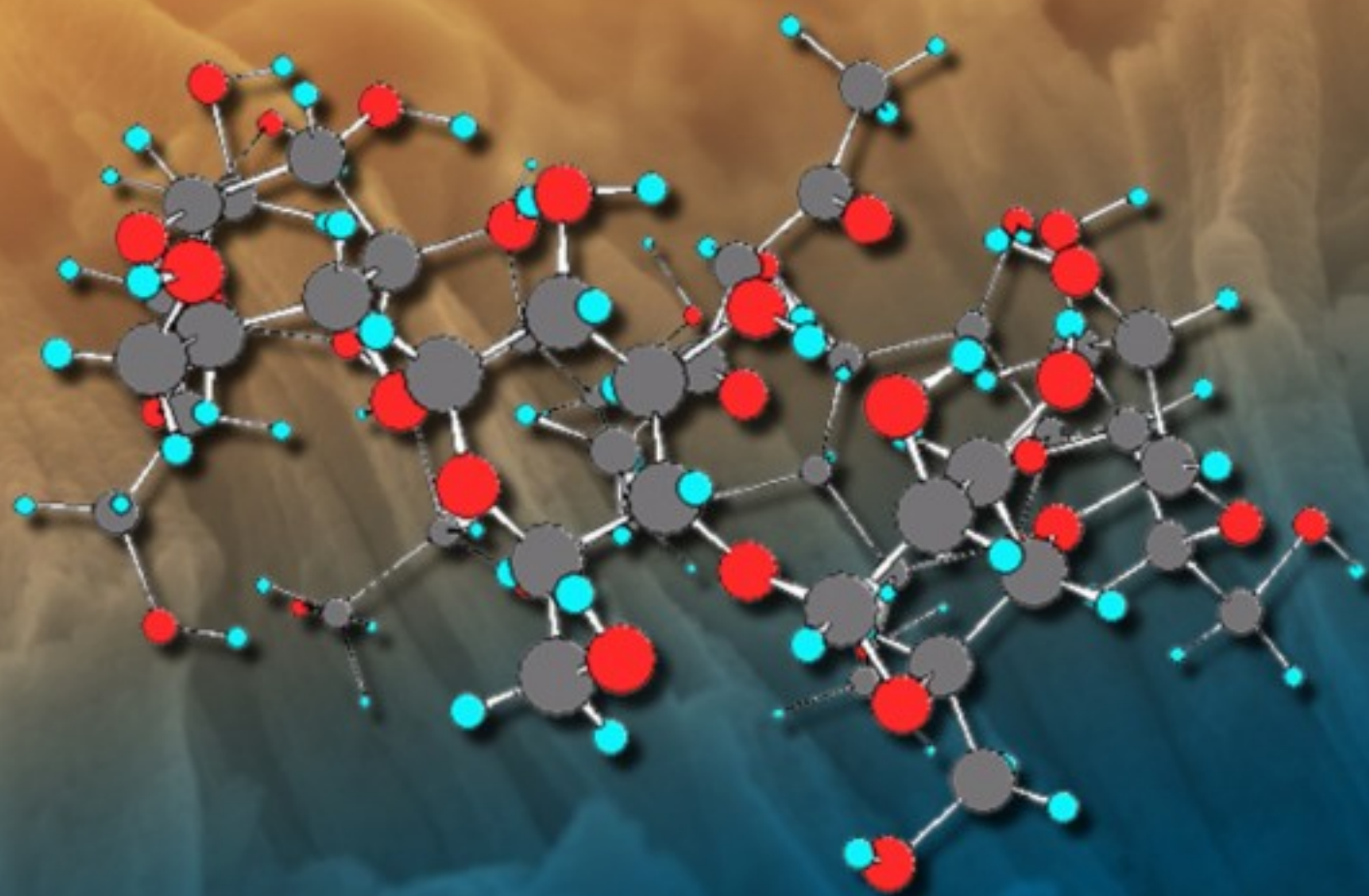


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Y^{3+} Added Nanocrystallite Mg-Cd Ferrite LPG, Cl_2 and C_2H_5OH Sensors

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Abstract: 5 % Y^{3+} added $Mg_{1-x}Cd_xFe_2O_4$ ($x = 0, 0.2, 0.4, 0.6, 0.8$ and 1) nanocrystallite samples were synthesized by oxalate co-precipitation method and studied for gas sensing properties. These samples were characterized by X-ray diffraction (XRD), scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FT-IR). The XRD confirms cubic spinel structure with orthoferrite ($YFeO_3$) secondary phase. The crystallite size lies in the range of 28.86 to 32.06 nm. The SEM study revealed that the average grain size is in the range of 0.37 to 0.69 μm . The FT-IR spectra showed two strong absorption peaks around 350-800 cm^{-1} . The highest sensitivity to LPG and Cl_2 (85 % and 79 % respectively) appears for Y-Mg ferrite sensor at 218 $^{\circ}C$. The highest sensitivity (89 %) to ethanol appears for Y-Cd ferrite sensor at 325 $^{\circ}C$. The $Y-Mg_{0.6}Cd_{0.4}Fe_2O_4$ sensor shows good sensitivity to LPG followed by Cl_2 and ethanol (82 %, 77 % and 70 % respectively) at 190 $^{\circ}C$. The addition of 5 % Y^{3+} in Mg-Cd ferrites enhances sensitivity and reduces response-recovery time and operating temperature. The sensing properties for LPG, Cl_2 and ethanol change with the operating temperature, composition, porosity and grain size. Copyright © 2012 IFSA.

Keywords: Chemical synthesis, Gas sensor, Sensitivity, Response/Recovery time.

