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X-ray, electrical conductivity, magnetic and infrared studies of the system $Co_{2-x}Ge_{1-x}Fe_{2x}O_4$

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Abstract. X-ray, electrical conductivity, magnetic hysteresis and IR studies for the system $Co_{2-x}Ge_{1-x}Fe_{2x}O_4$ were carried out. All the compounds, $0 \leqslant x \leqslant 1$, showed cubic symmetry. X-ray intensity calculations, magnetic hysteresis measurements and IR studies indicated the presence of Ge^{4+} at tetrahedral, Co^{2+} at octahedral and Fe^{3+} at both the sites. The activation energy and threshold frequency decreased with increasing value of x. The compounds with $x \leqslant 0{\cdot}5$ are p-type and those with $x \geqslant 0{\cdot}75$ are n-type semiconductors. Magnetic hysteresis indicated that all the compounds are ferrimagnetic except for $x=0$ which is antiferromagnetic. The shapes of χ/χ_i vs T plots, high H_c values and J_R/J_s ratios showed that all the compounds except $x=0$ exhibit single-domain behaviour. Curie temperature, T_c increased with increasing Fe^{3+} ions. The probable ionic configuration for the system is suggested as $Ge^{4+}_{1-x}Fe^{3+}_x[Co^{2+}_{2-x}Fe^{3+}_x]O^{2-}_4$.

Keywords. Spinel; electrical conductivity; mobility; magnetic hysteresis; coercive force; threshold frequency; cation distribution.

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1. Introduction

Oxidic spinels show interesting structural, electrical and magnetic properties. In these compounds the properties are controlled by the nature of the ions, their charge and site distribution amongst tetrahedral and octahedral sites. Several workers (Landolt-Börnstein 1970; Jain and Darshane 1983; Kulkarni *et al* 1985) have reported the solid solutions of ferrites by substituting suitable ions at tetrahedral and octahedral sites.

The compound Co_2GeO_4 possesses a normal spinel structure (Romeijn 1953), while $CoFe_2O_4$ is inverse (Jonker 1959) or partly inverse (Prince 1956; Sawatzky *et al* 1968, 1969). The ionic configuration of $CoFe_2O_4$, therefore, requires further investigation. This paper gives the results of our studies on the system $Co_{2-x}Ge_{1-x}Fe_{2x}O_4$ by x-ray, electrical conductivity, magnetic hysteresis and IR spectroscopic studies to arrive at the probable ionic configuration. Recently it has been pointed out (Radhakrishnamurty and Nanadikar 1979; Nagarajan and Radhakrishnamurty 1981) that magnetic hysteresis and initial susceptibility studies at various temperatures can help to distinguish between multi-domain, single-domain and super-paramagnetic behaviour. Therefore, an attempt has been made to use such studies to determine coercive force, Curie temperature and the magnetic domain behaviour of the compounds of the system.