Compact Modeling of Trap-Assisted Tunneling in Bilayer VCM Devices

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Transition metal oxide-based resistive switching devices are promising candidates for nonvolatile memory and neuromorphic computing applications. In particular, bilayer valence change memory (VCM) devices combining a tunnel oxide and a conductive oxide such as $Pr_{0.7}Ca_{0.3}MnO_3$ (PCMO) enable improved switching uniformity and controllability [1,2]. Despite these promising characteristics, a comprehensive physical understanding of the charge transport and resistive switching mechanisms in such systems is still lacking. In this work, we developed a physics-based compact modeling framework to describe trap-assisted tunneling (TAT) conduction in bilayer W/WO_3/PCMO/Pt VCM devices. Two models, TAT-E and TAT-H, are implemented in MATLAB to capture electron- and hole-mediated transport, respectively. The proposed models successfully reproduce the experimental *I-V* characteristics and switching polarity, providing insight into the dominant transport processes. Parametric studies further demonstrate that switching kinetics are strongly influenced by oxygen vacancy concentration, attempt frequency, migration barrier height, and the permittivity contrast between the two oxide layers. These results provide a physically consistent modeling framework to guide the design of PCMO-based valence change memory devices for low-power and energy-efficient neuromorphic computing.

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[2] M. Buczek et al., Chem. Rev., 125(13), 6156–6202, 2025.