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Sergey Y. Yurish



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Topic E2: Transportation & Mobility

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Linear Resistivity Response with Relative Humidity of Gd Doped Magnesium Ferrite

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Abstract: In present work sintered samples of gadolinium doped magnesium ferrite has yielded a linear response of resistivity for wide range of humidity. From 10 % to 95%RH change, a. c. resistivity of 2 mol% Gd doped sample drops linearly from 3.39×10^7 to 3.2×10^5 Ω-cm at 1 kHz. Gd doping also enhanced porosity. XPS shows enhancement in lateral oxygen peaks with Gd-doping in magnesium ferrite. The response and recovery time observed for 30 - 70%RH range for 2 mol% Gd doped magnesium ferrite are 140 s and 180 s respectively, which are excellent values for bulk humidity sensor material. *Copyright © 2012 IFSA.*

Keywords: Humidity sensitivity, Resistivity, Porous microstructure, Gd-doped magnesium ferrite.

1. Introduction

Chemical reactivity and the physical interaction of solids with gases are influenced by porous microstructure of the material [1]. As a result of physical interaction of material and gases electrical parameter of the material varies. The change in electrical parameters of a material by exposure to humidity is extremely sensitive to dopant and material microstructure [2, 3]. The localized electrostatic field due to surface charges weakens the physisorbed H_2O molecule bonding and dissociates water molecules 10^6 times higher than water molecules [4]. The variation in electrical parameters of porous material with humidity is a consequence of dissociation of water molecules. Metal oxides due to their defective (surface charge, pores) structure show good sensitivity towards water vapors. Oxides like TiO_2 [5, 6] Fe_2O_3 [7-9] $MgAl_2O_4$ [10, 11] and $MgFe_2O_4$ [12, 13] exhibit fall in resistance when exposed to water vapors at ambient temperature. However, only a few were found to be effective for

practical application due to their inherent drawbacks e.g. barely sensitive for a wide humidity range, short lifetime, large humidity hysteresis, and slow response etc. According to Fleming's model surface charges generates localized electrostatic field that attract water molecules to physisorbed via H-bonding [14]. Surface ions dissociate water molecules and form chemisorbed OH^-layers. These hydroxyl ions provide high electrostatic field and weaken the bonding of further water molecules. In addition, porous microstructure allows free access for water vapors to interact with the pore wall. Water vapors are dissociated as H^+ and OH^- ions on surface active sites forming chemisorbed OH^- layers [15]. Chemisorbed hydroxyl ions around pore necks create high electrostatic field and these capillary tubes exhibit lower-pressure hence water vapors get condensed inside them at higher humidity [16]. Theoretically electrostatic interaction between water molecules and surfaces has been also analyzed using topology [17]. With increasing humidity, physisorption of water molecules take place over chemisorbed OH^- layers. Protonic conduction happens in the physisorbed layers from one water molecule to other hence further decreases the resistivity of the material [18, 19]. The schematic for surface conduction mechanism on material surface is shown in Fig. 1. To obtain a linear response of resistivity for wide range of humidity both surface charges for physisorption of water molecules and porosity of the material should increase. The porosity of the metal oxide can be increased by adding foreign elements and monitoring sintering temperature. In the present work to get linear resistivity response for wide %RH range, 1 mol% and 2 mol% gadolinium oxide has been doped in $MgFe_2O_4$. A small amount of rare earth oxide addition can modify both microstructure and the electrical resistivity [20]. By Gd-doping, porosity, surface charge and base resistivity increased. A two order (10^7 to 10^5) linear decrease in resistivity has been observed for a change of humidity from 10 % to 95 %RH for 2 mol% Gd doped sample. The surface composition and porosity of Gd added samples has been investigated for enhancement of humidity sensitivity.

