments of Magnéli phase. Q. Liu et al. [2] describe, using *in-situ* TEM, in ZrO_2 based ReRAM devices, real-time observations of the CF formation and dissolution processes mechanism based on the local redox reaction inside the ZrO_2-electrolyte system. Besides, X. Wu et al. [3][4] observe the formation and dissolution of nanofilaments in HfO_2 based ReRAM devices by TEM in real time, observing oxygen ion drift and the subsequent Ni migration into the dielectric and the substrate from the top electrode.

In this work, the structural and chemical modifications of three different ReRAM systems are analyzed at the nanoscale after CF formation by means of HRTEM, EELS and EDX. The employed systems consist of: (1) silicon-aluminum oxynitride (SiAlON) thin film, grown by pulsed-laser deposition (PLD) [5]; (2) a HfO_2-based ReRAM inkjet-printed structure; and (3) a $Ni/HfO_2/Si$ structure with the HfO_2 film, grown by atomic layer deposition (ALD) [6].

Moreover, *in-situ* biasing TEM experiments are performed to observe the formation of the CF in real time and to understand the physical mechanism behind the CF formation in ReRAM devices.

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Microsc. Microanal. 25 (Suppl 1), 2019

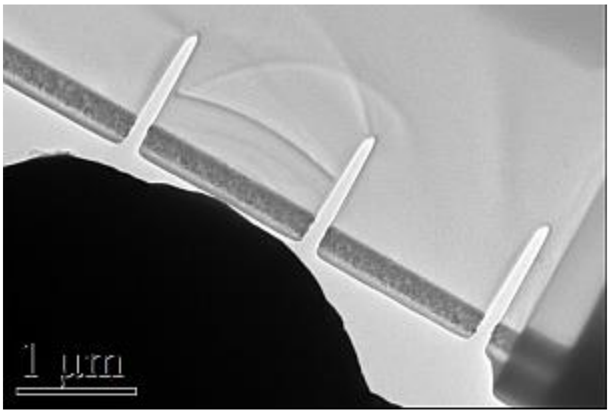

Figure 1. TEM image of the STM tip contacting the $Ni/HfO_2/Si$ ReRAM device

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