

Structural and Electrical Switching Properties of Cr³⁺ Substituted Cd-Co Ferrites

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Abstract. Polycrystalline ferrite samples with general formula Cd_xCo_{1-x}Fe_{2-y}Cr_yO₄ (x = 0.80, 0.85, 0.90, 0.95 and 1.00; y = 0.1) were prepared by standard ceramic method and characterized by XRD, IR and SEM techniques. The electrical switching was investigated at the room temperature. The X-ray analysis confirms the formation of single phase cubic spinel structure. The lattice constant increases with increase in Cd²⁺ content. The crystallite size of the samples decreases with increases in Cd²⁺. The IR study shows two absorption bands around 400 cm⁻¹ and 600 cm⁻¹ corresponding to octahedral (ν₁) and tetrahedral (ν₂) sites, respectively. The values of ν₁ and ν₂ decrease with increase in Cd²⁺. The SEM study shows that the grain size of all the samples decreases with increase in Cd²⁺. The required electrical switching field decreases with increase in the Cd²⁺ content. It decreases with decrease in grain size.

Keyword: Cd-Co ferrites; Structural Properties; Electrical switching.

INTRODUCTION

Cobalt ferrite is an inverse spinel structure and cadmium ferrite has a normal spinel structure [1]. The trivalent substations (Gd³⁺ and Cr³⁺) for iron have been reported [2]. Current Controlled Negative Resistance (CCNR) type of electrical switching at room temperature was observed in various spinel ferrites such as Cr and Al doped nickel ferrites [3, 4], Ti doped Mn-Zn ferrites [5], Cr³⁺ substituted Cd-Co ferrites [2] and Lithium ferrites [6]. The conductivity is switching between conduction and instability region in the initial phase. The slow switching in the final phase is due to CCNR type was observed [3].

In the present communication, we report structural and electrical switching properties of Cr³⁺ substituted Cd-Co ferrites.

EXPERIMENTAL

Polycrystalline spinel ferrites with general formula Cd_xCo_{1-x}Fe_{2-y}Cr_yO₄ (x = 0.80, 0.85, 0.90, 0.95 and 1.00; y = 0.1) were prepared by the standard ceramic method. The starting materials were AR grade cadmium oxide, cobalt oxide, chromic-tri-oxide and ferric oxide. These materials were weighed in the required stoichiometric proportion, presintered at 873K for 10 hr, sintered at 1273K for 24 hr. The pellets were final sintered at 1273K for 2 hr. The heating and cooling of the samples were carried out at 353K per hr.

The XRD patterns were recorded with Cr-Kα radiation on Philips PW-3710 X-ray powder diffractometer. FTIR spectrum was recorded on Perkin-Elmer spectrum one (USA). The SEM study was carried to analyze microstructure of fractured surfaces of the pellets on JEOL JSM 6360 SEM model

(Japan) at 5000X magnification. The grain size was calculated by linear intercept method. The electrical switching was recorded at room temperature with dc voltage of 0-600V from Aplab high voltage power supply.

RESULTS AND DISCUSSION

The X-ray diffraction patterns of all the samples under investigation are presented in Fig 1. The patterns confirm the formation of single phase cubic spinel structure and. The XRD patterns for cadmium ferrite agree with JCPDS card number-02-0975. The calculated values of lattice constant are presented in table.1. From this table it can be noticed that the lattice constant increases with increase in Cd²⁺. This increment is due to substitution of smaller ions (Co²⁺, 0.82Å⁰) by slightly larger ions (Cd²⁺, 0.97Å⁰). The crystallite size is also presented in table 1. The crystallite size decreases with increases in Cd²⁺. Similar results are reported by Nikumbh *et al.* [7].

The IR spectra presented in Fig.2 show two major absorption bands near 400 and 600cm⁻¹ corresponding to octahedral (ν₁) and tetrahedral (ν₂) sites, respectively. The values of ν₁ and ν₂ for all samples under investigation are presented in table.1. It is seen that ν₁ and ν₂ decrease with increase in Cd²⁺ content [7]. The typical micrograph of one of the samples presented in Fig.3 shows that the morphology of the particles is almost spherical and regular in shape and the particles are uniformly dispersed. From table.1 it can be seen that the grain size decreases with increase in Cd²⁺ content.

The plots of current vs electric field for all the samples under investigation are presented in Fig.4. The CCNR type of electrical switching is observed [2-

4] in all the samples. It is that the electrical switching field decreases with increase in Cd^{2+} content. The current has passed through instability conduction region and entered into an extremely high conductivity region i.e. the conductivity has switched between two regions of conduction and instability [2-4]. Table 1, it can be noticed that the switching field decreases with decrease in grain size. Similar results reported by Babbitt *et al.* [6].

When the switching cycle of the all sample was repeated after two weeks, the reduction in the field required for switching was observed.

CONCLUSIONS

The X-ray diffraction analysis confirms the formation of single phase cubic spinel structure of Cr^{3+} substituted Cd-Co ferrites. The Lattice constant of all samples increases with increase in Cd^{2+} content. The crystallite size and grain size of the samples decrease with increase in Cd^{2+} content. The values of absorption bands ν_1 and ν_2 decrease with increase in Cd^{2+} content. The grain size and electrical switching field decreases with increase in Cd^{2+} content.

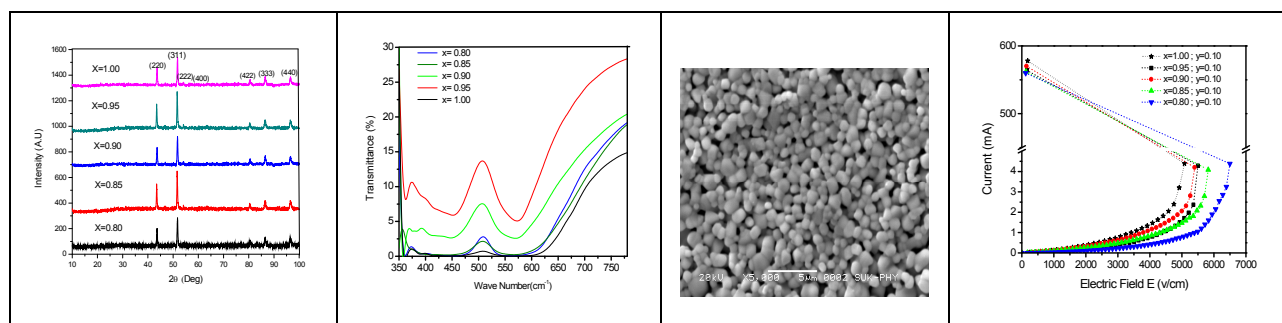


FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

XRD, IR, SEM and I-E characteristics of $\text{Cd}_x\text{Co}_{1-x}\text{Fe}_{2-y}\text{Cr}_y\text{O}_4$ ($x = 0.80, 0.85, 0.90, 0.95, 1.0$ and $y = 0.1$)

TABLE 1. Structural and switching properties of Cr^{3+} substituted Cd-Co ferrites

Cd^{2+} Content (x)	Cr^{3+} content (y)	Lattice constant	Crystallite size (D) nm	Grain size (μm)	Electrical field (E) V/cm	Electrical field After 15days (E) V/cm	IR Absorption band (cm^{-1})	
							ν_1	ν_2
0.80	0.10	8.729	51.1	1.45	6700	6600	575	450
0.85		8.731	46.2	1.30	5600	5550	570	441
0.90		8.735	39.4	1.10	5500	5300	568	427
0.95		8.739	37.3	1.00	5200	5100	563	425
1.00		8.748	34.3	0.90	5000	5000	561	420

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