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Synergistic influence of yttrium substitution and sintering temperature on structural, microstructural, and magnetic properties of samarium iron garnet: a comparative study

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ABSTRACT

Samarium iron garnet (SmIG) and yttrium-substituted SmIG (YSmIG; $Sm_{2.5}Y_{0.5}Fe_5O_{12}$) were synthesized via a solid-state reaction route to investigate the effects of Y^{3+} substitution and sintering temperature on their structural, microstructural, and magnetic-property relationships. XRD analysis confirmed that Y substitution promotes garnet phase formation at a lower temperature compared to SmIG and enhances densification while suppressing grain growth, resulting in a refined and more homogeneous microstructure. The activation energy for grain growth increased from 41.14 to 45.86 kJ/mol with Y substitution, indicating restricted grain boundary mobility and inhibited diffusion kinetics. Despite the reduced grain size, YSmIG exhibits significantly enhanced saturation magnetization and magnetic permeability which contradict conventional grain size-dependent models. This behavior is quantitatively interpreted by considering the dominant reduction in magnetocrystalline anisotropy induced by non-magnetic Y^{3+} substitution, which outweighs extrinsic grain size effects. The results establish that intrinsic magnetic modifications dominate over microstructural constraints, providing new findings into tailoring high-permeability garnet ferrites for high-frequency applications. Furthermore, these results further indicate that Y functions as an efficient microstructural and magnetic modifier, enabling lower-temperature synthesis while delivering superior magnetic performance, thereby emphasizing the strong potential of YSmIG for spintronic applications.

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