1. Introduction

Semiconductor metal oxide with general formula MFe_2O_4 have been investigated for both oxidizing and reducing gases [1-2]. Recently spinel ferrites [3-6] and perovskites [7, 8] have been tested as gas

sensors. Spinel Mg ferrite is used as catalyst [9] and humidity sensor [10]. Cadmium and magnesium ferrites are n-type semiconductors [11, 12]. Xiangfeng *et al.* [3] studied gas sensing property of zinc ferrite. They found that the ferrite shows highest sensitivity to CO, C₂H₂, LPG and C₂H₅OH at 375 °C and to petrol at 340 °C. The sensitivity of sensor depends on gas concentration. The response and recovery time at 375 °C are 30 s and 45 s respectively. It is believed that the smaller powder size corresponds to higher sensitivity due to large specific surface area. In this case gas sensing mechanism is surface controlled type. The gas sensitivity is relative to grain size, surface state, oxygen adsorption and lattice defects. Sandu *et al.* [4] reported nanocrystalline Co-Mn ferrite is sensitive to CO gas. Lee *et al.* [5] synthesized nano powder of nickel ferrite by pulse wire discharge method. The sensitivity for Cl₂ was studied with samples synthesized at 100 to 200 Torr with 360 J discharge energy. The maximum sensitivity was found at 280 °C and 350 °C for samples synthesized at 100 to 200 Torr respectively. They also found that the sensitivity is a function of chlorine concentration for both samples. Nanorods and nanocubes of nickel ferrite were prepared by hydrothermal method by Xiangfeng *et al.* [6]. The results of nanorods of nickel ferrite show sensitivity and selectivity to triethylamine. The nanocubes of nickel ferrite exhibited opposite behavior in the atmosphere of reducing gases.

The gas sensing is surface phenomenon of gas solid interaction where the resistance of ferrite semiconductor changes by adsorption of gases. The ferrite material surface hold various oxygen species such as OH⁻, O_{ad}²⁻, O_{2ad}⁻ and O⁻. Their number and distribution also play important role in the gas sensing property [12-14]. The nanoparticle size enhances the gas response of material [4, 6]. The nano size material has number of advantages such as high sensitivity, short response/recovery, apart from conventional gas sensors [6, 15]. The development of gas sensor is essential for safety requirement in homes and industry for detection of LPG and hazardous gases. Different methods such as ceramic, sol-gel, combustion and co-precipitation have been applied for preparation of ferrite materials. Recently chemical methods are used for preparation of nanocrystalline particles.

However, no information is available in the literature regarding gas sensing properties of rare earth ions added nanocrystalline Mg-Cd ferrites. It is expected that the substitution of small amount of yttrium for Fe³⁺ ion on B-site plays significant role in improving gas sensing properties of Mg-Cd ferrites. Therefore, it was decided to synthesize nanocrystalline Y³⁺ added Mg-Cd ferrites and to study their gas sensing properties.

2. Experimental

5% Y³⁺ added Mg_{1-x}Cd_xFe₂O₄ (x = 0, 0.2, 0.4, 0.6, 0.8 and 1.0) spinels were synthesized by the oxalate co-precipitation technique using high purity sulphates. The method of synthesis of samples under investigation is reported [16]. The precipitates were dried and presintered at 700 °C for 6 h in air. The presintered powder was milled and sintered at 1050 °C for 5 h. The sintered powder was again milled to have fine powders. The sensor elements (13 mm diameter pellets) were compacted by pressing the sintered powder in die with pressure of 7 tones/cm² under the hydraulic press. The pellets were finally sintered at 1050 °C for 5 h.

The X-ray diffraction (XRD) patterns were recorded in the range of 20-80° using CuK_α radiation (λ= 1.5424 Å) (Philips PW-3710 X-ray powder diffractometer) at room temperature. The size of the crystallites was calculated by using Debye Scherrer equation. The microstructure of fractured pellets was studied with a scanning electron microscope (JEOL – JSM 6360 model, Japan). The IR absorption spectrum of powdered samples was recorded by using KBr pellet technique in the range of 350 cm⁻¹ to 800 cm⁻¹ (Perkin-Elmer FT-IR spectrum one spectrometer).

For gas sensing measurements, the ferrite sensor elements were placed on heater in a glass chamber [17]. Two conducting silver foils were used to form ohmic contacts on the face of a pellet sensor (Fig. 1).

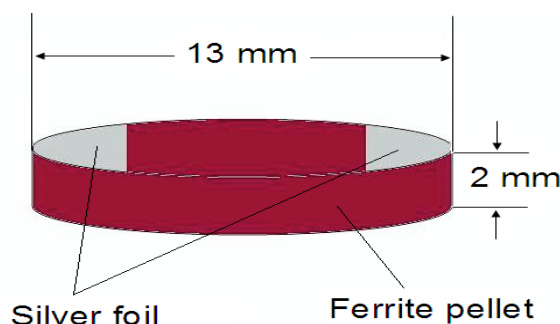


Fig. 1. Design of ferrite sensor with silver foil.

The DC electrical resistance was measured by a two-probe method with a digital picometer (DMM-111, Scientific instrument Rookee). The test gases were injected with high precision syringe into the glass chamber. The measurements were carried in the temperature range of 100 °C to 400 °C. The operating temperature was measured with the well calibrated chromel alumel thermocouple located in close proximity of the sensor. The resistance of the sensor element in air (R_a) and in the presence of the test gases (R_g), LPG, chlorine and ethanol was calculated by recording the current through the element at different temperatures. The sensor elements were subjected to heat treatment at 100 °C for 5 minutes after each change of the test gas to get their initial structure and thermal stabilization. The sensitivity of each sensor element was calculated by using the relation [18],

$$S(\%) = \frac{\Delta R}{R_a} \times 100 = \frac{|R_a - R_g|}{R_a} \times 100 \quad (1)$$

3. Results and Discussion

3.1. Structural Analysis

A typical XRD pattern of Y^{3+} added Mg-ferrite, which confirms cubic spinel structure with orthoferrite ($YFeO_3$) secondary phase, is presented in Fig. 2. The XRD results show the formation of nanocrystalline material. The average crystallite size of all the samples is in the range of 28.86 to 32.66 nm. The lattice parameter increases with increase in Cd^{2+} content. The SEM image of typical sample is presented Fig. 3. The micrograph shows porous microstructure containing irregular shaped aggregates of particles. The grains in all the samples are of submicron size. Many large and small pores are located at the junction of the agglomerations. The pores are intergranular. The intergranular porosity increases with increase in Cd^{2+} content and Y^{3+} addition in Mg-Cd ferrites. The average grain size of the samples lies in the range 0.37 μm to 0.69 μm . The grain size increases with Cd^{2+} content and decreases with Y^{3+} addition in Mg-Cd ferrites. The typical FT-IR spectra for Y^{3+} added $Mg_{0.6}Cd_{0.4}Fe_2O_4$ system presented in Fig. 4 shows strong absorption peaks around 350–800 cm^{-1} corresponding to stretching vibrations of tetrahedral (ν_1) and octahedral (ν_2) group complexes. They are observed in the frequency range of 563 to 576 cm^{-1} and 435 to 472 cm^{-1} respectively. The structural analysis of Y^{3+} added Mg-Cd ferrites under investigation is already reported [16]. For ready reference,

the structural parameters such as crystallite size, lattice parameter, grain size, porosity, v_1 , v_2 are listed in Table 1.

