L.6: Realization of fast resistive switching in Au/NiO/Pt devices for high-speed non-volatile memory application

Currently there is spurt in research activity on realization of fast resistive switching (RS) in transition metal oxide thin films for development of high-speed, low-power and high-density non-volatile memory devices. One of the prevailing issues in resistive switching memories is lack of information on resistive switching time, i.e. how fast is switching process from one state to other state. We have studied the dynamic evolution of resistive switching in NiO thin film exhibiting unipolar switching and evolved schemes to achieve fast (~10's of ns) switching times. For these studies ~ 10 nm thick polycrystalline NiO thin films were grown by optimized pulsed laser deposition on Pt/TiO_2/SiO_2/Si (100) substrates and top electrodes of Au of diameter ~ 200 μm and thickness ~ 50 nm were deposited by DC sputtering using shadow masking to fabricate Au/TiO_2/Pt devices. The switching time of RS events namely set (switching from high to low resistance state) and reset (switching from low to high resistance state) processes, both the voltage pulse applied across the device and current flowing through device were measured simultaneously.

The current-voltage measuring setup containing electrical probe station, voltage pulse source and digital storage oscilloscope to study transient resistive switching characteristics in Au/NiO/Pt device is shown in Fig. L.6.1(a). Schematic of device is shown as inset in same figure. A clear unipolar resistive switching between high and low resistance states with resistance values ~12 kΩ, and 48 Ω, respectively has been observed by DC sweep measurement at current compliance of 5 mA with non-overlapping set and reset voltages in the range of ~0.5-0.8 V and 1.3-1.8 V respectively over 200 test cycles. The temporal evolution of the current and voltage in set and reset switching processes recorded using digital storage oscilloscope are shown in Fig. L.6.1 (b & c). The sudden rise in current at ~1.8 V to a constant level of ~ 5 mA due to preset current compliance accompanied by sharp drop in the voltage during set event is indicative of change of resistance state. The switching time evaluated by measuring the time taken by current to rise from 10 to 90% of its peak value, was found to be ~10 ns as shown by dotted vertical lines in inset of Fig. L.6.1(b), which was certainly not limited by measuring circuit. In the same way the reset switching time was measured to be ~150 μs, much slower than set event perhaps due to thermal nature of reset process which involves dissolution of conducting filaments as a consequence of Joule heating generated by the reset current, hence much slower than the field driven set process. Fast reset with switching time ~27 ns was observed by applying higher amplitude voltage pulse of 1.2 V, smaller than the set voltage as shown in Fig. L.6.1(c) wherein rapid drop in the current flowing through the device and rise in voltage applied to device with the same rate as that of current imply reset event. The observed fast set/reset switching (write/erase) time in Au/NiO/Pt devices may have important implications in development of low power, high-speed non-volatile data storage solutions. (For further details please refer: Studies on resistive switching times in NiO thin films grown by pulsed laser deposition, P. Misra, V. K. Sahu, R. S. Ajimsha, A. K. Das and B. Singh; *J. Phys. D: Appl. Phys.* 50, 415106 (2017)

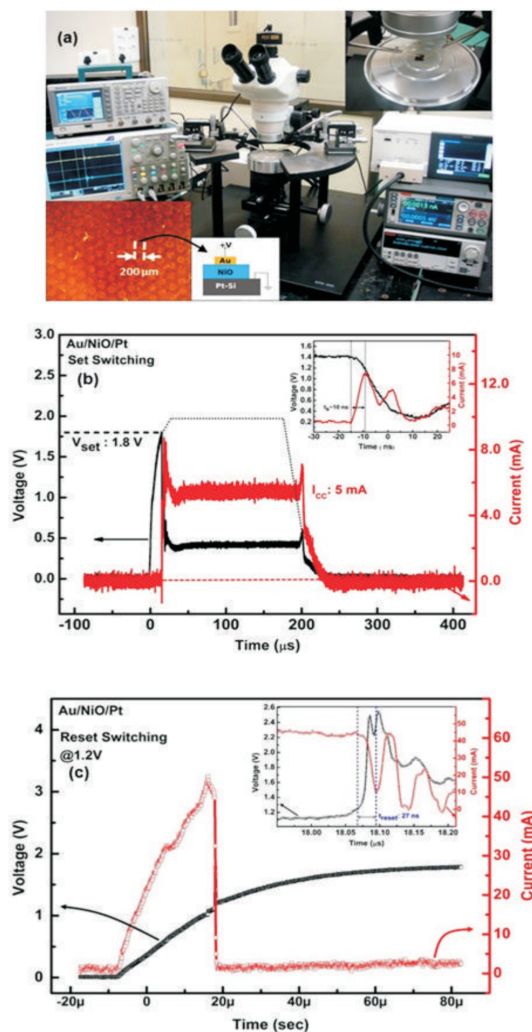

Fig. L.6.1: (a) Image of transient current-voltage measuring setup with schematic of Au/TiO_2/Pt device in inset. Variation in voltage pulse applied across the device and current flowing through device as a function of time during (b) set and (c) reset switching processes at voltages 1.8 V and 1.2 V, respectively. The zoomed view shown in inset of respective figures was used to estimate the switching time

Reported by:
P. Misra (pmisra@rrcat.gov.in) and colleagues