First Growth and Characterization of KTaO₃ Thin Films Using Molecular-Beam Epitaxy

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Introduction

ABO₃-type perovskites can add novel functionalities and performance enhancement to electronics [1]. KTaO₃ (KTO) in particular has high spin-orbital coupling with electronic and structural similarities to SrTiO₃ (STO) which points to ferroelectricity KTO [2].

Molecular-beam epitaxy uses vacuum deposition of heated sources onto a substrate for epitaxial growth. KTO film growth has been dire due to volatile K-atoms and non-volatile Ta-atoms [3]. Oxide MBE offers absorption-controlled growth, high oxidation, enhanced thin-film crystal quality, independent growth parameters, and interfacial control. Interfacial control of KTO opens the door to several applications in spintronics, memory devices, and photovoltaics.

Data & Results

Based on the intensity of (100) KTO peaks and fringe character, 10.5nm KTO films derived from both a sub-oxide TaO₂ source and an e-beam Ta source yielded comparable crystallinity — with the sub-oxide films edging by just a small margin (confirmed by extremely similar rocking curves with narrow FWHM).

A 10μm AFM scan revealed a high concentration of impurities on the sub-oxide films compared to e-beam films (further shown in 2μm scan).

Previous literature suggests that these impurities are KO agglomerates [1].

Conclusions

This study has shown a successful growth of KTO using MBE, comparable crystallinity and differing surface character with e-beam and sub-oxide Ta heating methods, as well as full strain with (110) GSO substrates and partial strain with (110) DSO substrates. Compared to pulsed-laser deposition, MBE grown KTO exhibited better crystallinity, however different GSO substrates were used [4].

Future Work

- Additional RSM analyses with thinner films (further knowledge regarding compressive strain behavior and limitations)
- Ferroelectric behavior of MBE KTO thin films testing (point toward the usability/application of the material)

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References