Influence of aluminum substitution on microstructural, electrical, dielectric, and electromagnetic properties of sol-gel synthesized yttrium iron garnet (YIG)

ABSTRACT

Aluminum-substituted Yttrium iron garnet (Al-YIG) ($Y_3Al_xFe_{5-x}O_{12}$; x = 0.4, 0.8, 1.2, 1.6, and 2.0), samples were synthesized via an auto-combustion sol-gel technique. The obtained powder was heated at 950 °C, pressed into pellets, and sintered at 1200 °C. The sample microstructures were studied using field emission scanning electron microscopy (FESEM). The average grain size decreased from 0.46 μm at x = 0.4 to a minimum value of 0.33 μm at x = 2.0. The elemental composition of the samples was studied by energy dispersive x-ray (EDX), while the bulk density was measured by the Archimedes principle. Electrical and dielectric measurements were carried out using an Agilent impedance analyzer. Generally, the sample resistivity decreased with Al concentration. At 1 MHz frequency, the sample x = 0.4 has the highest resistivity of 2.19 × 10^5 Ωm, which decreases down to its minimum value of 1.75 × 10^4 Ωm at x = 2.0. The dielectric constant for all the samples decreased with frequency. For the sample x = 0.4, the ε'_r decreased from 49.03 at 40 Hz to 8.08 at 1 MHz. The dielectric loss tangent, tan δ, decreased with increasing frequency, while it increased with Al substitution. Permeability values were calculated from permittivity data. The real permeability decreased from 1263.12 at x = 0.4 to 6.96 at x = 1.2 and decreased down to 11.74 at x = 2.0. The high dielectric constant, low resistivity, and low loss values of the samples indicate their suitability for miniaturization of radio frequency devices, antenna, and filter resonators.