Manganese Vanadium Oxide: First Epitaxial Thin Film and Photodetector

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High quality semiconducting oxide materials have shown potential for applications in optoelectronics owing to their excellent optical properties. Recently, there has been a focus on tertiary, transition metal oxides due to the large window available to tune their structural and optical properties by controlling the stoichiometry of the oxide. In this study, we present, for the first time, an epitaxial thin film of a novel spinel Manganese Vanadium Oxide (MVO) grown by pulsed laser deposition (PLD). First, we study the changes in structural properties of polycrystalline MVO caused by changing the deposition pressure and optimize the growth to achieve lesser polycrystallinity. Atomic force microscopy (AFM) for polycrystalline thin films show low RMS roughness of 1.36 nm and small globular structures for sample grown at low-pressure and as the deposition pressure is increased, a columnar growth is observed. The optical properties of these have been measured using Visible- NIR spectroscopy and optical bandgaps for polycrystalline samples show an increasing trend from 0.24 eV to 0.45 eV on increasing deposition pressure from 1.2×10⁻⁵ mbar to 2.5×10⁻³ mbar.

Next, we optimize the PLD conditions to achieve epitaxial MVO on STO substrate. The cubic epitaxial thin films of MVO were characterized by XRD using Reciprocal Space Maps (RSM) and pole figure measurements which show a cube-on-cube orientation for MVO on STO. Symmetric and asymmetric RSM depict the relaxed nature of MVO films with an excellent match between in-plane and out-of-plane lattice parameters of MVO. Structural parameters such as mosaicity and coherence lengths have been derived from RSM. X-ray photoelectron spectroscopy has been used to confirm the oxidation states of Mn and V in MnV₂O₄. The optical properties of MnV₂O₄ and the realization of epitaxial films on a technologically relevant substrate like STO make it a potential candidate for optoelectronic applications and we demonstrate a photodetector with epitaxial MVO in the IR region.

Figure 1. Figure shows the symmetric MVO (004) and asymmetric MVO (404) reciprocal space maps on STO substrates

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