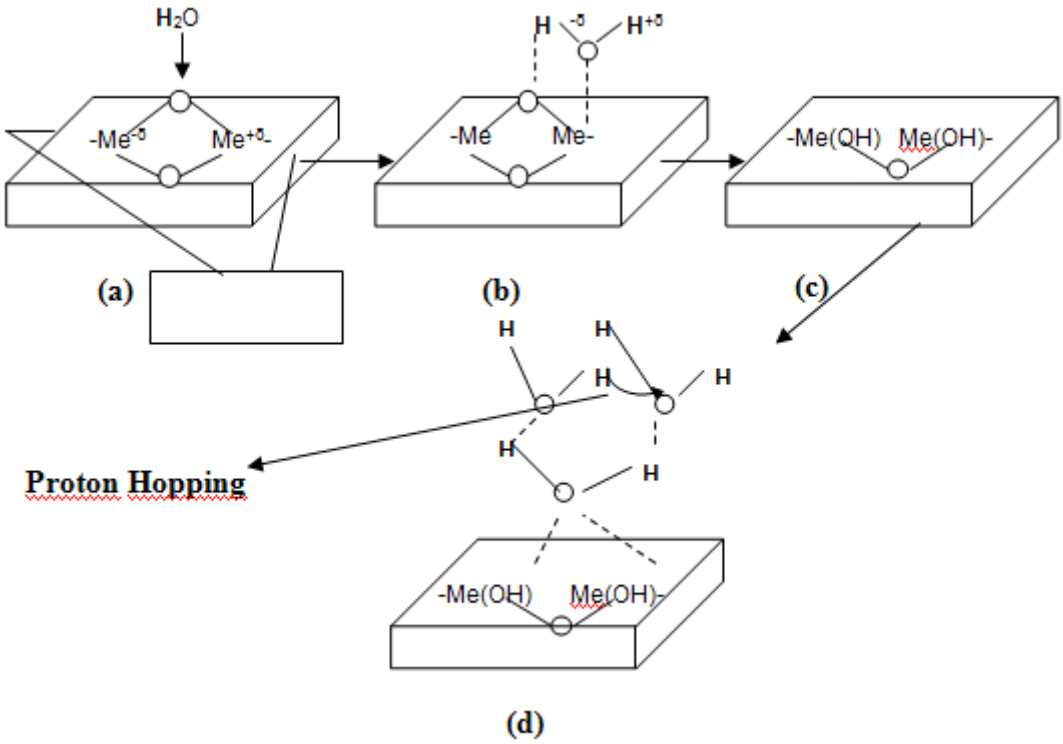


Fig. 1. Surface conduction mechanism steps, (a) Magnesium ferrite sample surface, Me (surface cations); (b) Adosorption of water molecule; (c) Dissociation and chemisorption of water molecule; (d) Physisorption of water molecules, protonic transportation through hydrogen bonding in physisorbed water molecules.

2. Experimental

The samples were prepared with solid-state reaction method by mixing MgO and Fe_2O_3 in a molar ratio 1:1. Gd_2O_3 was added at 1 and 2 mol% in prestine sample. The precursors were ground and followed by prefiring at 800 ^oC in air for 8 h. Organic binder polyvinyl acetate (PVA) was added 0.01 % to form rectangular pellets of prefired powder at a pressure of 10 tons. Sintering of pellets was carried out at 1050 ^oC with a heating/cooling rate 5 ^oC/min for 5 h in air. To carry out electrical measurements the lateral edges of the rectangular pellets were silver pasted and cured at 350 ^oC for 1 h. Electrodes were soldered at these silvered edges. X-ray photoelectron spectroscopy measurements have been carried out for the sample series, using a Perkin Elmer 1257 model. The average pore size and grain size distribution were calculated by performing linear intercept method on SEM micrograph. All resistivity humidity responses were carried out at 1 kHz by Fluke 81 50 MHz Function Generator. One-volt a.c. was applied to avoid any polarization effect due to dipole moment of water molecules. High resistivity was measured by Kiethley 6517A electrometer. For taking relative humidity versus ac resistivity measurements a two pressure method based standard humidity generator (Thunder Scientific 2500 series) was used for 10-95 %RH change. The % RH accuracy of the generator is ±0.5 % with a resolution of 0.02 %. Use of such standard humidity generator provides more precise measurements to relative humidity compared to the saturated salt solutions. Samples response and recovery time were determined at 25 °C for 30 to 70 % RH change.

The working principle of RH generator is based on a two vapor pressure technique:

$$\%RH = \left(P_x / P_{sat}\right) \times 100, \tag{1}$$

where P_x is the partial water vapor pressure and P_{sat} is the saturated water vapor pressure at a given temperature.

The lattice parameter of the different samples was determined by the relation:

$$a = d \times (h^2 + k^2 + l^2)^{1/2} \tag{2}$$

Here d is the lattice spacing and h, k, l are the miller indices.

Bulk Porosity of the samples was calculated by using the equation:

$$\%P = \left(1 - d_{\exp} / d_x\right) \times 100 \tag{3}$$

where d_x and d_{exp} are the X-ray density and the experimental density of the samples.

The specific surface area of the particle was calculated by the formula

$$A_{sp} = 6 / D\rho \tag{4}$$

where A_{sp} is the specific surface area (m^2/g) and ρ is the $MgFe_2O_4$ theoretical density (ρ=4.50 g/cm^2) and D is the particle diameter. All particles considered to be spherical shaped.

The electrical resistivity of the samples was calculated by using the relation:

$$\rho_{res} = RA / L \tag{5}$$

Here R, A and L are the resistance, contact area and length of the rectangular pellets respectively.

3. Results and Discussions

XRD peaks as shown in Fig. 2 confirm the spinel phase formation of $MgFe_2O_4$ [JCPDS Card No. 36-0398]. By Gd-doping in pure sample XRD peaks slightly broaden. Broadening may arise due to increase in oxygen vacancies defects [21]. No second phase peaks have been observed with Gd-doping. This suggests that such a nominal amount of Gd has been incorporated in to spinel lattice. The lattice parameters of $MgFe_2O_4$ decreased with Gd-doping.

