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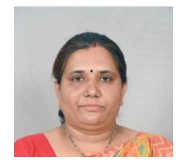
Structural, morphological, magnetic hysteresis and dielectric properties of cobalt substituted barium–lead hexagonal ferrites for technological applications



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ABSTRACT

M-type, $Ba_{0.4}Pb_{0.6}Fe_{12\text{-}x}Co_xO_{19}$ ($x = 0.00$, 0.10, 0.20, 0.30, 0.40) hexaferrites, synthesized using citrate gel auto combustion method, and heated at 950 °C, 4 h for lossless applications. XRD analysis shows the development of the M-phase, along with PbM and hematite. The microstructural analysis reveals the stacking clusters of hexagonally shaped platelets. TEM image and SAED pattern of $x = 0.3$ composition shows polycrystalline nature and formed particles observed to fused with neighbouring particles. M − H loops of all samples reveal hard magnetic behaviour and possess multi-domain structure. The maximum saturation magnetization of 55.427 A m^2/kg is observed in $x = 0.10$ composition and coercivity of prepared hexaferrites was found to vary from 0.058 T to 0.390 T. The cobalt substitution has a strong influence on the dielectric properties of prepared hexaferrites. The value of ac conductivity increases with cobalt substitution from $x = 0.00$ to $x = 0.10$, and followed by a reduction from $x = 0.10$ to $x = 0.40$. The same trend is observed for the dielectric constant. The low value of loss tangent for all compositions shows apt scope for lossless application.

1. Introduction

Hexferrites are materials of interest due to their applications in diverse fields; they are used for the preparation of permanent magnets because of their high Curie temperature, admirable chemical stability , and large-scale production [1–5]. These materials are also used for the development of anti-electromagnetic materials, radar, interference coating, microwave absorbers, etc. Among six types of hexaferrites, M-type hexaferrite possesses a magnetoplumbite structure and exhibits permanent magnetic property [6–10]. These magnetic materials attribute high coercivity with non-interacting, single domain particles that are randomly oriented [11,12]. The unit cell of M-type hexaferrite is made up of close packing of hexagonal stacked layers consisted of ten layers of oxygen ions. M-type hexaferrites are constructed from RSR*S* blocks; where * indicates the revolution of a block around hexagonal *c*-axis by 180̊ degree. S (spinel) block is made up of two oxygen layers, while R-block is formed from the three-layers arrangement with Ba ions. In M-type hexaferrite, Fe^{3+} ions can occupy on five possible interstitial sites: 2a, 12k, $4f_2$, $4f_1$, and 2b. Out of these five sites, 2a, 12k, and 2b possess parallel spins during the magnetically ordered state in their crystallographic *c*-axis, whereas $4f_1$ and $4f_2$ sites point in a reverse direction. In M-type hexagonal lattice, replacement of cations by other divalent or trivalent ions can lead to the modification of almost all the properties of materials [13]. Magnetic properties of the barium

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