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Magnetic and Electrical Studies in Al-Substituted Ferrites

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Abstract

Ba-Hexaferrites ($BaFe_{12}O_{19}$) with Al-substitution is found to exhibit M-type symmetry. The lattice parameters were determined on polycrystalline materials and magnetic, electrical and Seebeck co-efficient measurements have also been carried out. Substitution of Al^{+3} ion for Fe^{+3} ion reduces magnetization and hence Curie temperature. These differences were explained on the basis of exchange interactions within the sublattice. Activation energy in paramagnetic region is higher than that in ferrimagnetic region with n-type semiconductor for all ferrites. The values of H_K obtained are in the range of 6.8 – 16.9Koe.

INTRODUCTION

There had been numerous investigations on the hexagonal ferrite. The interest in this wide family is continuously growing due to their technological significance as permanent magnets, microwave device materials and magnetic recording heads. These applications need different magnetic and electrical specifications and in this view, several attempts have been made to modify the properties of hexagonal ferrites using different materials processing routes including foreign additives [1-2]. In BaM ferrites Fe^{+3} ions are distributed among five lattices sites [3] in different co-ordination and spin orientation, namely 2a, 2b, $4f_1$, $4f_2$ and 12K. The magnetic behavior of the compound has been explained as being mainly due to the interaction between the ions occupying these five sites. Due to several possible site distributions, various comparative magnetic interactions can arise in the lattice and in turn all these decide the magnetic properties.

In this investigation we report magnetic and electrical properties of Al-substituted Ba-ferrite prepared by usual standard ceramic process. The results are discussed on the basis of X-ray diffraction, magnetic susceptibility, electrical resistivity and Seebeck coefficient measurements carried out for all useful samples.

EXPERIMENTAL

The polycrystalline Al-substituted Ba-ferrite were synthesized by sintering the reactants mixed in stoichiometric ratio, i.e. $BaFe_{12-x}Al_xO_{19}$ with $2 \le x \le 8$. The specimens (after grinding and milling into fine powders) pressed as cylindrical pellets were sintered at 1250 °C for 120 hrs. The process was carried out repeatedly till single phase ferrite was obtained. The structure of the product was ascertained by X-ray diffractometry.

The electrical (AC) resistivities (ρ) of the cylindrical pellets (0.75 cm length and 1.22 cm diameter) was measured [4] with the help of impedance bridge. Thermoelectric measurement was carried out after sandwiching pellets between two copper rods from room temperature to 523K. Magnetic susceptibilities of the samples were measured by Gouy's method using mercury-cobalt-tetrathiocynate as calibrant [5]. The d. c. Susceptibility measurements were made in the temperature range 273-400K.

RESULT AND DISCUSSION

The replacement of Fe^{+3} ions has been investigated because of resemblance of the ionic radii. It is seen that the former ions are very easily replaced at any substitutional ratio without changing the crystal geometry. The lattice parameters 'a' and 'c' decreases linearly with substitution of Al^{+3} ion in Ba-ferrite. The numerical values of compositional data such as lattice constant and cell volume is reported in table 1. The crystallographic analysis of the data shows that the compounds are hexagonal. It is interesting to note here that the cell dimensions for Al-substituted Al-ferrites are close to that $BaFe_{12}O_{19}$, which is obvious as Fe^{+3} ions have larger ionic radii (0.64 Å) than Al^{+3} (0.50 Å) and hence 'a' is predominantly governed by larger Fe^{+3} ions. A persual of the structure shows that 'c' is more susceptible to stoichiometric changes than 'a'.

The electrical resistivity of polycrystalline Al-substituted barium ferrites has been measured from 300-500 K. The logarithmic resistivity for the