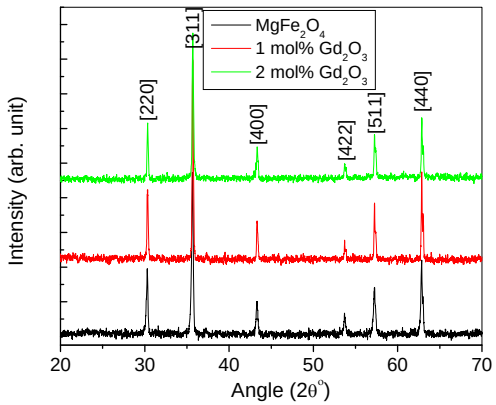


Fig. 2. XRD for magnesium ferrite, 1 mol% Gd_2O_3, and 2 mol% Gd_2O_3 doped samples.

XPS survey spectra performed in the range of 0-1350 eV is shown in Fig. 3. Corrections due to charging effects were taken care by using C(1 s) as an internal reference and the Fermi edge of a gold sample. It is evident from survey scan spectra depicting its position as sharp peaks of C 1s (2845 eV), O 1s (532 eV), Mg 1s (1304 eV), Gd 3d5/2 (1186 eV), Fe(2p3/2) and Fe(2p1/2) at 710.6 eV and 724.3 eV respectively. Auger peak of O (KLL) and Mg (KLL) were also observed. All XPS peaks are very close to reported literature value [22]. To make out the effect of oxygen ions, deconvolution performed on O (1s) core level spectra.

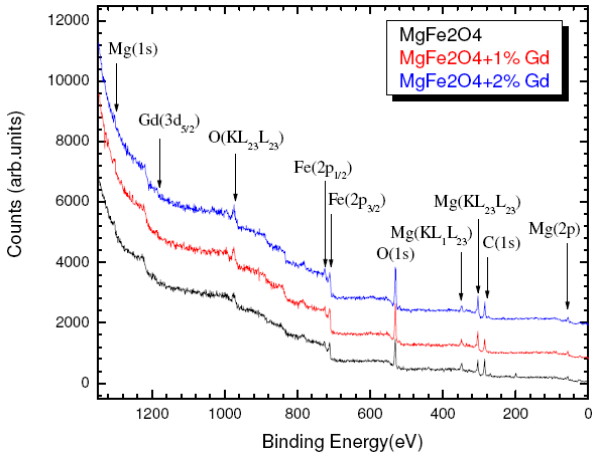


Fig. 3. XPS Survey scan spectra of $MgFe_2O_4$ with different Gd concentration.

Fig. 4(a) shows the deconvoluted spectra of oxygen that has two-peak structure. The first peak P1 is characteristic peak of O^{2-} ions of the lattice oxygen, while peak P2 denotes O (1 s) lateral structure. This lateral peak corresponds to the ionization of weakly adsorbed species [23]. Further, it suggests

that the existence in the subsurface of oxygen ions that bear lower electron density than the O^{2-} ions. Normally, these oxide ions described as O^{-} species or excess oxygen [24]. When Gd doping increased the area ratio of these two peaks also changes. The variation of P1 and P2 with Gd concentration is shown in Fig. 4(b). Hence X-ray photoelectron spectroscopy confirms enhancement in lateral oxygen peak P2 by deconvoluting O(1 s) peak of the samples. Consequently, more active sites for water molecule adsorption increases. It leads to enhancement of humidity response of Gd doped magnesium ferrite. This effect is distinctly evident in resistivity variation with humidity.

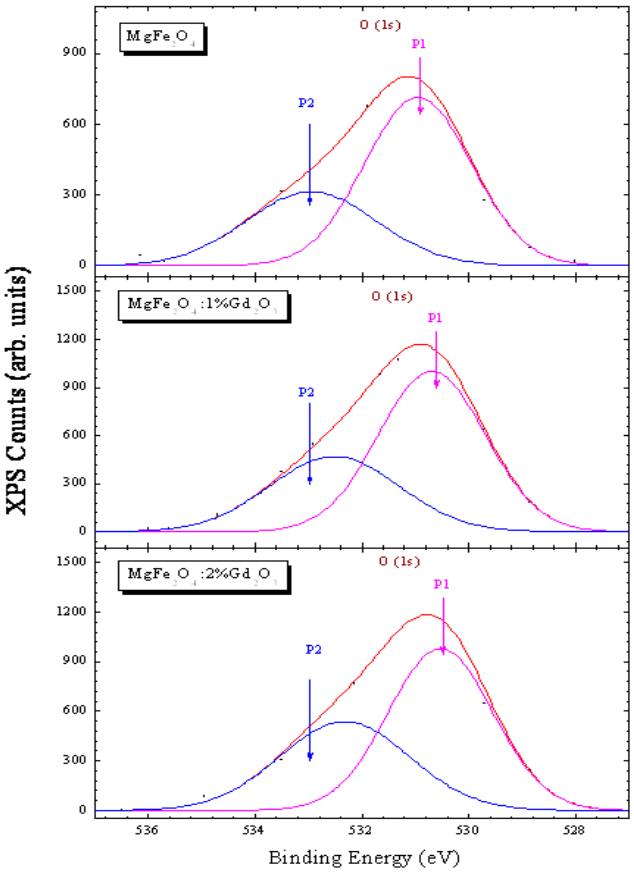


Fig. 4(a). XPS deconvoluted spectra of O 1s core level.

