Resistive switching in Hafnium oxide

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Metal-insulator-metal (MIM) capacitor-like structures based on transition metal oxides, have lately been considered as a promising candidate for the next generation of non-volatile memory devices. The operation of such devices is based on the resistive switching effect, which consists in the alternation two different resistance states, high resistance state (HRS) and low resistance state (LRS) by the application of electrical pulses. These resistance states are non-volatile, i.e., they are kept even when no potential is applied. In this work, we present a MIM HfO_2 based device for nonvolatile memory applications. Hafnium oxide thin film (20 nm) was deposited by atomic layer deposition at 300^{o}C, while both bottom (Titanium) and top electrode (Gold or Cobalt) were deposited by sputtering. To form a capacitor structure, top electrodes of different sizes were patterned (from $64x10^4$ μm^2 to $1x10^4$ μm^2). These memory cells show low working currents (<$5x10^{-5}$ A/cm^2), and a resistance ratio between HRS and LRS larger than 10^3 (Figure 1) irrespective of the top metal contact size. In addition, stable retention (>$5x10^2$ s) and stability (>400 cycles) properties (Figure 2) are found. The pristine device displays a HRS (OFF) and can be switched to a LRS (ON) by a SET process. Viceversa, the RESET process occurs by the application of a negative voltage (Figure 1). An explanation for this behavior could be the growth of conductive filaments in the hafnium oxide insulating matrix. Such conducting filaments are though to be formed by defects percolating under the application of electric field. Ohmic behavior observed in the low resistance state (LRS), agrees this filamentary conduction mechanism. The RESET process has also been found to be gradual, occurring at a relatively wide potential range. The progressive rupturing of the conducting filaments could explain this gradual RESET process which gives rise to intermediate resistive states.

Figures

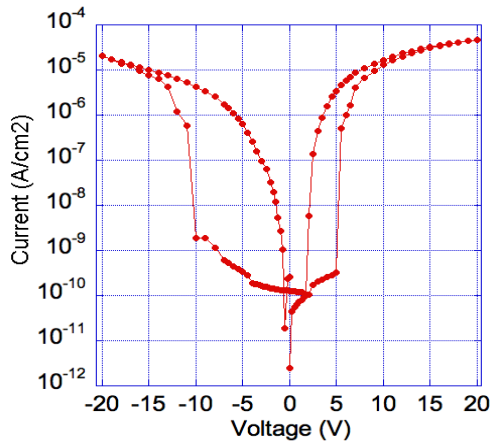

Figure 1: Current-Voltage characteristic of Ti-HfO_2-Au capacitor-like structure.

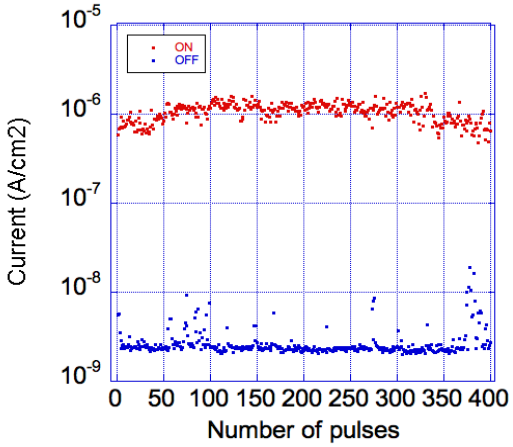

Figure 2: stability characteristics of Ti-HfO_2–Au capacitor-like structure obtained by programming ON and OFF states.