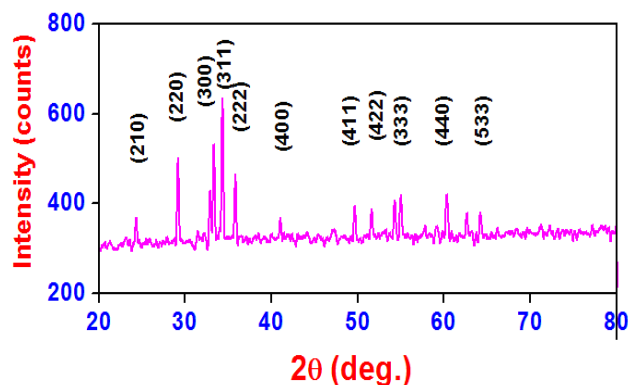


Fig. 2. Typical X-ray diffraction pattern of 5 % Y^{3+} added $MgFe_2O_4$ system ($x = 0$).

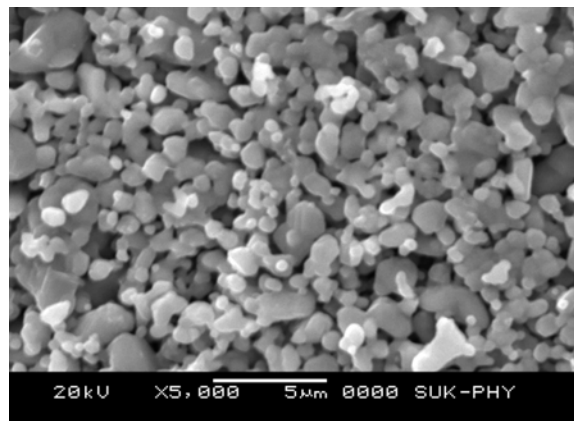


Fig. 3. SEM micrograph of 5 % Y^{3+} added $CdFe_2O_4$ system ($x = 1$).

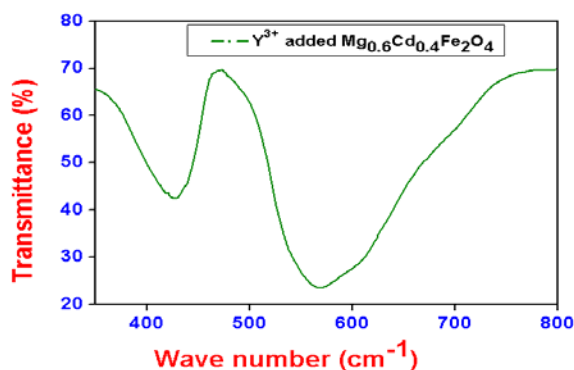


Fig. 4. Typical FT-IR spectra of 5 % Y^{3+} added $Mg_{0.6}Cd_{0.4}Fe_2O_4$ system ($x = 0.4$).

Table 1. Gas sensing parameters of 5% Y^{3+} added $Mg_{1-x}Cd_xFe_2O_4$ ($x = 0, 0.2, 0.4, 0.6, 0.8$ and 1) system.

Cd ²⁺ content x	Lattice constant (Å ^o)	Crystallit e size (nm)	Grain Size (μm)	Porosity %	Operating temperature (°C)	Sensitivity (%)		
						LPG	chlorine	ethanol
0	8.37	30.07	0.374	6.04	218	85	79	62
0.2	8.38	31.96	0.506	10.47	197	85	75	65
0.4	8.39	32.06	0.566	16.19	190	82	77	70
0.6	8.45	30.47	0.542	18.64	215	67	71	77
0.8	8.50	30.88	0.652	22.06	236	47	46	83
1.0	8.70	28.86	0.691	19.35	325	45	41	89

3.2. Gas Sensing Characteristics

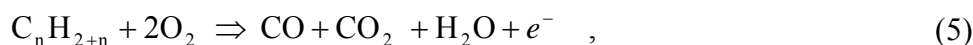
The gas sensitivity of sensors is greatly influenced by operating temperature. We have investigated the temperature dependent behavior of Y-Mg-Cd ferrite sensors for LPG, chlorine and ethanol at 100–400 °C. In absence of reducing/oxidizing gases, the electrons are removed from conduction band

of Y-Mg-Cd ferrite sensor by the reduction of O₂, resulting in formation of adsorbed O₂⁻, O⁻ and O²⁻ species on the surface, decreasing the conductance (increase in resistance) of Y-Mg-Cd ferrite sensor [14]. Depending upon the temperature, O₂⁻, O⁻ and O²⁻ are stable below 100 °C, between 100 and 300 °C and above 300 °C respectively [13, 19]. The formation of O²⁻ that is directly incorporated in to lattice occurs above 597 °C [20]. For n-type semiconducting materials an increase in resistance is observed, while decreased resistance is observed for p-type material.

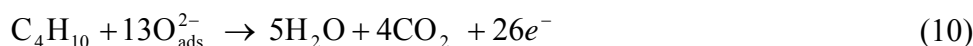
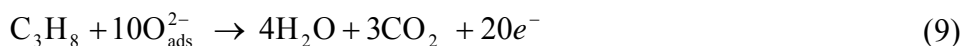
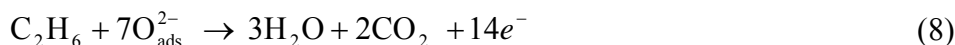
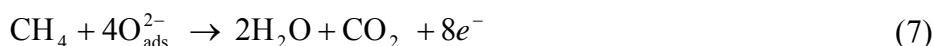
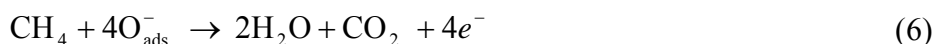
The gases can be split in to two groups namely reducing and oxidizing. When Y-Mg-Cd sensor is exposed to reducing gases such as LPG and ethanol, they react with chemisorbed oxygen releasing electron back to conduction band giving decreased resistance. The general reaction for reducing gases on the surface of ferrite sensor with oxygen species O⁻ and O²⁻ are given below [13, 21],



i) The exposure of the ferrite sensor element to LPG results in reaction with chemisorbed oxygen. After interaction with hydrocarbons (C_nH_{2n+2}) of LPG the adsorbed oxygen is removed and gaseous species and water vapour are formed. The reaction of LPG with chemisorbed oxygen can be given as [22],

