INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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SHORT ABSTRACT

The pursuit of advanced multifunctional materials has drawn significant attention to Rare Earth Iron garnets (RIGs) because of their remarkable magnetic, dielectric, and magneto-dielectric properties. This research focuses on the systematic investigation of magnetic and dielectric behaviors in RIG ceramics with the objective of understanding and tuning their multifunctionality for potential applications in microwave devices, spintronics, and energy storage systems. For this, a series of RIG systems based on Gadolinium, Samarium, and Dysprosium along with novel high entropy garnet ceramics containing multiple rare-earth cations were synthesized via the solid-state reaction route. The materials were thoroughly characterized for their phase purity, structural integrity, and microstructural features using techniques such as XRD, FESEM, TEM, Raman spectroscopy, and XPS. Magnetic measurements revealed ferrimagnetic ordering across all garnet systems along with intriguing phenomena such as spin reorientation transitions, magnetic compensation, and magnetization reversal. These transitions are linked to the interaction among Fe^{3+} ions and the substituted rare earth elements at different lattice sites. Additionally, magnetization reversal and negative magnetization were observed in specific compositions that indicates strong magnetic anisotropy and competing sublattice interactions. Dielectric studies demonstrated that these garnets possess a high dielectric constant with low loss. The impedance analyses reveal the contributions of grains and grain boundaries to the overall dielectric relaxation. The dielectric behavior in several compositions displayed a strong temperature dependence, and in selected systems anomalies were detected around magnetic transition temperatures, suggesting magneto-dielectric coupling. High-entropy garnet ceramics were also explored that shows promising multifunctional responses and enhanced stability. Therefore, this work offers valuable insights into the tunability of magnetic and dielectric properties in RIG systems through rare-earth substitution and compositional complexity. The observed multifunctional behaviors establish these materials as strong candidates for microwave devices and energy storage applications.