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Electrical studies of lithium–aluminate ferrite ceramics

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Abstract : In the present investigation four lithium aluminate ferrite ceramics with chemical composition $Li_{0.5}\ Fe_{0.5+x}\ Al_{12-x}\ O_{19}$ ($2<x<5$) have been synthesised with a view to study the effect of substitution on the structural and electrical properties. All the ferrites extribit M-type symmetry with space group $P6_3/mmc$. The dc conductivity measurements were carried out over the temperature range 300-800 K. Seebeck co-efficient studies were made, so that the conductivity of these ferrites could be discussed. Activation energy of the compounds were found in between 0.50 to 0.73 ev. Electrical conduction in these ferrites were explained on the basis of Verway model.

Keywords : Synthesis, electrical conductivity, seebeck co-efficient.

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1. Introduction

With a view to study the conduction mechanism in ferrites the electrical properties like electrical conductivity, dielectric constant, thermoelectric power as a function of composition and temperature have been studied by us [1-2]. In continuation of this work, it was thought desirable to undertake for the first time a study of the dependence of the electrical conductivity of the mixed lithium ferrites on the composition and temperature with magnetic susceptibility measurement carried out from room temperature to 800 K and result of these studies are presented in this paper. In addition, the substitutional effect on composition and structure have been reported for reviewing the crystal symmetry.

2. Experimental details

The samples with chemical composition $Li_{0.5}\ Fe_{0.5+x}\ Al_{12-x}\ O_{19}$ (x=2, 3, 4 5) were synthesised by standard ceramic technique by taking Li_2O, Fe_2O_3, Al_2O_3 in stoichiometric proportions. Li_2O oxide was carefully dehydrated before the mixing procedure. After grinding the mixtures under acetone for 6 hr, powders were fired at 1300°C for 100 hr. The phases of final samples were verified by X-ray diffractometry using Ni-filtered copper radiations. The mean grain size of the polycrystalline sample was in the range of 30 to 50 nm.

The magnetic susceptibility of the samples were measured by Gouy's method using mercury tetra-thiocynate cobaltate [$Hg\ Co(CNS)_4$] as a calibrant [3]. The dc susceptibility measurements were made in the temperature range 300-500K. All the samples studied showed paramagnetic behaviour.

The electrical conductivity of the samples was measured using LCR-bridges [Megaohmmeter Model RM 160/3 (BPL India) and Digital LCR meter VLCR-176 (Varanashi Electronics)]. Pellets were prepared by mixing 5% Polyvinyl acetate (PVA) as a binder under 10 tonnes/inch pressure. Initially pellets were heated at 300°C for 5 hours and then at 1200°C by gradual rise in temperature. The final sintering was carried out for 3 hours and the sample were furnace cooled. A thin layer of silver paste was applied over the crack free pellet for good electrical contacts and measurements were carried out from room temperature to 800K. Thermoelectric measurements were carried out after sandwitching thick pellets between two copper rods from room temperature to 493 K.

3. Result and disussion

In the present work lithium aluminate substituted hexaferrites were introduced with general chemical formula expressed as $Li_{0.5}\ Fe_{0.5+x}\ Al_{12-x}\ O_{19}$ with $2<x<5$. The ions in BaM compounds, can be replaced partially by Al^{+3} or completely by Li^{+1} and a combination of Fe^{+3} and Al^{+1} ions without changing crystal lattice symmetry. In all the specimens, substituted ions would be chosen to keep electrical neutrality and to have similar ionic radii. In these ferrites aluminium plays a important role in property variations. XRD technique is used to confirm the formation of hexagonal M-structure of the compounds belonging to SG : $P6_3/mmc$ (No. 194). Due to resemblance of ionic radii of Fe^{+3} and Al^{+3} ions, the ferrite ions were replaced by Aluminium. It is seen that the former ions are very easily replaced at any substitutional ratio without changing the crystal structure. The lattice parameter