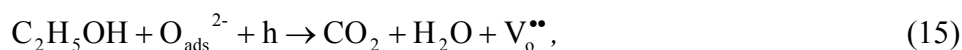
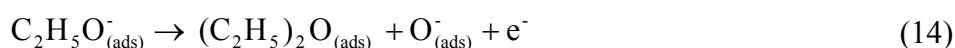
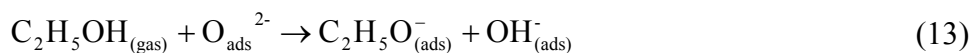
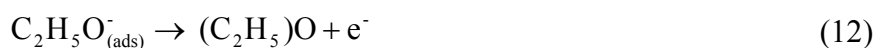
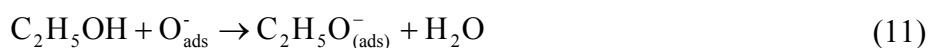


where C_nH_{2+n} represents various hydrocarbons of LPG. The release of electrons to the conduction band in the reactions of hydrocarbons such as CH₄, C₂H₆, C₃H₈, C₄H₁₀ with adsorbed O⁻ and O²⁻ are given as [13, 23],



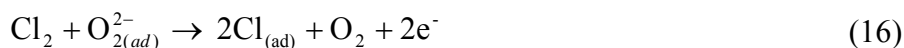
The reactions show that the concentration of electrons on the surface increases increasing conduction band electrons of Y-Mg-Cd ferrite sensor giving decreased resistance [13, 23].

ii) When ethanol is introduced, it reacts with adsorbed O⁻ and O²⁻ and giving increased electrons in the conduction band of sensor resulting in decreased resistance. The possible reactions on the surface of the sensors can be given as [24, 25],



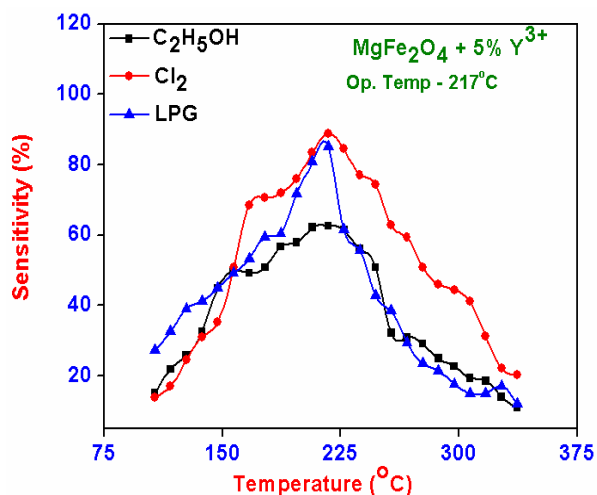
where $\text{V}_\text{o}^{\bullet\bullet}$ is the doubly charged oxygen vacancy, h is the hole.

iii) On exposure to the sensor element, chlorine reacts with metal oxides to form chlorides. It might react with or displace lattice oxygen at the interface or might sorbs onto surface oxygen vacancies. It's reactions on the surface of the sensor elements are given as [26, 27],

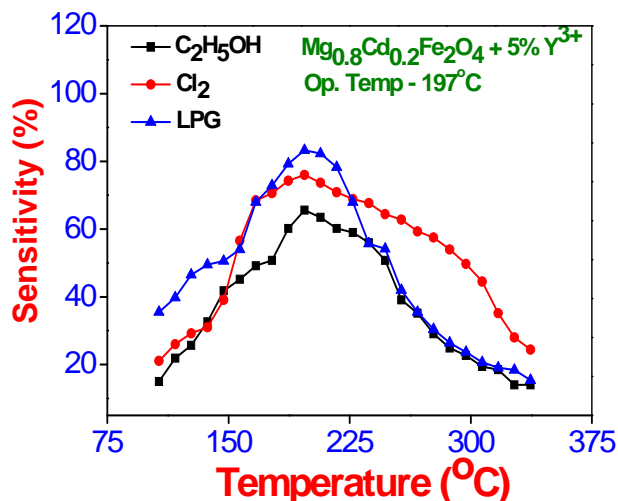


where o is the species occupying the lattice oxygen site, V_o is the oxygen vacancy and x is the denotes neutrality. The reactions (16) and (17) represent electron donation to the conduction band of Y-Mg-Cd sensor indicating decreased resistance. Thus the chlorine surface reaction mechanism discussed by Dawson *et al* [26] is favorable for chlorine sensing in Y-Mg-Cd ferrite sensor.

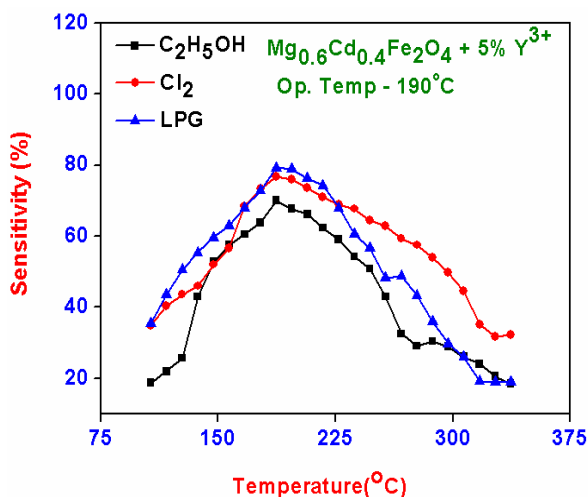
The plots of sensitivity versus temperature for Y-Mg-Cd ferrite sensors are presented in Fig. 5(a-f). From this figure it is seen that the sensitivity of all the sensors presents a trend of increase- maximum-decay to various gases with increase in operating temperature. The difference in operating temperature for various gases can be attributed to their oxidation by different oxygen species [28]. The highest sensitivity to LPG and Cl_2 (85 % and 79 % respectively) appears for Y-Mg ferrite sensor at 218 °C. The highest sensitivity to ethanol appears for Y-Cd ferrite sensor at 325 °C. From this figure it can be further noticed that Y-Mg_{0.6}Cd_{0.4}Fe₂O₄ sensor shows good sensitivity to LPG followed by Cl_2 and ethanol (82 %, 77 % and 70 % respectively) at 190 °C. At low temperature the surface reaction is limited by the rate of chemical reaction and at high temperature it is limited by diffusion rate [29]. Thus the lower sensitivity at low temperature can be expected as the gas molecule does not have enough thermal energy to react with the surface adsorbed oxygen species O_2^- . i.e. the reaction rate between the target gas and O_2^- is essentially low [28]. The increase in sensitivity with increased operating temperature can be attributed to sufficient increase in thermal energy of gas molecules to overcome the activation energy barrier of the surface reaction. The temperature corresponding to peak value is function of gas, chemical composition, additives and catalyst [29]. This temperature is referred to be operating temperature. The reduction in sensitivity after maximum is due to the difficulty in exothermic gas adsorption at higher temperature [30].



