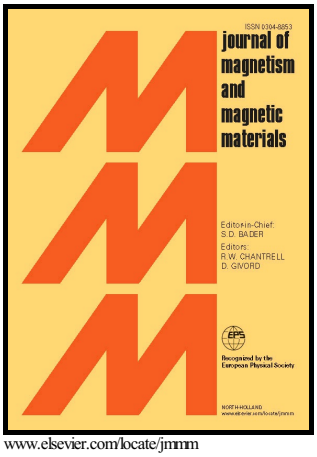

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Effects of La^{3+}-Zn^{2+} doping on the structure, magnetic, electrical, and dielectric properties of low temperature sintered Sr-hexaferrites

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Abstract

The $Sr_{1-x}La_xFe_{12-x}Zn_xO_{19}$ (x=0-0.3) hexaferrites with Bi_2O_3 additive were prepared by microwave sintering method at low sintering temperatures, and their crystal structure, microstructure, magnetic, electrical, and dielectric properties were studied. The results show that the pure M-type phase is obtained for the ferrites with $x \leq 0.2$. With x further increasing to 0.3, the multiphase structure is inevitably formed, where the $LaFeO_3$ phase coexists with the M-type phase. In the single phase region, the varied magnetic, electrical, and dielectric properties with La^{3+}-Zn^{2+} doping amount are well explained by the occupancy effects of La^{3+} and Zn^{2+} in magnetoplumbite structure. It is suggested that the Zn^{2+} ions replace the Fe^{3+} ions at $4f_1$ site with $x \leq 0.15$, but the substitution of Zn^{2+} for Fe^{3+} occurs at 2b site preferentially when the La^{3+}-Zn^{2+} doping amount exceeds 0.15.

Keywords: Hexaferrites; Low temperature sintering; Magnetic properties; Electrical transport; Polarization

1. Introduction

Lack of high-performance gyromagnetic ferrites hinders the development of LTCF (low temperature co-fired ferrite) circulators and isolators, which have important significance for the miniaturization and integration of microwave communication system such as the "satellite-satellite", "satellite-space", and "satellite-earth" systems [1-4]. As we know, the gyromagnetic ferrites used to prepare the nonreciprocal LTCF devices need to meet the basic conditions: (1) can be sintered at low temperatures (≤900 °C) compatible with low temperature co-fired ceramics systems [2]; (2) can provide good electromagnetic performance, which satisfies the demands of devices [5]; (3) can realize self-biasing or have at least a weak dependence on external magnetic field worked as the substrates of circulators and isolators, especially at high frequency bands [3]. It is noteworthy that the $BaFe_{12}O_{19}$ and $SrFe_{12}O_{19}$ based hexaferrites can provide relatively high saturation magnetization, magnetic anisotropy field, Curie temperature, and excellent electromagnetic performance in parts of microwave and millimeter wave bands. It strengthens the attraction on investigating their low temperature sintering characteristics as the most promising gyromagnetic ferrites for the integrated microwave LTCF circulators and isolators undoubtedly [5-8]. However, the obtained low temperature sintered $BaFe_{12}O_{19}$ and $SrFe_{12}O_{19}$ based hexaferrites have not exhibited satisfactory performance for the actual device applications at present, such as the intrinsic coercivity, self-biased field, gyromagnetic efficiency, and electromagnetic loss [9-13].

In our previous works, the low temperature sintered Sr-hexaferrites with La^{3+}-Co^{2+} and La^{3+}-Cu^{2+} substitution were successfully prepared by microwave-assisted synthesis route, and their magnetic, electrical, and dielectric properties were found to depend on the doping amount intensively [13-15]. Electrical transport and dielectric behaviors of the Sr-hexaferrites are correlated with the hopping of electrons between Fe^{2+} to Fe^{3+} at octahedral sites (12k, 2a, and $4f_2$) [16,17]. In fact, the substitution of Co^{2+} for Fe^{3+} occurs at the octahedral 2a and $4f_2$ sites, and the Cu^{2+} ions replace Fe^{3+} ions at $4f_2$ site too. Interestingly, the Zn^{2+} ions are suggested to replace the Fe^{3+} ions at tetrahedral $4f_1$ site and trigonal