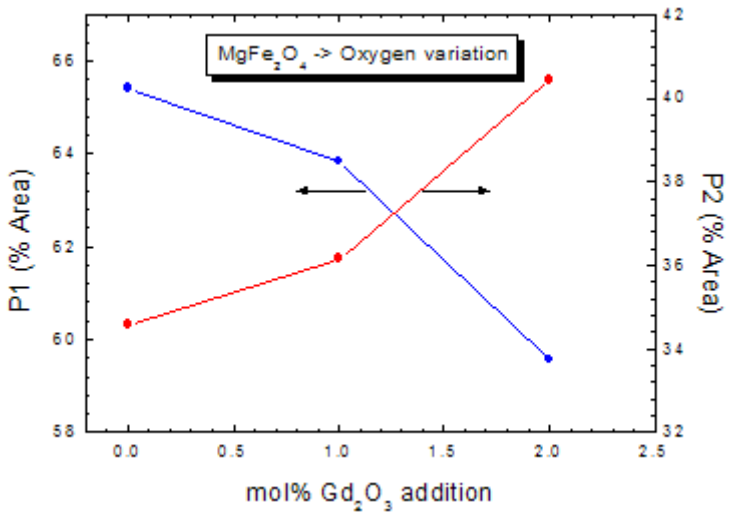
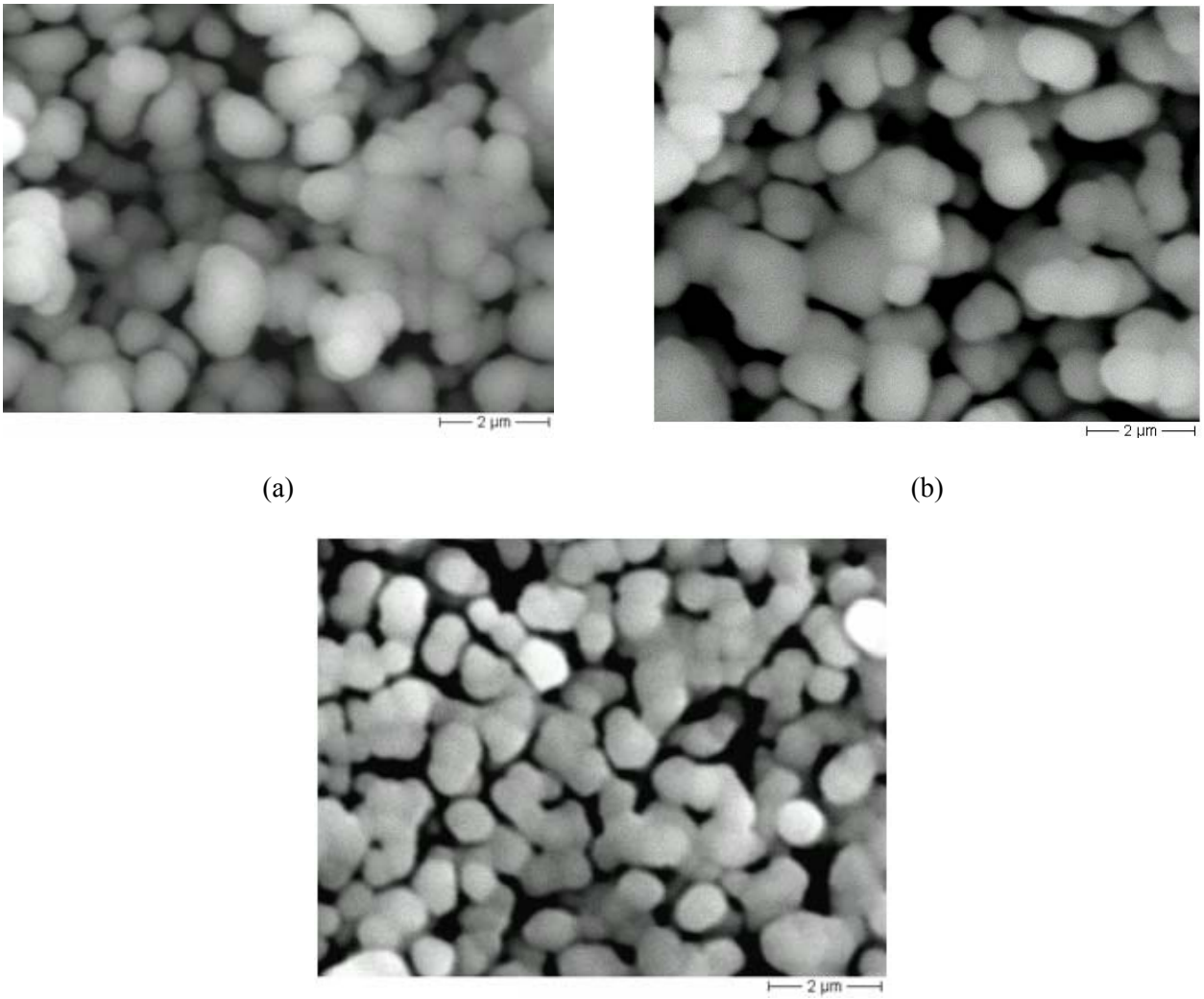


Fig. 4(b). Variation of P1 and P2 as function of Gd_2O_3 concentration.

