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# HUMIDITY SENSING CHARACTERISTICS OF CADMIUM FERRITE

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**ABSTRACT**

The cadmium ferrite was synthesized by oxalate co-precipitation method. The crystal structure and surface morphology were examined by X-ray diffraction, SEM and FT-IR techniques, respectively. The resistivity of the samples decreases with increase in percentage relative humidity (%RH). The decrease is found to be exponential for 40 to 80 %RH and linear for 80 to 90%RH. The sensor shows sensitivity at low humidity range of 40 to 80%RH. The response and recovery time of Cd sensor shorter than Mg sensor.

**Keywords:** Cd ferrites; Grain size; Humidity sensitivity; Response time.

## 1 INTRODUCTION

Cadmium ferrite ($CdFe_2O_4$) has a normal spinel structure [1]. The spinel ferrite structure $AB_2O_4$ contains eight tetrahedral coordinated sites and 16 octahedral coordinated sites for divalent and trivalent cation occupancy. The normal spinel structure has A-sites occupied by divalent cations and B-sites occupied by trivalent cation [2]. In $CdFe_2O_4$ divalent cadmium ions ($Cd^{2+}$) occupy tetrahedral sites, but trivalent iron ions ($Fe^{3+}$) occupy octahedral sites. Cadmium ferrite despite its non-magnetic behavior has attracted interest in last decade due to potential application as a gas sensor [3] and photo catalysis [4].

Humidity plays an important role in human life in many ways, drastically influencing the working efficiency. Therefore the measurement and the control of humidity are quite necessary [5]. The monitoring of water content estimate are practically essential in various fields, including air quality detection, inflammable gas inspection, food, healthcare, clinical, biological sectors and defense [6]. Polycrystalline ferrites can be used as good humidity sensor elements. Bagum *et al.* [7] observed that the Cu-Zn ferrites with low doping of $MgCl_2$ could be a suitable candidate for humidity sensing. Similar results are reported by Sundaram *et al*. [8]

In this communication, we report the humidity sensing properties of cadmium ferrite.

## 2. MATERIAL & METHODS

Polycrystalline powder of $CdFe_2O_4$ was prepared by the oxalate co-precipitation method using sulphates. The detail method of synthesis for sample under investigation is reported elsewhere [9].

The co-precipitated product was dried to get powder which was pre-sintered at 700$^{o}$C for 6 h in air. The pre-sintered powder was milled in an agate mortar with acetone as a base and sintered at 1050$^{o}$C for 5 h and pressed in the form of pellet at pressure of 7 ton/cm$^2$ for 5 minutes under hydraulic press. Polyvinyl alcohol (2 % wt) was used as a binder. The polycrystalline ferrite powder under investigation, were characterized by X-ray powder diffraction on Philips PW-3710 X-ray diffractometer with $CuK_\alpha$ radiation ($\lambda$= 1.5424 A$^{o}$). Each sample was scanned in range 20$^{0}$ to 80$^{0}$ with a step size of 0.02$^{0}$. The SEM micrographs of fractured were recorded on

scanning electron microscope, JEOL – JSM 6360 model, Japan. The FT-IR absorption spectra of powered samples were recorded in the range 350 $cm^{-1}$ – 800 $cm^{-1}$, on a Perkin-Elmer model: Spectrum one FT-IR spectrometer by KBr pellet technique.

The humidity testing of sample was conducted in a microprocessor controlled humidity chamber (Aditi Associate make, Model ASC-10, Mumbai) in the range of 40%RH to 90%RH in steps of 10%RH. The resistance of sensor (pellet) was measured by two probe method with a picometer. The measurement was performed at the temperature $27^0$C.

## 3. RESULTS AND DISCUSSION

### 3.1 Characterization

The structural analysis (XRD, SEM and FT-IR) of Cd ferrites under investigations is already reported [9]. The XRD pattern of $CdFe_2O_4$ is presented in Fig. 1 and confirms the formation of cubic spinel structure. The crystallite size is determinied by Debye Sherrer formula foe most intense (311) peak of cadmium ferrite. The lattice constant (8.71), crystallite size (30.4nm) and grain size (1.2 µm) of all the samples under investigation is listed in table I. From this table, it is observed that lattice constant of prepared by oxalate co-precipitation method are very close to those reported for samples prepared by ceramic method [10]. The grain size is smaller than that sample prepared by sol-gel combustion method and ceramic method [11]. The microphotographs and FT-IR spectra of $CdFe_2O_4$ is presented in Fig. 2 and Fig. 3 respectively. FT-IR show two major absorption bands in the frequency range 350–800 $cm^{-1}$. The grain size is smaller than that prepared by ceramic method.

