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# Dependence of magnetic and microwave loss on evolving microstructure in yttrium iron garnet

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**Abstract**

The parallel magnetic and microwave loss dependence on microstructural evolutions in several polycrystalline yttrium iron garnet samples were studied in detail, focusing on the attendant occurrence of their relationships. In this study, polycrystalline YIG samples were synthesized by employing the mechanical alloying technique and sintering toroidal compacts at temperatures from 600 to 1400 °C. The samples were characterized for their evolution in crystalline phases, structure, microstructure, magnetic hysteresis parameters, microwave losses and electrical resistivity. The results showed an increasing tendency of the saturation magnetization with grain size, which is attributed to crystallinity increase in the grains. The *M–H* hysteresis loop results showed a transition from disordered-to-ordered magnetism which belongs to different magnetically dominant stages of formation. The starting appearance of room temperature ferromagnetic order suggested by the sigmoid-shaped loops seems to be dependent on crystallinity, phase purity and a sufficient number of large enough magnetic domain-containing grains having been formed in the microstructure. An increasing trend of transmission loss with grain size may be attributed to increment of loss contribution from hysteresis and domain wall resonance of the samples. The changes in crystallinity and microstructure, and the associated processes of microwave resonance and relaxation due to domain wall movements and damping of spin rotation contributes to the variations in transmission loss and ferromagnetic linewidth of the samples. The increased electrical resistivity while the microstructure was evolving is believed to strongly indicates improved phase purity and compositional stoichiometry.

## 1 Introduction

The general concern based on the need of developing high technological devices especially in magnetic and magneto-optical applications has been stimulated recent years. These applications usually require magnetic materials with high electrical resistivity, high magnetization and low magnetic loss due to their ability to be operated in high frequency range. Yttrium iron garnet (YIG; $Y_3Fe_5O_{12}$), both pure and with various dopants, is the most versatile magnetic material and most suitable for high frequency applications. It is categorized as a soft ferrimagnetic material where its magnetic properties are contributed by the net magnetic moment of $Fe^{3+}$ ions on octahedral and tetrahedral sites. Research on YIG was started since 1950s due to its superior characteristics i.e. low energy loss when used in microwave frequency range, having the smallest magnetic-resonance linewidth among other magnetic materials [1]. Furthermore, stoichiometric valency stability contributed by $Y^{3+}$ ions make this material the best choice in research and applications as compared to that of other soft ferromagnetic materials.

Recently, it has become known that magnetic nanostructures may have superior characteristics to those of micron-size grain microstructure due to their smaller length scales of physical phenomena in the nanosized grains. The dependence of magnetic properties on nanosized-particle YIG

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