Hasan Iraqi Journal of Science, 2022, Vol. 63, No. 12, pp: 5232-5241
DOI: 10.24996/ijs.2022.63.12.13

ISSN: 0067-2904

Synthesis and Dielectric Properties of MgO:ZnO Composites

Ahmad A. Hasan
Department of Physics, College of Science, University of Baghdad, Baghdad, Iraq

Received: 5/10/2021 Accepted: 23/2/2022 Published: 30/12/2022

Abstract:
The dielectric properties of the fabricated composites MgO:ZnO with various mixing ratios (100,75:25,50:50,25:75, and 100 wt. %)were investigated. The structure analysis was conducted using X-ray diffraction. The structure phase, crystallite size and purity of the fabricated MgO:ZnO composites were confirmed using X-ray diffraction spectra. The results declared that the diffraction spectrum of 100%MgO composite samples were compatible with cubic structure along the plane (200) while the structures of residual composite's samples were compatible with hexagonal structures. The crystal size of the most pronounced plane (101) for crystal growth was changed from 30.4 nm to 53.2 nm by increasing ZnO ratio from 25 to 100wt%. The dielectric properties were studied as function of frequency over the range (50Hz-10MHz). The a.c conductivity $\sigma_{a.c}(\omega)$ showed power low dependence for the full frequency range except for the composites samples of 0 and 75 %wt. ZnO which showed d.c region in the low frequency range. The exponent (s) values which represents the slope of ln $\sigma_{a.c}(\omega)$ and ln(ω) changed in non-regular manner by increasing the ZnO ratio. The dielectric constant ε1 and the dielectric loss ε_2 increased with the increase of the ZnO ratio up to 75% ZnO and then decreased with further increase of ZnO ratio. The dielectric loss peaks observed in the plot diagram of ε_2 against ln(ω) is found to shift towards the high-frequency side which indicates the decrease of relaxation time and prompt movement of charge carriers .The polarizability values (α) estimated from the COLE –COLE diagram increased from 0.112 to 0.467 when the ratio of ZnO changed from 0 to 50wt.% which referred to reduction of the intermolecular forces. While (α) reduced drastically at 75wt.% ZnO which referred to the growing of the intermolecular forces.

Keywords: A.C conductivity , dielectric properties of MgO:ZnO composites , x-ray diffraction

التحضير والخواص العزلية لمتراكبات MgO:ZnO

احمد عباس حسن
كلية العلوم ,قسم الفيزياء, جامعة بغداد,بغداد , العراق

الخلاصة
تم دراسة الخواص العزلية لمتراكبات اوكسيد المغنيسيوم اوكسيد الزنك بنسب خلط مختلفة (100,75:25,50:50,25:75, and 100 wt. %) .تم تحليل التركيب بواسطة حيود الاشعة السينية .تم التاكد من الطور , الحجم البلوري وكذلك النقاوة من طيف الاشعة السينية .اظهرت النتائج ان طيف الحيود لاوكسيد المغنيسيوم كان متطابقا مع الطور المكعبي وفي الاتجاه (200) في حين ان بقية المتراكبات كانت متطابقة مع الطور السداسي .الحجم البلوري للمستوي المفضل للنمو (101) تغير من

*Email: ahmadabhasan2000@gmail.com

30.4 nm الى 53.2 nm مع زيادة نسبة الخلط من 25 الى 100wt% . تم دراسة الخواص العزلية كدالة للتردد ضمن المدى (50Hz−10MHz). اظهرت التوصيلية المتناوبة $\sigma_{a.c}(\omega)$ اعتمادا اسيا على التردد ماعدا النموذجين ZnO .wt% 0 and 75 والذين اظهرا توصيلية مستمرة عند الترددات الواطئة . قيم العامل الاسي (s) والذي يمثل ميل الرسم بين $\ln \sigma_{a.c}(\omega)$ و $\ln(\omega)$ وجد انه يتغير بصورة غير منتظمة مع زيادة نسبة اوكسيد الزنك. لوحظ قمم في طيف معامل الفقد ε_2 مع $\ln(\omega)$ والذي وجد انها تزحف باتجاه الترددات العالية والذي يشير الى هبوط في زمن الاسترخاء وحركة سريعة لحاملات الشحنة . الاستقطابية والتي تم حسابها من منحني وجد انها ازدادت من 0.112 الى 0.467 عند زيادة نسبة اوكسيد الزنك من 0 الى 50wt.% والتي تشير الى هبوط القوى الرابطة الجزيئية في حين هبطت قيم الاستقطابية بشدة عند نسبة 75wt.% من اوكسيد الزنك والذي يشير الى تنامي القوى الرابطة الجزيئية.

