Epitaxial growth and phase stabilization of Pyrochlore Iridate thin films on YSZ (111) oriented substrate

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ABSTRACT

Geometric frustration in a system creates a playground of unusual magnetic ground states and excitations, which leads to many exotic phenomena [1]. Interest and study of frustrated magnets have intensified recently and have provided new insights into the topological electronic states in those systems. The pyrochlore iridates ($R_2Ir_2O_7$; R rare-earth ion) family has emerged as a promising topological magnetic material that manifests in the Weyl semi-metal (WSM) state by first-principle calculations [2]. It stabilizes in all-in/all-out (AIAO) magnetic ground states that break time-reversal symmetry without reducing cubic lattice symmetry, thus making the system remarkably suitable for realizing topological states. An external perturbation excites the system to different magnetic states; spin-ice and monopole crystal states. In the magnetic state, the easy axis of rare-earth and Ir spin lies along the local direction. The role of rare-earth ions (higher magnetic moment) on the realization of WSM state, magnetic ground states, and excitations is not well explored. In probing the WSM state and stabilizing it in the ground state, it warrants that pyrochlore iridate is in single crystal or oriented thin film configuration. We deposited (111) oriented thin films of $R_2Ir_2O_7$ (R=Dy, Gd) on YSZ(111) substrates using pulsed laser deposition (PLD). We chose rare-earth Dy and Gd ions because of their high magnetic moments among the rare-earth family. Pyrochlore iridates exhibit metal-to-insulator transition (MIT) where Ir^{4+} orders in the AIAO state. We found that the Iridium concentration strongly influences MIT transition [3]. Reciprocal space maps (RSM) confirmed changes in in-plane lattice parameters caused by thin film deposition conditions, and the nature of resistivity variation with temperature reveals how annealing the films ex-situ can tune the MIT favourably. We confirmed epitaxial growth by probing the 3-fold symmetry of the in-plane (662) plane. A primary understanding has evolved through this study as a platform for exploring, in detail, the topological states of oriented $R_2Ir_2O_7$ thin films.

Keywords: Epitaxial growth, PLD, Metal-to-insulator transition (MIT), Weyl-Semimetal, AIAO ordering.

References

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