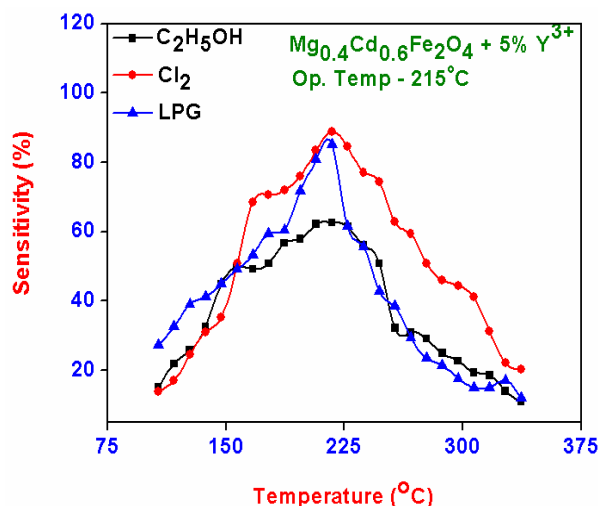
(a) 5 % Y³⁺ added MgFe₂O₄.



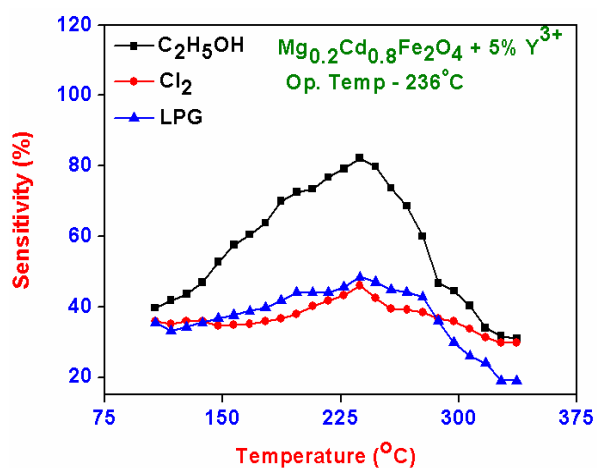
(b) 5 % Y³⁺ added Mg_{0.8}Cd_{0.2}Fe₂O₄.



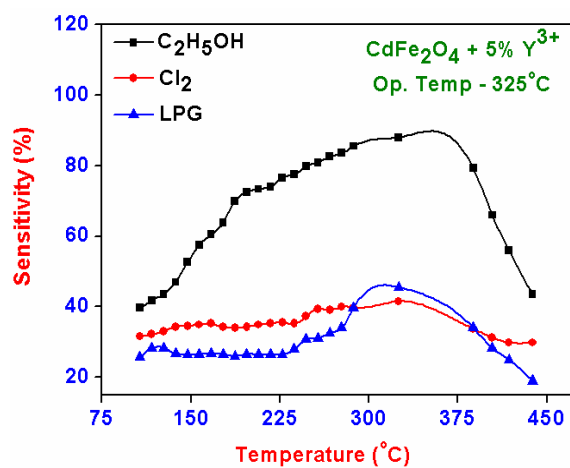
(c) 5 % Y³⁺ added Mg_{0.6}Cd_{0.4}Fe₂O₄.



(d) 5 % Y³⁺ added Mg_{0.4}Cd_{0.6}Fe₂O₄.



(e) 5 % Y³⁺ added Mg_{0.2}Cd_{0.8}Fe₂O₄.



(f) 5 % Y³⁺ added CdFe₂O₄.

Fig. 5. Variation of sensitivity as a function of operating temperature of 5 % Y³⁺ added Mg_{1-x}Cd_xFe₂O₄ system.

The variation of gas sensitivity with Cd^{2+} content in 5 % Y^{3+} added Mg-Cd ferrites is presented in Fig. 6. From this figure it can be seen that, the sensitivity decreases for LPG and Cl_2 and increases for $\text{C}_2\text{H}_5\text{OH}$ with increase in Cd^{2+} content. The trend observed in sensitivity is similar to that for Mg-Cd ferrites [17]. With increasing Ni content in Ni-Zn ferrite, Kazin et al [15] reported decreased sensitivity for NH_3 while increase in it for ethanol. Fig. 6 shows that $\text{Y-Mg}_{0.6}\text{Cd}_{0.4}\text{Fe}_2\text{O}_4$ sensor shows good sensitivity to all test gases. This ferrite has the largest grain size and the higher porosity than Y-Mg ferrite. The figure also shows that Y-Cd ferrite is the most sensitive sensor to ethanol. The improvement is related to the interaction of hydroxyl groups OH^- with porous ferrites. This group acts as a reducing agent generating free electrons into the semiconductor ferrites increasing the conductivity [31]. This higher sensitivity of Y-Cd ferrite for ethanol is observed to be two times larger than that for LPG and chlorine. This could be explained by a stronger interaction between ethanol molecules and Y-Cd ferrite components. The higher operating temperature of Y-Cd ferrite sensor is due to the smaller specific area and lower surface activity of this sensor, resulting in weaker interaction between test gas and sensor surface [12].

The higher sensitivity of Y-Mg-Cd ferrite sensors than Mg-Cd ferrite sensors to the test gases under investigation is attributed to [14, 17].