Introduction:

Recent research have focused on investigating the properties of mixed metal oxides due to many applications in different fields like physics, chemistry and engineering science. Materials with novel properties can be obtained by combining more than one metal oxide to the oxide matrix. The fabrication of metal oxides attracted valuable consideration because of their very important applications in optoelectronic and photonic devices [1-5]. Zinc oxide, an n-type semiconductor with a band gap of 3.37 eV at R.T, has considerable uses due to its optoelectronic, catalytic, electrical, and photochemical properties [6]. Magnesium oxide semiconductor is of a wide band gap with characteristic structures that lead to unique electronic, optical, magnetic, mechanical, thermal, and chemical properties [7]. The development of new composites from mixing both oxides opens a new field of applications. Recent research is concerned with the fabrication of ZnO/ MgO for their applications in advanced materials technologies. Different methods were used to synthesise ZnO/MgO nanoparticles [8-19]. These composites in small sizes attracted attention because of the confinement effect [20-22].

The present work is concerned with the synthesis of zinc oxide/magnesium oxide (ZnO/MgO) composites as well as the study of their dielectric properties. Many valuable information can be obtained from the dielectric properties measurements like the dc conductivity, dielectric constant, dielectric loss, polarizability, capacitance, and relaxation time.

Materials , experimental procedure, and basic concepts

MgO and ZnO oxides (particle size of 45-50μm) with high purity were provided from Sigma Aldrich. Composites samples were synthesized according to the following mixing ratios of MgO:ZnO of (100:0, 75:25, 50:50, 25:75, and 0:100 wt. %) using solid solution interaction operation. The samples were sintered at a temperature of 1273^{o}C for 5 hours. The materials were grinded to obtain good homogeneity; and pressed into pellets by subjecting a pressure of 8 tons for 20 sec. The structure of the synthesized composites was examined using X-ray diffraction. The dielectric properties were measured using a dielectric analyzer (type Hewlett Packard model-HP4274A) which were done by inserting the pellets samples between two electrodes .The obtained data include the resistance, capacitance and loss factor as a function of frequency(f) in the range (50-10 MHz).The alternative current conductivity $\sigma_{(tot)}(\omega)$ at certain angular frequency (ω=2*3.14*f) is expressed by two terms $\sigma_{tot} = \sigma_{a.c}(\omega) + \sigma_{d.c}$: the first does not depend on frequency but on temperature, the second depends on frequency which may be written as $\sigma_{a.c}(\omega) \propto \omega^{s}$ or $\sigma_{a.c}(\omega) = A\omega^{s}$ (2) where

A is constant, The value of (s) can be measured from the decline of $\ln \sigma_{a.c}(\omega)$against $\ln(\omega)$.

The following equations were used to measure the a.c conductivity (σ_{ac}), dielectric constant ε_1 and dielectric loss ε_2:

$$\sigma = \frac{t}{R..A^*} \quad (3)$$

$$\varepsilon_1 = C.t / \varepsilon_0 .A^* \quad (4)$$

$$\varepsilon_2 = \sigma_{ac} / \omega \varepsilon_o \quad (5)$$

Where: ω, t, R, A*, C and ε_0 are the angular frequency =2*π*f, film thickness, the sample resistance, the effective area for capacitance, and the **p**ermittivity of free space =8.854x10^{-14} (F/cm), respectively.

Results and Discussion

The X-ray spectra of MgO:ZnO composites with mixing ratios:(100:0, 75:25, 50:50, 25:75, and 0:100 wt. %) are displayed in Figure 1 . It was clearly observed that all diffraction peaks for 100%MgO belonged to magnesium oxide with cubic structure according to the card number 96-100-0054 and the growth occurred at 2θ =42.83° at the plane (200). The composites samples of the ratios (75:25, 50:50, 25:75 wt.%) occurred at 2θ of 36.42° at plane (101), according to the card number 96-230-0113, which belonged to cubic and hexagonal structures. The peaks for 100% ZnO matches well the hexagonal structure of zinc oxide. The obtained results are compatible with those of Anandan1 et al. [23] and Siregar and Panggabean [24]. The plane of crystal growth changed from (200) to (101) by the continuous addition of ZnO to MgO. This change was accompanied by gradual reduction of the peak intensity of the (200) plane on the expense of the growing of the peak intensity of the (101) plane, till it vanished at 100%ZnO.The size of crystal has increased from 12.8 to 53.2nm by the effect of the continuous addition of ZnO .

