Journal of ELECTRONIC MATERIALS, Vol. 42, No. 4, 2013
DOI: 10.1007/s11664-012-2398-6

Synthesis of Low Coercive $BaFe_{12}O_{19}$ Hexaferrite for Microwave Applications in Low-Temperature Cofired Ceramic

VIVEK A. RANE,[1] SHER SINGH MEENA,[2] SURESH P. GOKHALE,[3] S.M. YUSUF,[2] GIRISH J. PHATAK,[1,5] and SADGOPAL K. DATE[4]

1.—Electronic Packaging Group, Centre for Materials for Electronics Technology (C-MET), Panchawati, Off. Pashan Road, Pune 411 008, India. 2.—Solid State Physics Division, Bhabha Atomic Research Centre (BARC), Trombay, Mumbai 400 085, India. 3.—Physical and Materials Chemistry Division, National Chemical Laboratory (NCL), Dr. Homi Bhabha Road, Pune 411 008, India. 4.—Department of Physics, University of Pune, Ganeshkhind, Pune 411 007, India 5.— email: gjp@cmet.gov.in

Polycrystalline M-type barium hexaferrite ($BaFe_{12}O_{19}$) samples have been synthesized by solution combustion route at different pH and calcination conditions in order to reduce the coercivity for microwave applications in low-temperature cofired ceramic (LTCC) substrates. Structural, morphological, and magnetic properties of $BaFe_{12}O_{19}$ were studied by x-ray diffraction (XRD), field emission scanning electron microscopy (FESEM), Raman spectroscopy, vibrating sample magnetometry (VSM), and Mössbauer spectroscopy. The formation of a single-phase hexagonal structure was confirmed by XRD. The Raman spectra reveal all characteristic peaks of $BaFe_{12}O_{19}$, illustrating the phase purity and crystal lattice symmetry of the synthesized material. Mössbauer spectra illustrate the existence of Fe^{3+} cations at all five crystallographic lattice sites. The microstructural features observed by FESEM disclose the growth of nanoregime particles into hexagonal platelet particles after calcination at temperatures from 800°C to 1200°C. The VSM results show a lower coercivity (1350 Oe to 3500 Oe) together with reasonably high saturation magnetization (55 emu/g to 60 emu/g) and a high bulk resistivity ($> 10^9$ Ω-cm) at room temperature. The dependence of magnetic and electrical properties on the preparation and processing conditions is also discussed.

Key words: Barium hexaferrite, LTCC, coercivity, Mössbauer spectroscopy, Raman spectroscopy

INTRODUCTION

Low-temperature cofired ceramic (LTCC) has been the technology of choice for three-dimensional (3D) integration of high frequency circuits. With continued interest in miniaturization, the next generation of inductive passives need to be integrated into the host packaging materials. Some of these devices include integrated inductors, filters, transformers, etc.[1,2] A need for integration has also been felt for nonreciprocal components, such as circulators, isolators, etc. While standalone devices are already in use, there are almost no reports on integration of these devices with LTCC. Very recently, there has been an attempt to integrate ferrite based microstrip junction circulators in LTCC.[3] While this report concentrates upon device properties, significant materials integration challenges persist. Specifically, optimization of magnetic properties for such applications is necessary.

$BaFe_{12}O_{19}$ hexaferrite is a well reported material that has been employed to fabricate nonreciprocal devices. These devices rely upon the intrinsic

(Received July 19, 2012; accepted December 20, 2012; published online February 1, 2013)