Investigation of Voltage Polarity-Dependent Switching and Carrier Conduction Mechanisms of Lead-Free STO-based Resistive Memory

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Abstract

This study investigates the polarity-dependent switching and carrier conduction mechanisms of lead-free perovskite strontium titanate (STO) resistive memory in a Cu/STO/n+-Si structure. The amorphous STO thin film, approximately 10 nm thick and deposited via RF sputtering, exhibits high thermal stability, high resistivity, and a high breakdown electric field. Research confirms that the device demonstrates stable bipolar resistive switching (RS) characteristics with a strong dependence on voltage polarity: the forming and set processes can only be triggered by a positive bias, which facilitates the migration of copper ions to form conductive filaments (ECM mechanism), while a negative bias is required for the reset operation to rupture these filaments. If the negative voltage exceeds -11 V, the device undergoes irreversible hard breakdown and permanently loses its insulating properties. Analysis of ln(I)-ln(V) curves reveals that the device follows the Ohmic conduction mechanism ($J \propto V$) at low electric fields and is controlled by space-charge-limited conduction (SCLC, $J \propto V2$) at high electric fields. Furthermore, the energy barrier at the n+-Si/STO interface effectively suppresses electron injection, reducing leakage current and enhancing data retention capability. This study highlights the potential of STO films for advanced memory-in-logic computing architectures that are high-speed, stable, and CMOS-compatible.

Index Terms

Resistive Random-Access Memory, Sputtering, Perovskite Materials