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Resistive transition in $(V_x Cr_{1-x})_2 O_3$ Mott-Insulator thin films for memory applications

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The performance and storage reliability of Flash memories approach their limits as the new 10 nm technology node encounters not only unwanted physical effects due to miniaturization but also short economical payback. Among studied alternatives, Mott Insulators (MI) are promising candidates for the next generation of memory devices. It was recently observed that the Insulator-to-Metal Mott transition (IMT), characteristic of canonical MI such as $(V_{0.95}Cr_{0.05})_2O_3$ [1], $Ni(S,Se)_2$ or chalcogenides AM_4Q_8 [2], can be triggered by electric pulses. MI can reproduce the writing-erasing process of memory devices by a reversible non-volatile IMT [1].

Our work has shown that all $(V_{1-x} Cr_x)_2O_3$ compounds ($0 < x < 1$) share the same crystalline phase and are thus expected to be Mott insulators such as $(V_{0.95} Cr_{0.05})_2O_3$ and Cr_2O_3. Moreover, the electronic structure, and thus the band gap, can be tuned within the solid solution. The resulting range of electric properties can be used to optimize the resistive switching (RS) characteristics in the framework of memory devices. MI thin films were deposited and annealed in various conditions leading to a good stoichiometry and crystalline quality. A large gap composition x=0.60 was then chosen to perform RS cycles in MIM structure (Figure 1), and competitive programing time of 100 ns (> 10 µs for Flash memory) have been observed.

[1] E. Janod, et al., Adv. Funct. Mater., 25, 6287–6305 (2015)
[2] L. Cario et al., Adv. Mater., 22, 5193–5197 (2010)

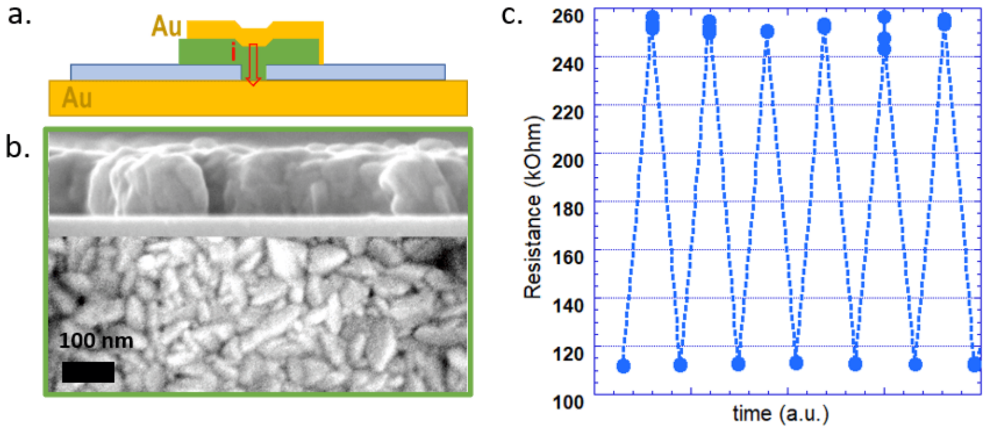

Figure 1: (a) Schematic view in cross section of the Metal Insulator Metal (MIM) structure, (b) Scanning electron microscopy images (surface and cross section) of a $(V_{1-x} Cr_x)_2O_3$ thin film after annealing, (c) Resistive switching cycles obtained in MIM configuration on a 50 nm thick $(V_{0.40} Cr_{0.60})_2O_3$ thin film.