The SEM micrographs of the different samples revealed the microstructure of the samples altered due to the doping of gadolinium oxide as shown in Fig. 5. It is clearly observed in SEM micrograph a porous microstructure with distributed interconnected pores. Pore size distribution, grain size distribution was calculated by applying linear intercept method on SEM micrograph. It is clearly visible from SEM images pore size distribution increased with Gd doping in $MgFe_2O_4$. This may be due to creation of oxygen vacancies as observed by decrease in lattice oxygen XPS peaks and broadening of XRD peaks.



(a) (b)

(c)

Fig. 5. SEM pictures of (a) $MgFe_2O_4$, (b) 1 mol% Gd_2O_3, and (c) 2 mol% Gd_2O_3 doped samples.

Fig. 6 shows the resistivity response of three sample pellets with increasing relative humidity. Resistivity of the sample was determined by using equation 5. Resistivity response of undoped $MgFe_2O_4$ was unchanged up to 40 %RH then starts to drop linearly with increasing %RH. Slope of resistivity for 1 mol% Gd doped sample slightly increased than undoped sample. 2 mol% Gd doped sintered sample showed drastic linear drop in resistivity for the entire humidity range 10-95 %RH. However linear resistivity response with humidity observed in case of nanostructure due to high reactivity of nanoparticles [25]. The resistivity at 10%RH of the undoped sample 1.38×10^7 Ω-cm increased to 3.4×10^7 Ω-cm for 2 mol% Gd doping. This may be due to increased porosity from 19 % to 36.6 % as observed [26, 27]. The percentage porosity was calculated by using equation 3.

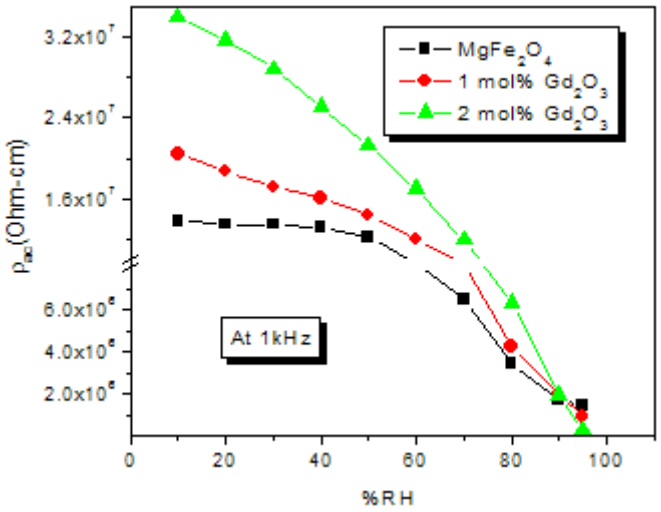


Fig. 6. Evolution of ρ_{ac} as a function of relative humidity for the investigated sample series measured at 1kHz.

The linear dependence of resistivity with porosity in our samples observed is shown in Fig. 7. Theoretical modeling on the effect of porosity on material constants has also been proposed [28]. Resistivity gradient of pure sample was 2×10^4 Ω/%RH up to 40 %RH that exhibits less defective sites for water molecules to dissociate. By 1 mol% Gd-doping resistivity response increased to 5.3×10^4 Ω/%RH at lower humidity. With 2 mol% Gd-doping a large slope in resistivity 2.6×10^5 Ω/%RH was observed up to 40 %RH. This increment in RH sensitivity reveals more defective sites availability for hydroxide bonding. OH^- ions at pore necks create high electrostatic field for further water vapors to dissociate. It is also observed in XPS that lateral oxygen peaks increased by Gd-doping due to more OH^- adsorption.

