Lithionic two-terminal resistive switching devices with analog memory and a nanobattery architecture based on $Li_{1-x}CoO_2$ cathode, SiO_x electrolyte and $Li_{4+3x}Ti_5O_{12}$ anode

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Memristor technologies are emerging as the most viable successor to CMOS-based transistor technologies for the implementation of neuromorphic computing, due to their two-terminal design which allows the non-von Neumann architecting of bioinspired artificial neural networks (ANN's), enabling the reduction of the energy- and silicon "real-estate"- costs [1].
A new class of ion migration-based resistive switching (RS) devices, that rely on the electrochemical Li^+ migration to produce reversible changes in the device conductance, has shown potential as binary or analog memristors [2], and artificial synapses [3].
The insulator to metal transition of $Li_{1-x}CoO_2$ (LCO) during delithiation ($0 \leq x \leq 0.25$) has been utilized in thin film nanobattery devices based on LCO cathode, SiO_2 electrolyte and Si anode to produce multistate RS, through the reversible field-driven migration of Li^+ from the LCO cathode to the Si anode [4]. Recently, devices based on $Li_{4+3x}Ti_5O_{12}$ (LTO, $0 \leq x \leq 1$) with a Pt/LTO/Pt architecture have shown non-volatile RS with analog conductance modulation capabilities, through the electric field driven Li^+ migration which leads to a phase separation between insulating $Li_4Ti_5O_{12}$ and metallic $Li_7Ti_5O_{12}$ domains and the formation of conductive bridges between the two Pt electrodes [5].
Leveraging on mutually-beneficial electric field driven delithiation and lithiation of $Li_{1-x}CoO_2$ cathode and $Li_{4+3x}Ti_5O_{12}$ anode respectively in terms of conductance tunability, and the "zero"-strain property of LTO during lithiation in terms of endurance enhancement, the fabrication of Au/LCO/SiO_x/LTO/Pt RS nanobattery devices is hereby examined. Such devices are capable of non-filamentary, non-volatile, and analog RS with prolonged retention ($\sim 10^5 s$) and endurance ($\sim 10^4$ cycles). On the other hand, a small memory window ($I_{on}/I_{off} < 10$), strong potentiation/depression asymmetry, and indications of environmental-related degradation have been observed.

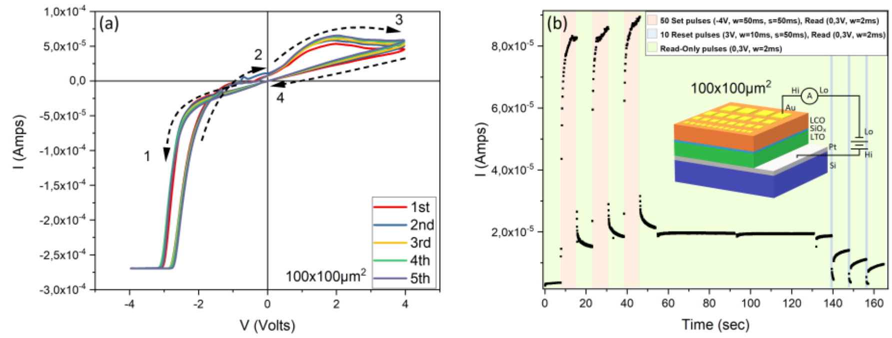

Figure 1: Current-Voltage characteristic curves of a typical Au/LCO/SiO_x/LTO/Pt device, showing reversible RS (a). Pulsed voltage characterization of this device showing non-volatile multistate conductance modulation (b).

References:

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