- i) Formation of secondary phase on the grain boundaries that reduces grain size [16]. The smaller grain size samples thus have higher surface area leading to higher sensitivity to gases [32].
- ii) Porous structure promotes the increase in sensitivity. The gas will easily penetrate into the internal part of the porous giving a large change in the resistance (large sensitivity).

The gas sensing property of Sn and Mo substituted Mg ferrites is studied by Doroftei *et al.* [21, 33]. They related the gas sensitivity with change in porosity and grain size (specific surface area).

The variation of operating temperature (for LPG, Cl_2 and ethanol) and saturation magnetization with Cd^{2+} content for 5 % Y^{3+} added Mg-Cd ferrites is presented in Fig. 7. From this figure it is seen that, the operating temperature for all test gases decreases up to $x = 0.4$ and increases thereafter for further increase in Cd^{2+} content. The minimum value of the operating temperature is observed for the sensor for which the saturation magnetization is highest. Thus the addition of Y^{3+} in Mg-Cd ferrites reduces the operating temperature and improves the gas sensitivity. The reduction in operating temperature could be attributed to large surface area, smaller grain size and change in composition [14].

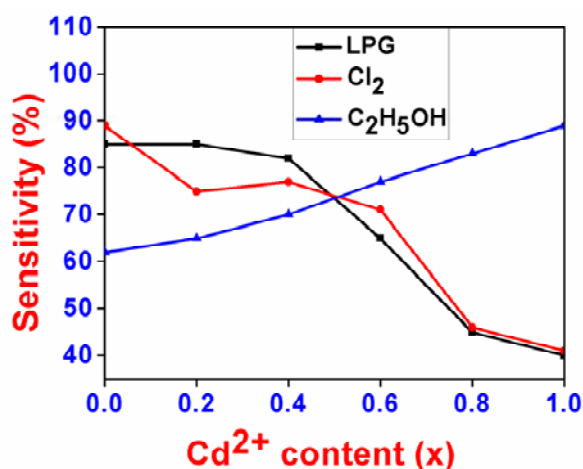


Fig. 6. Variation of gas sensitivity with Cd^{2+} content in 5 % Y^{3+} added Mg-Cd ferrites.

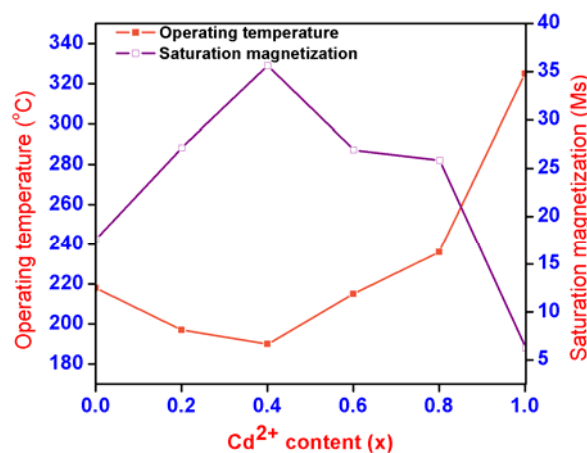
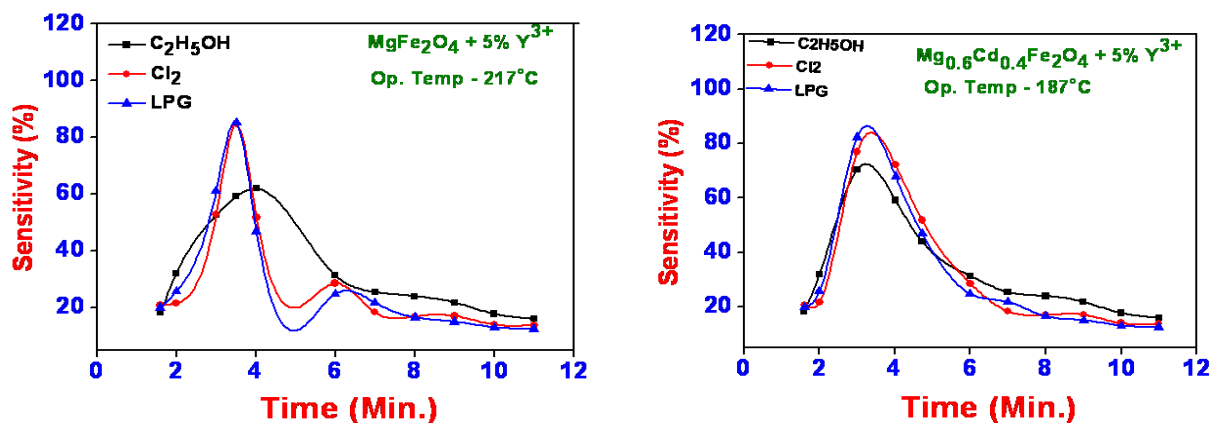


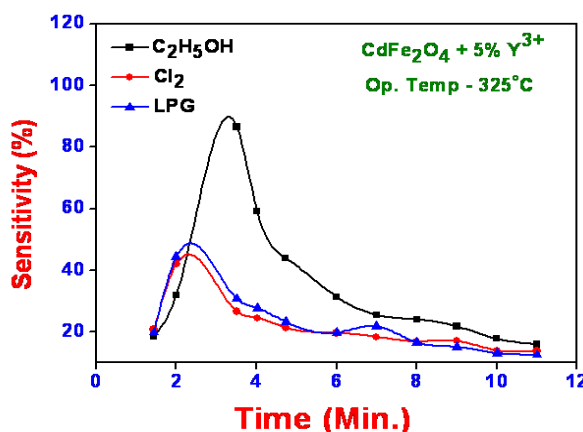
Fig. 7. Variation of sensitivity with operating temperature, saturation magnetization (Ms) with Cd^{2+} content in 5 % Y^{3+} added Mg-Cd ferrites.