The resistivity values of pure sample with Gd-doping reveals Gd^{3+} ion substituting Mg^{2+} ion hence increasing the base resistivity. However, substitution of Mg^{2+} ion (0.78 Å) by Gd^{3+} ion (1.07 Å) due to larger ionic radii does not allow but lower decomposition temperature of Gd_2O_3 (2330 ^oC) than MgO (2800 ^oC) allows partial replacement of Mg^{2+} by Gd^{3+}. Gd^{3+} ion occupies more spacious octahedral position due to larger ionic radius. Mg ion placement to interstitial site by Gd ions makes magnesium ferrite more sensitive towards bonding with OH^- ions as Mg ions possess high affinity towards water molecules. Thus surface cations and hydroxyl ions create high electrostatic field to weaken physisorbed water molecules bonding and provide hydronium ions to conduct. Also continuous pores connected through grain necks facilitate transportation of ions at low RH. Resistivity gradient increased (2.48×10^7 Ω/%RH) at high RH for 2 mol% Gd doped sample is observed. Macropore neck provide high field to dissociate water molecules and large surface area to interact with pore walls that can accommodate multilayer of water molecules. Protons (H^+)/hydronium ions (H_3O^+) are the major conduction carriers at higher RH [29]. Protonic conduction increases as physisorbed water vapor layer increased. Porosity plays dominant role for multilayer adsorption of water vapors. All the samples show almost linear resistivity response at higher humidity >40 %RH due to porosity of the compound [30, 31]. Gd-doping in pure sample increased the porosity hence high drop in resistivity at high humidity. Porosity increased due to gradients in chemical potential, of MgO, Fe_2O_3 and Gd_2O_3 as different diffusion couples, the vacancy flux may result in a large local concentration of vacancies that condense into pores especially at grain boundary. Researchers have frequently observed such porosity [32].

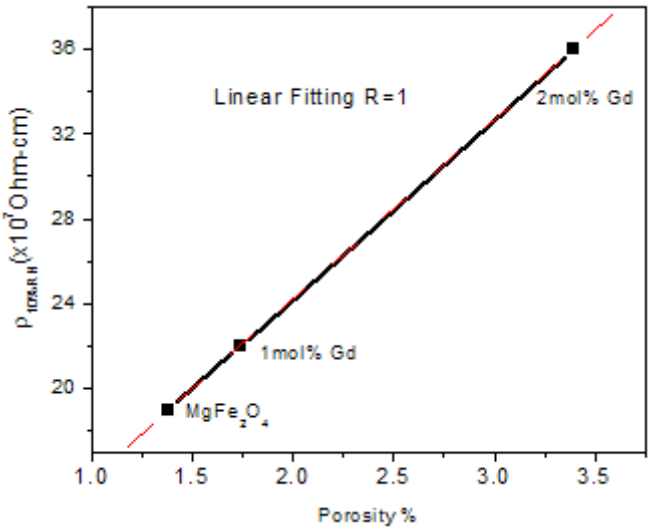


Fig. 7. % Porosity vs. Resistivity ρ_{ac} at 10%RH, curve for three compositions.

Magnesium ferrite exhibits anomalous oxygen defects along a grain boundary due to large activation energy of grain boundary diffusion [33]. This suggests the increased OH^- species other than lattice oxygen due to dissociation of water molecule. This was confirmed by XPS data by increased peak area of lateral oxygen P2 than lattice oxygen peak. It reveals increased number of pores exposed more grain boundary oxygen vacancies. It ultimately enhances more active sites for water molecules adsorption. The response time and recovery time was measured for 30 %RH to 70 %RH i.e. the mid range of relative humidity. The time taken by the sample with changing humidity from 30 % to 70 %RH is the response time and resistivity response for 70 % to 30 %RH is the recovery time. Practically time taken to attain 90 % of the resistivity value at 70 %RH is considered to be the response time. The response/recovery time observed for three samples is given in Table 1. The humidity response time was observed a least of 140 s for 2 mol% Gd doped sample is quite good for ceramic humidity sensor. It is due to the higher porosity providing larger surface area of the grains ultimately increasing adsorption of water molecules in less time. Moreover, samples were also prepared with higher Gd doping but the base resistance of the samples increased beyond 700 MΩ, and also showed deviation from linearity. The stability of sample resistivity with time was also observed by measuring its resistivity at different %RH for the period of twelve months and it was found only 0.1-1 % variation in resistivity values. This durability test establishes Gd doped magnesium ferrite a potential candidate for humidity sensor application.

Table 1. Structural parameters and response time of $MgFe_2O_4$-Gd_2O_3 samples.

Samples	**Lattice Parameter (Å)**	**Bulk Density (g/cm^3)**	**Total Porosity (%)**	**Average Pore Diameter (μm)**	**Specific Surface Area of Particle (m^2/g)**	**Adsorption /Desorption Time (s)**
$MgFe_2O_4$	8.36	3.62	19.5	1.3	0.44	180/200
1 mol% Gd_2O_3 doped	8.35	3.43	22.4	1.7	0.54	170/195
2 mol% Gd_2O_3 doped	8.33	2.85	36.6	2.4	0.69	140/180

4. Conclusions

Doping of 2 mol% Gd in magnesium ferrite drastically increased the porosity and active sites for dissociation of physisorbed water molecules. Resistivity response of such Gd doped sample shows linear behavior of resistivity for the entire humidity range (10-95 %RH). The minimum humidity response/recovery time is observed 140/180 s for 2 mol% Gd doped sample. Therefore it is an appropriate material for humidity sensor with fast response time and good stability.

