HfO_2 based RRAM : Insight from experiment and ab-initio calculations

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In recent years, considerable research effort have been devoted to the development and understanding of resistive random access memories *(RRAM)* due to, among others, their low power operation, ease of integration and compatibility with *CMOS* [1-2]. The working principle of these *RRAMs* relies on the reversible breakdown of the oxide layer (in this case HfO_x) that leads to a deep resistance change. By alternating the voltage polarity (for bipolar devices) at proper levels or using the same polarity at different voltage levels (for unipolar devices), the resistance of the oxide layer can be changed from low resistance state (*LRS*) to high resistance state (*HRS*) or vice versa. *LRS* is attributed to the creation/reconstruction of a conductive path called conductive filament *(CF)* while *HRS* is associated with the rupture of the *CF*. An initial forming step that leads to *CF* creation is required in these *RRAM* devices. This forming operation generally involves high voltages and places considerable electrical stress on the memory cells affecting their expected behavior.

For the purpose of investigating the forming operation, the methodology to reduce and/or eliminate this step, and assessing the choice of electrode material on *RRAM* performance, different types of samples were processed and characterized. Furthermore, we used ab-initio calculations to gain more insight on both the effects of electrode material choice on the forming step of RRAM devices and the possible atomistic structure of samples not requiring forming.

Références

[1] H. Akinaga and H. Shima, *Resistive random access memory (ReRAM) based on metal oxides*, IEEE vol. 98, pp. 22372251, 2010.

[2] V. Sriraman et al., *HfO_2 based resistive switching non-volatile memory (RRAM) and its potential for embedded applications*, IPCSIT vol.32, pp. 101105, 2012.

[3] B. Traoré et al., *Investigation of the role of electrodes on the retention performance of HfO_x based RRAM cells by experiments, atomistic simulations and device physical modeling*, IEEE IRPS, 2013.

[4] B. Traoré et al., *On the forming-free operation of HfO_x based RRAM devices: Experiments and ab initio calculations*, IEEE ESSDERC held in Bucharest, 2013.

[5] M. Sowinska et al., *Hard x-ray photoelectron spectroscopy study of the electroforming in Ti/HfO_2-based resistive switching structures*, APL, vol. 100, p. 233509, 2013.

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