MATERIALS ENGINEERING
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"Synthesis and Electrical Behavior of VO2 Thin Films Grown on SrRuO3 Electrode Layers"

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ABSTRACT

Owing to the fascinating metal-insulator transition (MIT) in the vicinity of room temperature, vanadium dioxide (VO2) has attracted significant research interest in terms of material physics, synthesis, and device applications. Upon heating above ~340 K, VO2 undergoes an abrupt MIT showing several orders of resistivity drop, drastic changes in the optical properties, as well as a change in the crystal structure. Electric-field induced MIT (E-MIT) of VO2 is of particular interest for its potential applications in emerging electronic device paradigms. Previous studies on planar-type VO2 devices fabricated on sapphire or similar insulating substrates revealed that an electric field on the order of 10^5-10^6 V/cm is required to trigger the E-MIT. Therefore, a short gap between electrodes (L) is essential to realize switching under low voltage bias. The growth of VO2 films on conductive layers is a promising approach that is expected to reduce the voltage required for switching in vertical devices that is of interest to cross-bar type memory and neuromorphic devices.

In this study, VO2 films were grown on conducting oxide SrRuO3 (SRO) layers. Besides applications in magnetism, SRO is a widely studied template material to create multi-functional oxide heterostructures. Here, SRO buffered SrTiO3 (STO) (111) substrate was selected since the perovskite (111) surface with 3m symmetry offers lattice templating to promote the growth of high quality single-phase VO2. In addition, SRO buffered Si/SiO2 was selected for its compatibility with CMOS technology and to develop comparative understanding with polycrystalline VO2 film properties. The properties of VO2 films grown on SRO buffer layers, as well as thermally and electric-field induced MIT were systematically studied. Numerous growth experiments were conducted to identify the optimal growth conditions. Utilizing the current shunting associated with the conductive underlayer, E-MIT was investigated in both the in-plane and out-of-plane configurations. A distributed resistance network is proposed to predict the MIT behavior of VO2 grown on conducting layers with general applicability to understanding insulator-metal transitions.

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