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References

[1]. G. Férey, Physical chemistry: Trapped gas, *Nature*, 436, 2005.
[2]. J. C. Dupin, D. Gonbeau, P. Vinatier, A. Levasseur, Systematic XPS studies of metal oxides, hydroxides and peroxides, *Phys. Chem. Chem. Phys.* 2, 2000, p. 1319.
[3]. W. Wang, A. V. Virkar, A conductimetric humidity sensor based on proton conducting perovskite oxides, *Sensors and Actuators B*, 98, 2004, p. 282.
[4]. E. Traversa, Ceramic sensors for humidity detection: the state of the art and future developments, *Sens. Actuators B*, 23, 1995, p. 135.
[5]. S. P. Yawale, S. S. Yawale, G. T. Lamdhade, Tin oxide and zinc oxide based doped humidity sensors, *Sens. Actuators A.*, 135, 2007, p. 388.
[6]. A. B. Rives, T. S. Kulkarni, A. L. Schwaner, Nitrogen and water adsorption on combinations of titania and ferric oxide, *Langmuir,* 9, 1993, p. 192.
[7]. J. M. Tulliani, P. Bonville, Influence of the dopants on the electrical resistance of hematite-based humidity sensors, *Ceram. Int*., 31, 2005, p. 507.
[8]. I. C. Cosentino, E. N. S Muccillo, R. Muccillo, The influence of Fe_2O_3 in the humidity sensor performance of ZrO_2:TiO_2-based porous ceramics, *Materials Chem. Phys*., 103, 2007, p. 2.
[9]. A. V. Adakimchik, N. I. Gorbachuk, M. I. Ivanovskaya, D. A. Kotikov, M. G. Lukashevich, V. B. Odzhaev, Yu. V. Sidorenko, The dependence of the conductivity of SiO_2–γFe_2O_3 film composites on air humidity, *Russian Journal of Physical Chemistry*, A, 84, 2010, p. 684.
[10]. G. Gusmano, G. Montesperelli, E. Traversa, G. Mattogno, Microstructure and electrical properties of $MgAl_2O_4$ thin films for humidity sensing, *J. Am. Ceram. Soc*., 76, 1993, p. 743.
[11]. Z. Wang, C. L. Chang, X. Zhao, W. Qian, X. Zhang, Z. Xie, B. H. Hwang, C. Hu, J. Shen, R. Hui, $MgAl_2O_4$-based humidity-sensing material for potential application in PEM fuel cells, *Journal of Power Sources*, 190, 2009, p. 351.
[12]. N. Rezlescu, C. Dorofti, E. Rezlescu, P. D. Popa, Structure and humidity sensitive electrical properties of the Sn^{4+} and/or Mo^{6+} substituted Mg ferrite, *Sens. Actuators B: Chem*., 115, 2006, pp. 589–595.
[13]. J. Shah, R. K. Kotnala, B. Singh, H. Kishan, Microstructure-dependent humidity sensitivity of porous $MgFe_2O_4$–CeO_2 ceramic, *Sensors and Actuators B: Chemical*, 128, 1, 2007, pp. 306- 311.
[14]. W. J. Fleming, SAE Paper 810432 presented at the *SAE International Congress*, Detroit, MI, February 23, 1981.
[15]. J. Ahdjoudj, C. Minot, Adsorption of H_2O on metal oxides: a periodic abinitio investigation, *Surface Science,* 402–404, 1998, pp. 104-109.
[16]. M. E. Green and J. Lu, Simulation of water in a small pore: effect of electric field and density, *J. Phys. Chem. B*, 101, 1997, p. 6512.
[17]. Y. Aray, M. Marquez, J. R. Guez, S. Coll, Y. S-Manso, C. Gonzalez, D. A. Weitz, Electrostatics for Exploring the Nature of Water Adsorption on the Laponite Sheets' Surface, *J. Phys. Chem. B,* 107, 2003, p. 8946.
[18]. B. M. Kulwicki, Humidity sensors, *J. Am. Chem. Soc*., 74, 1991, p. 697.
[19]. Z. Chen, C. Lu, Humidity sensors: a review of materials and mechanisms, *Sens. Lett*., 3, 2005, p. 274.