**TABLE 1: Humidity Sensing parameters of $CdFe_2O_4$.**

| Crystallite size (nm) | Lattice constant ($A^0$) | Grain Size (µm) | Humidity sensitivit (MΩ/%RH)y | Response Time (Sec) | Recovery Time (Sec) |
|---|---|---|---|---|---|
| 30.4 | 8.71 | 1.2 | 200 | 170 | 285 |

### 3.2 Humidity sensing

Variation of resistivity with humidity (% RH) of Cd ferrite sensors is presented in Fig. 4. The sample exhibits a significant decrease in the electrical resistivity with increased relative humidity in the range of 40 to 90 %RH. The highest decrease in resistivity is observed between 40 to 70% RH. The resistivity of these sensor elements follows the equation [12],

$$\rho = \rho_0 \, e^{-SRH} \qquad (1)$$

where, S - humidity sensitivity and RH - relative humidity.

The humidity is surface adsorption phenomenon in which higher humidity sensitivity is attributed to higher surface area of the samples. The fall in resistivity between 40 to 90 %RH for all the samples is due to increase in electrical conductance or charge carriers. At low humidity, water adsorption on surface is dominant factor for electrical conductance. The higher surface area would provide more sites for water adsorption and produce more charge carriers for electrical conductance [13]. All the samples show decrease in resistivity with increase in %RH indicating the conductance occurs at the grain surface is due to water adsorption of molecule [14]. At low humidity levels chemiabsorption takes place leading to formation of two hydroxyl group with charge transports occurring by hopping mechanism [15]. At higher %RH physisorption of water molecules and electrolytic conduction takes place. The adsorption of humidity on the surface decreases the resistivity due to the increase of charge carriers, protons, in the ferrite and water system. The adsorption of water on the surface of the material leads to the dissociation of hydrogen ions.

The resistivity of the cadmium ferrite is very sensitive in a wide humidity range, between 40% to 70%RH. The sensitivity of humidity sensor has been defined as the change in resistivity (Δρ) of sensing element per unit change in relative humidity

(%RH). Kotnala *et al.* [16] reported increase in sensitivity for lithium substituted magnesium ferrite in the range 10-80%RH. All the samples are humidity sensitive in lower humidity range.

The response (time to attain a steady state value of the resistivity) and recovery characteristics of $CdFe_2O_4$ system to relative humidity between 40 to 90%RH are shown in Fig. 5. The response/recovery time of all samples lies between 170-285 s.

