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Synthesis of Ca^{2+} doped SrLa-ferrite powder through molten salt assisted calcination process

Li Yuping[1, 2*], Bao Daxin[3], Wang Zhangzhong[1, 2], Huang Ye[1, 2], Kong Bin[1, 2]

(1. School of Materials Science and Engineering, Nanjing Institute of Technology, Nanjing 211167, China; 2. Jiangsu Key Laboratory of Advanced Structural Materials anf Application Technology, Nanjing 211167, China; 3. Hengdian Group DMEGC Magnetics Co., LTD. Jinhua 322118, China;)

Abstract: Ca^{2+} doped SrLa-ferrite powder was synthesized through molten salt assisted method. The influence of Ca^{2+} doping on the microstructure and magnetic properties of SrLa-ferrite poweder was discussed. The results showed that non-agglomerated $Sr_{0.7-x}Ca_xLa_{0.3}Fe_{12}O_{19}$ ferrite powder with narrow particle size distribution could be synthesized by molten salt assisted calcination process. This powder exhibited excellent magnetic properties after eliminating the impurity phase through Ca^{2+} doping.

Key words: ferrite powder, grain growth, molten salt assisted method, ceramic process.

1. Introduction

Sr-ferrite ($SrFe_{12}O_{19}$) is an important permanent magnetic material with large magnetic crystalline anisotropy constant (K_1～3.5×10^6erg/cm^3) and high saturation magnetization (～74.3Am^{2}kg^{-1})[1,2]. It is widely used in various applications, such as microsized motors, loudspeakers, and actuators, etc., because of its excellent chemical stability and high performance-price ratio [3-5]. Sr-ferrite exhibits a magnetoplumbite structure, and its unit cell consists of two formula units with 64 ions on 11 different symmetry sites. The O^{2-} ions exist as closed packed layers stacked along the *c*-axis, with Sr^{2+} ions substitute in the hexagonal layer. The Fe^{3+} ions occupy five different sites: three octahedral sites (2a, 12k, and $4f_2$), one tetrahedral site ($4f_1$), and one trigonal bipyramidal site (2b) [6,7]. The properties of Sr-ferrites can be tailored via various substitutions of Sr^{2+} and Fe^{3+} by rare earth elements and metals. For example, rare-earth elements, such as La^{3+}, Ce^{3+}, Sm^{3+}, and Nd^{3+}, can be used to substitute for Sr^{2+}, whereas transition metals, such as Co^{2+}, Zn^{2+}, Mn^{2+}, Cu^{2+}, and Ni^{2+}, can replace Fe^{3+} [8-10]. However, in the conventional ceramic method, these substitutions require high temperature (≥1200℃) calcination, which leads to the formation of hard agglomerated particles. Therefore, a long-time ball milling process, which may cause an amorphous nature and inhomogeneous particle size, is necessary for producing sintered ferrites. Moreover, unsatisfactory ion substitutions, which are caused by changed binding energy and lowered ion diffusion, introduce impurity phases during calcination. For example, $LaFeO_3$, $CoFe_2O_4$, and hematite Fe_2O_3, etc., are usually detected in Sr-ferrites fabricated with a high La-Co concentration[11, 12].

Recently, a molten salt synthesis route has been developed to fabricate high performance ferrite[13,14]. Compared with the conventional ceramic process, the molten salt process involves markedly lower calcination temperature (800-1100℃) and therefore helps to prevent particle agglomeration and abnormal growth [15]. Nanoscale or micronscale ferrite particles can be fabricated through molten salt synthesis method.

In this study, Ca^{2+} doped SrLa-ferrite powder is prepared via molten salt synthesis method. It is worth noting that both La^{3+} and Ca^{2+} have similar ionic radii and valence to those of Sr^{2+}[16, 17]. Therefore, using La^{3+} or Ca^{2+} to substitute for Sr^{2+} is a workable approach to tailor the magnetic properties of Sr-ferrites. Previous studies have reported the synthesis of La^{3+} or Ca^{2+} substituted Sr-ferrites through various methods[16-21]. So far, however, the synthesis of La^{3+}-Ca^{2+} co-doped Sr-ferrites by using the molten salt method has not been reported. Herein, systematic variation of Ca concentration is carried out to study the influence of Ca^{2+} doping on La^{3+} solubility in $Sr_{0.7-x}Ca_xLa_yFe_{12}O_{19}$ ferrites. The La concentration is set to a moderate value (y=0.3) referring to previous reports[16-19]. The effects of Ca^{2+} doping on the microstructure and magnetic properties of SrLa-ferrites are studied