[20]. E. Rezlescu, M. Rezlescu, P. D. Popa, L. Rezlescu, K. Pasnicu, The influence of R_2O_3 (R = Yb, Er, Dy, Tb, Gd, Sm and Ce) on the electric and mechanical properties of a Nickel–Zinc ferrite, *Phys Stat Sol*., A 162, 1997, p. 673.
[21]. J D. Makinson, J. S. Lee, S. H. Magner, R. J. De Angelis, W. N. Weins, A. S. Hieronymus, X-Ray Diffraction Signatures of Defects in Nanocrystalline Materials, *Advances in X-ray Analysis*, 42, 2000, pp. 407-411.
[22]. A. P. Grosvenor, B. A. Kobe, M. C. Biesinger, N. S. McIntyre, Investigation of multiplet splitting of Fe 2p XPS spectra and bonding in iron compounds, *Interface Anal.*, 36, 2004, p. 1564.
[23]. M. Mullet, V. Khare, C. Ruby, XPS study of Fe(II)–Fe(III) (oxy) hydroxycarbonate green rust compounds, *Surf. Interface Anal*., 40, 2008, p. 323.
[24]. W. Cao, O. K. Tan, W. Zhu, J. S. Pan, J. Bin, Study of x Fe_2O_3 (1-x)ZrO_2 Solid Solution for Low-Temperature Resistive Oxygen Gas Sensors, *IEEE Sens. J*., 3, 2003, p. 421.
[25]. Y. P. Leung, C. H. Wallace, T. I. Yuk, Linear resistivity humidity sensor based on quasi one-dimensional ZnSe nanostructures, *Chem. Phys. Letters*, 457, 2008, p. 198.
[26]. G. L. Kulcinski, P. Wagner, L. R. Cowder, The effect of porosity and pore interconnection on the thermal conductivity and electrical resistivity of tungsten, *J. Less Common Metals*, 7, 1964, p. 383.
[27]. M. E. Pérez-Ramos, A. Manzano-Ramírez, P. Yu. Vorobiev, P. P. Horley, Yu. V. Vorobiev, J. González-Hernández, Anomalous Effect of Porosity upon Electrical Properties of Fe-Based Samples Made by Powder Metallurgy, *Inorganic Materials*, 39, 1, p., 2003, p. 37.
[28]. F. Euler, Simple Geometric Model for the Effect of Porosity on Material. Constants, *J. Appl. Phys*., 28, 11, 1957, p. 1342.
[29]. V. K. Khanna, R. K. Nahar, Surface conduction mechanisms and the electrical properties of Al_2O_3 humidity sensor, *Applied Surface Science,* 28, 1987, p. 247.
[30]. H. H. Kung, Transition metal Oxides: Surface chemistry & catalysis studies in surface science catalysis *Elsevier*, Amsterdam, 45, 1989.
[31]. K. S. Chou, T. K. Lee, F. J. Liu, Sensing mechanism of a porous ceramic as humidity sensor, *Sens. Actuators B*, 56, 1999, p. 106.
[32]. E. O. Kirkendall, Zinc Diffusion in. Alpha Brass, *Trans. AIME,* 147, 1942, p. 104.
[33]. H. Haneda, I. Shindo, H. Yamamura, S. Shirasaki, Oxygen self-diffusion in single and polycrystalline magnesio-ferrite, *J. Mat. Sci.,* 19, 1984, p. 2948.

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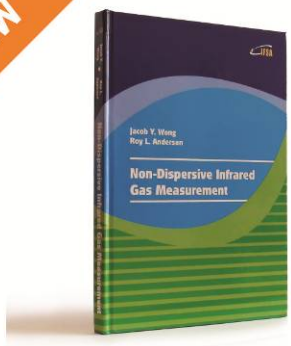
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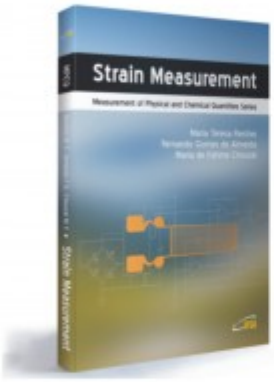
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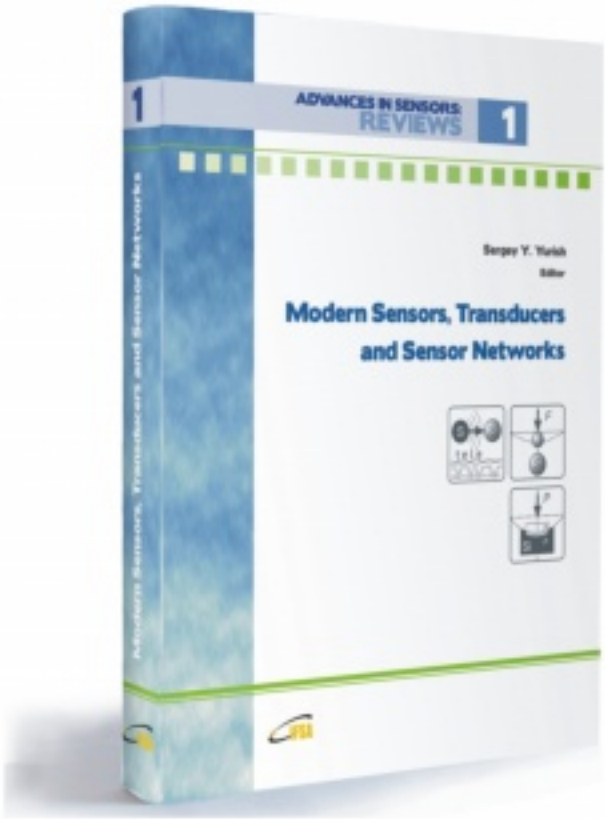
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