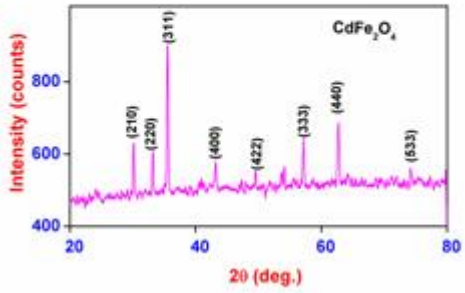


**Fig. 1 XRD of $CdFe_2O_4$.**

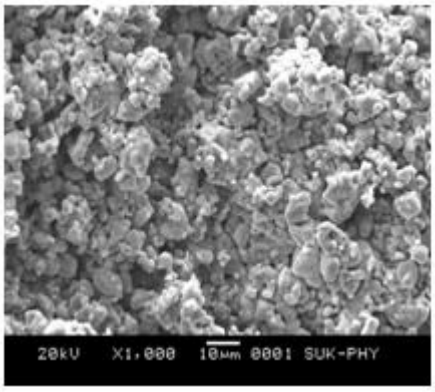


**Fig. 2 SEM photograph of $CdFe_2O_4$.**

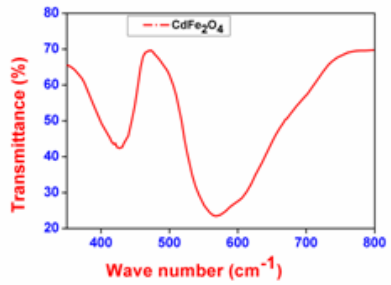


**Fig. 3 FT-IR of $CdFe_2O_4$**

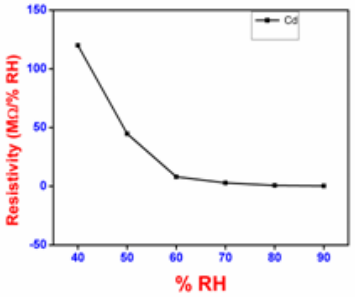


**Fig. 4 Resistivity of $CdFe_2O_4$**

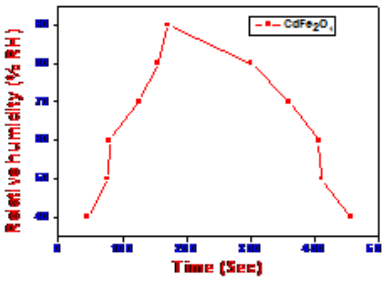


**Fig. 5 Humidity Response/recovery characteristics of $CdFe_2O_4$**

## 4. CONCLUSION

The XRD confirms single phase cubic spinel structure of cadmium ferrite. Nanocrystalline ferrite materials of size 30.40 nm were obtained by co-precipitation method. The grain size is smaller than that sample prepared by sol-gel combustion method and ceramic method. FT-IR shows two absorption bands in high and low frequency range. The resistivity of the cadmium ferrite is very sensitive in a wide humidity range, between 40% to 70%RH. The sensor is humidity sensitive in lower humidity range. The response/recovery time of all samples lies between 170-285 s.

## 5. REFERENCES

[1]. Mahamoud MH, Abdallas AM, Hamdeh HH, Hikai WH and Taher SM, *J. Magn. Mag, Mater.*, 2003, (263)3: 269-274.

[2]. Valenzula R, Magnetic Ceramic, Cambridge Melbourne, 1994, 81.

[3]. Gadkari AB, Shinde TJ and Vasambekar PN, AIP Conference Proc., 2015, (1665)59: 50001-2.

[4]. Heris KN, Bhojya Naik HS, Prashant Kumar PN and Viswanath R, *Catal. SciTechnol.*, 2012, (2): 1033-1039.

[5]. Yadav BC, Srivastava R, Sing M, Kumar R and Dwivedi CD, *Sensors and Transducers J.*, 2007, 85(11): 1765-1770.

[6]. Feng YS, Wang B, Feng Y, He and Zhang T, *Sensors and Actuators A*, 2009,(152):104-109.
[7]. Begum N, Gafur MA, Bhuiyan AH and Saha DK, *Phys. Status Solidi A,* 2010, (207)4: 986-992,
[8]. Sundaram R, Raj ES and Nagaraja KS, *Sens. Actuators B: Chem.,* 2004, 99(2-3) : 350-354.
[9]. Gadkari AB, Shinde TJ and Vasambekar PN, *Rare matel ,* 2010, (29)2: 168-173.
[10]. Vishwanathan B and Murthy VRK, *Ferrites Materials, Science and Technology,* Norosa Pub. House New Delhi (India), 1990, 6.
[11]. Sutka A, mezinskis G, Jakovles D and Korsaks V, *J. Australian Ceram. Soc.,* 2013, 49(2): 136-140.
[12]. Rezlescu E, Rezlescu N, and Popa PD, *Phys. Stat. Sol., (c)* 2004, (1)12: 3636-3639.
[13]. Chou KS, Lee TK, Liu FJ, *Sens. Actuators B: Chem.,* 1999, (56)(1-2): 106-111,
[14]. Sears WM, *Sens. Actuators B:Chem.,* 2000, (67)(1-2) : 162-172,
[15]. Qu W, Wlodarski W, Meyer JU, *Sens. Actuators B: Chem.,* 2000, (67)(1-2) : 76-82.
[16]. Kotnala RK, Shah J, Sing B, Kishan H, Sing S, Dhawan SK, Sengupta A, *Sensors and Actuators B: Chem,* 2008, (129)2: 909-914