The response characteristics of 5%Y³⁺ added MgFe₂O₄, Mg_{0.6}Cd_{0.4}Fe₂O₄, Mg_{0.2}Cd_{0.8}Fe₂O₄ and CdFe₂O₄ sensors for test gases under investigation are presented in Fig. 8(a, b, c). The response time (the time required for the gas sensitivity to attain 90 % of its maximum value) is about 215 s for Y-Mg ferrite, 180 s for Y- Mg_{0.6}Cd_{0.4}Fe₂O₄, and 150 s for Y-Cd ferrite. The recovery time (the time required to fall the sensitivity to 10 % of its maximum value) is longer, about 200-300 s for all ferrite sensors. The smaller response of Y-Cd ferrite is due to the highest porosity of these ferrites. The response and recovery times of the sensors to other test gases showed similar results.



(a) 5 % Y³⁺ added MgFe₂O₄.

(b) 5 % Y³⁺ added Mg_{0.6}Cd_{0.4}Fe₂O₄.



(c) 5 % Y³⁺ added CdFe₂O₄.

Fig. 8 Response and recovery characteristics of 5% Y³⁺ added Mg_{1-x}Cd_xFe₂O₄ system. (x = 0, 0.4, 0.8 and 1).

4. Conclusions

5 % Y³⁺ added Mg_{1-x}Cd_xFe₂O₄ sensors were synthesized by oxalate co-precipitation method and tested for LPG, chlorine and ethanol. The XRD confirms biphasic and nanocrystalline nature of the samples. The micrographs show irregular shaped aggregates of particles. The intergranular porosity increases with increase in Cd²⁺ content and Y³⁺ addition. FT-IR shows strong stretching vibrations corresponding to tetrahedral and octahedral group complexes. The sensitivity of the sensors increases with increase in Cd²⁺ content for LPG and chlorine, while decreases for ethanol. The response toward LPG, chlorine and ethanol is found to increase with decrease in grain size and increase in porosity. The

operating temperature is lower in 5 % Y^{3+} added Mg-Cd ferrite sensors than that in Mg-Cd ferrite sensors. The Y-Cd ferrite has shorter response and recovery time. The gas sensitivity is found to be dependent on operating temperature, composition, porosity and grain size.

References

- [1]. N. Rezlescu, E. Rezlescu, F. Tudorache, and P. D. Popa, Some spinel oxide compounds reducing gas sensors, *Sens. Transducers J.*, Vol. 78, Issue 4, 2007, pp. 1134-1142.
- [2]. C. V. Gopal Reddy, S. V. Manorma, and V. J. Rao, Preparation and characterization of ferrites as gas sensor materials, *J. Mater. Sci. Letts.*, Vol. 19, No. 9, 2000, pp. 775-778.
- [3]. C. Xiangfeng, L. Xingqin, and M. Guangyao, Effect of CdO dopent on the gas sensitivity properties of $ZnFe_2O_4$ semiconductors, *Sens. Actuators B: Chem.*, Vol. 65, No. 1, 2000, pp. 64-67.
- [4]. I. Sandu, L. Presmanes, P. Alphonse, and P. Tailhades, Nano structured cobalt manganese ferrite thin films for gas sensor application, *Thin Solid Films.*, Vol. 495, No. 1-2, 2006, pp. 130-133.
- [5]. P. Y. Lee, K. Ishizaka, H. Suematsu, W. Jiang, and K. Yatsui, Magnetic and gas sensing property of nanosized $NiFe_2O_4$ powders synthesized by pulsed wire discharge, *J. Nanoparticle Res.*, Vol. 8, No. 1, 2006, pp. 29-35.
- [6]. C. Xiangfeng, J. Dongli, and Z. Chenmou, The preparation and gas sensing properties of $NiFe_2O_4$ nanocubes and nanorods, *Sens. Actuators B: Chem.*, Vol. 123, Issue 2, 2007, pp. 793-797.
- [7]. M. C. Carotta, G. Martineiii, Y. Sadaoka, P. Nunzianle and E. Traversa, Gas sensitive electrical properties of perovskite type $SmFeO_3$ thick films, *Sens. Actuators B: Chem.*, Vol. 48, Issue 1-3, 1998, pp. 270-276.
- [8]. P. Song, H. Qin, K. An, Z. Lin, J. Hu and M. Jiang, The structure, electrical and ethanol sensing properties of the $La_{1-x}Pb_xFe_2O_4$ perovskite ceramic with $x_{0.3}$, *Sens. Actuators B: Chem.*, Vol. 104, Issue 2, 2005, pp. 312-316.
- [9]. Y. H. Lee, G. D. Lee, S. S. Park and S. S. Hong, Catalytic removal of carbon particulates over $MgFe_2O_4$ catalytsis, *React. Kinet. Catal. Lett.*, Vol. 84, No. 2, 2005, pp. 311-317.
- [10]. Y. Shimizu, H. Arai and T. Seiyama, Theoretical studies on the impedance-humidity characteristics and ceramic humidity sensors, *Sens. Actuators B: Chem.*, Vol. 7, Issue 1, 1985, pp. 11-22.
- [11]. Benko and F. P. Koffyberg, The effect on photoelectrochemical properties of semiconductor $MgFe_2O_4$, *Material Res. Bull.*, Vol. 21, Issue 10, 1986, pp. 1183-1188.
- [12]. N. S. Chen, X. J. Yang, E. S. Liu, and J. L. Huang, Reducing gas-sensing properties of ferrite compounds MFe_2O_4 ($M = Cu, Zn, Cd$ and Mg), *Sens. Actuators B: Chem.*, Vol. 66, Issue 1-3, 2000, pp. 178-180.
- [13]. K. Wetchakun et al, Semiconducting metal oxide as sensors for environmentally hazardous gases, *Sens. Actuators B: Chem.*, Vol. 160, Issue 1, pp. 580-591, 2011.
- [14]. A. B. Gadkari, T. J. Shinde and P. N. Vasambekar, Ferrite gas sensors, *IEEE Sensors J.*, Vol. 11, Issue 4, 2011, pp. 849-861.
- [15]. A. P. Kazin et al, Microstructure and gas sensing properties of nanocrystalline $NiFe_2O_4$ prepared by spray pyrolysis, *Inorganic Materials*, Vol. 46, No. 11, 2010, pp. 1254-1259.
- [16]. A. B. Gadkari, T. J. Shinde and P. N. Vasambekar, Structural analysis of Y^{3+} doped Mg-Cd ferrites prepared by oxalate co-precipitation method, *Mater. Chem. Phys.*, Vol. 114, Issue 2-3, 2009, pp. 505-510.
- [17]. A. B. Gadkari, T. J. Shinde and P. N. Vasambekar, Studies on gas sensing properties of $Mg_{1-x}Cd_xFe_2O_4$ system, *IEEE Sensors J.* (in Review).
- [18]. S. Sing, B. C. Yadav, R. Prakash, B. Bajaj, J. R. Lee, Synthesis of nanorods and mixed shaped copper ferrite and their application as liquid petroleum gas sensors, *Appl. Surf. Sci.*, Vol. 257, 2011, pp. 10763- 10770.
- [19]. T. V. Belysheva, L. P. Bogovtseva, E. A. Kazachkov and N. V. Serebryakola, Gas sensing properties of doped In_2O_3 films as sensors for NO_2 air, *J. Anal. Chem.*, Vol. 58, No. 6, 2003, pp. 583-587.
- [20]. N. Barson, M. S. Berweizer, W. G. Fresenius, *J. Anal. Chem.*, Vol. 365, 1999, pp. 287-304.
- [21]. K. Arshak and I. Gadian, Development of a novel gas sensor based on oxide thick films, *Mater. Sci. Eng. B*, Vol. 118, Issue 3, 2005, pp. 44-49.
- [22]. S. Darshane and I. S. Mulla, Influence of palladium on gas sensing performance of magnesium ferrite nanoparticles, *Mater. Chem. Phys.*, Vol. 119, No., 2010, pp. 319-323.
- [23]. D. R. Patil, L. A. Patil, G. H. Jain, M. S. Wagh, S. A. Patil, Surface activated ZnO thick film resistors for LPG gas sensing, *Sens. Transducers J.*, Vol. 74, Issue 12, 2006, pp. 874-883.

- [24].Z. Sun, L. Liu, D. Jia and W. Pan, Simple synthesis of CuFe_2O_4 nanoparticles as gas sensing materials, *Sens. Actuators B: Chem.*, Vol. 125, Issue 1, 2007, pp. 144-148.
- [25].V. D. Kapase, S. A. Ghosh, F. C. Raghuwanshi, S. D. Kapashe, U. S. Khandekar, Nanocrystalline $\text{Ni}_{0.6}\text{Zn}_{0.4}\text{Fe}_2\text{O}_4$, A novel semiconducting material for ethanol detection, *Talanta*, Vol. 78, Issue 1, 2009, pp. 19-25.
- [26].D. H. Dawson and D. E. Williams, Gas sensitive resistors: surface interaction of chlorine with semiconducting oxide, *J. Mater. Chem.*, Vol. 6, Issue 1, 1996, pp. 406-414.
- [27].C. Xiangfeng, High sensitivity chlorine gas sensors using CdIn_2O_4 thick film prepared by co-precipitation method, *Mater. Res. Bull.*, Vol. 51, No. 5-6, 2006, pp. 631-640.
- [28].V. A. Aroutiounian and G. S. Aghabian, To theory of semiconductor gas sensor, *Sens. Actuators B: Chem.*, Vol. 50, Issue 1, 1998, pp. 80-84.
- [29].T. G. Nenov, S. P. Yordanov, Ceramic Sensors, Technology and applications, *Tech-nomic Publication*, Lancaster, 1996, pp. 137-138.
- [30].G. Zhang, C. Li and F. Cheng and J. Chen, ZnFe_2O_4 tubes: Synthesis and application to gas sensors with high sensitivity and low-energy consumption, *Sens. Actuators B: Chem.*, Vol. 120, Issue 1, 2007, pp. 403-410.
- [31].E. Rezlescu, E. Rezlescu, F. Tudorache and P. D. Popa, Gas sensing properties of porous Cu-, Cd- and Zn-ferrites, *Romanian Reports in Physics*, Vol. 61, No. 2, 2009, pp. 223-234.
- [32].C. Doroftei, E. Rezlescu. L. Rezlescu and P. D. Popa, Gas sensing properties of samarium substituted lithium ferrite, *J. Optoelec. Adv. Mater.*, Vol. 10, No. 9, 2008, pp. 2390-2395.
- [33].C. Doroftei, E. Rezlescu, N. Rezlescu, P. D. Popa, Magnesium ferrite with Sn^{4+} and Mo^{6+} substitutions as gas sensing element for acetone and ethanol, *Rom. J. Phys.*, Vol. 51, Issue (5-6), 2006, pp. 631-640.

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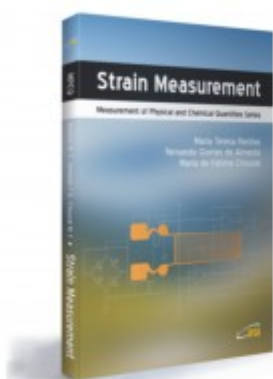


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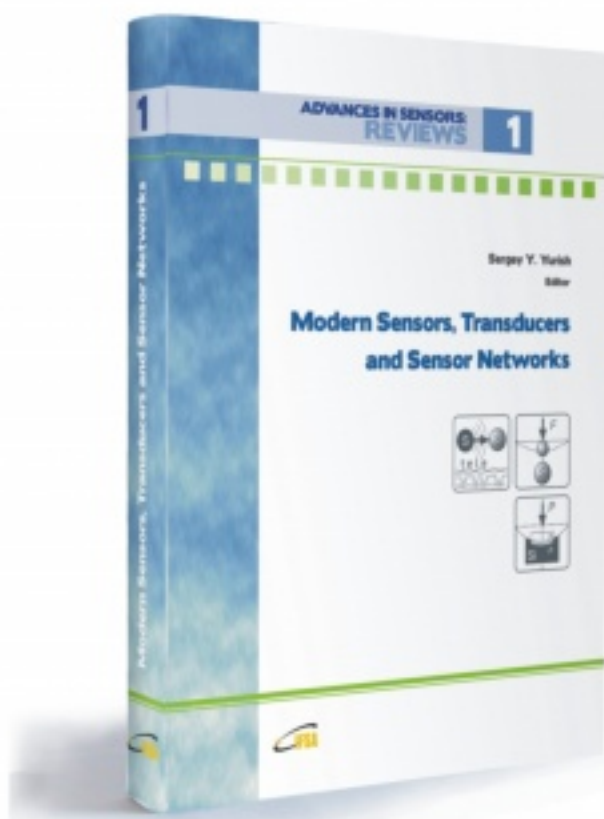
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