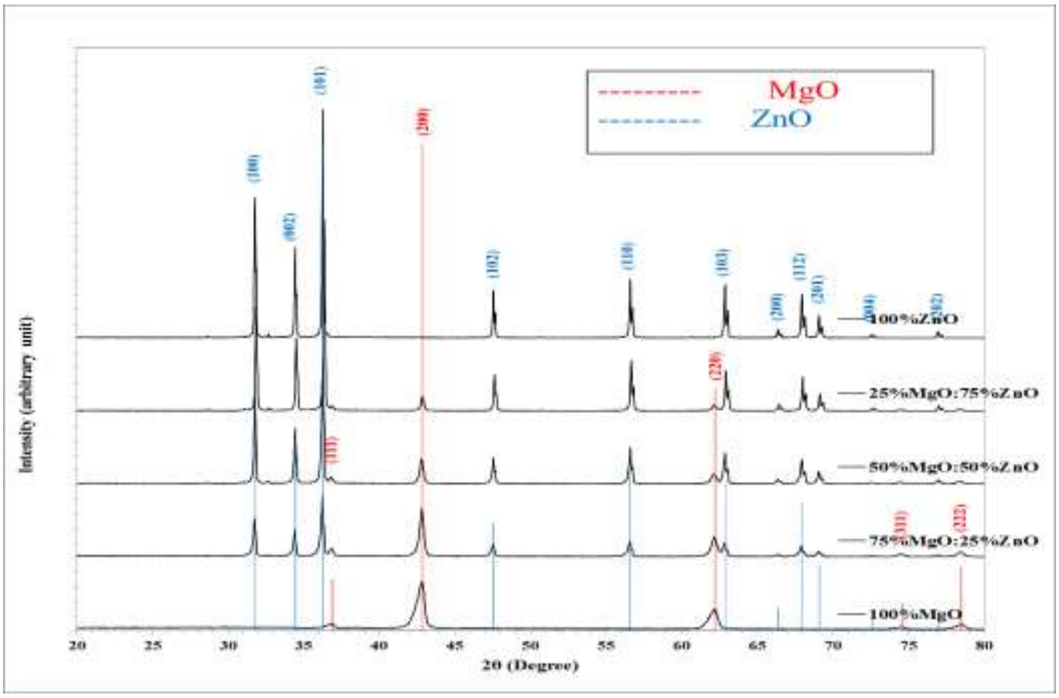

Figure 1: The X-ray diffraction pattern of MgO:ZnO composites.

Figure 2 shows the change of ln $\sigma_{a.c}(\omega)$ against ln angular frequency(ω) for MgO:ZnO with different ratios. Two regions can be noticed for 100%MgO and 25:75, the first region at high frequency usually called D.C region, this is due to the fast movement of charge carriers and jumping from one available site to another. Succeeded jumping to the nearest neighbor sites participate in the D.C conductivity, where the frequency is lower than that for the jumping named ωp. In the second region, the high frequency region, the frequency overtakes ωp, the conductivity showed proceeding increase with increasing of frequency [25-29].

The other composites showed only one region (the frequency dependent region). It can be observed that the conductivity is clearly affected by increasing the ZnO ratio. The conductivity increased by increasing the ZnO ratio up 75 % and then it decreased. Indeed, the conductivity increased from $3.95\text{x}10^{-8}$ to $3.41\ \text{x}10^{-5}$(ohm .cm)$^{-1}$ when ZnO ratio increased from 0 to 75 % and then fall to $1.78\ \text{x}10^{-6}$ (ohm .cm)$^{-1}$ with further increase of ZnO ratio. The exponent values (s) which were deduced from the slope of Figure 2 are shown in Table 1. It is worthy to note that the s values lie in the range $0 < s < 1$ where s takes a value of zero when there is an ideal Debye dielectric type while it takes a value of 1 for an the ideal ionic type [30-32].

It can be observed that (s) change in a non-regular manner i.e. decreases and increases by the continuous addition of ZnO. The reduction of (s) suggested that the correlated barrier hopping (CBH) is the most convenient model. This occurred when the electrons get to hope over the potential barrier between two neighbor sites. Here the alternative current conductivity $\sigma_{a.c}(\omega)$ takes place as a results of jumping between two states or dangling bonds (D+D−) [33-34]. The growing of (s) suggested that small poloran (SP) is the most suitable to illustrates the behavior of the fabricated composites. When the factor (s) increases with ZnO ratio, this is because of large amount of domestic lattice distortion, which is named small polaron,

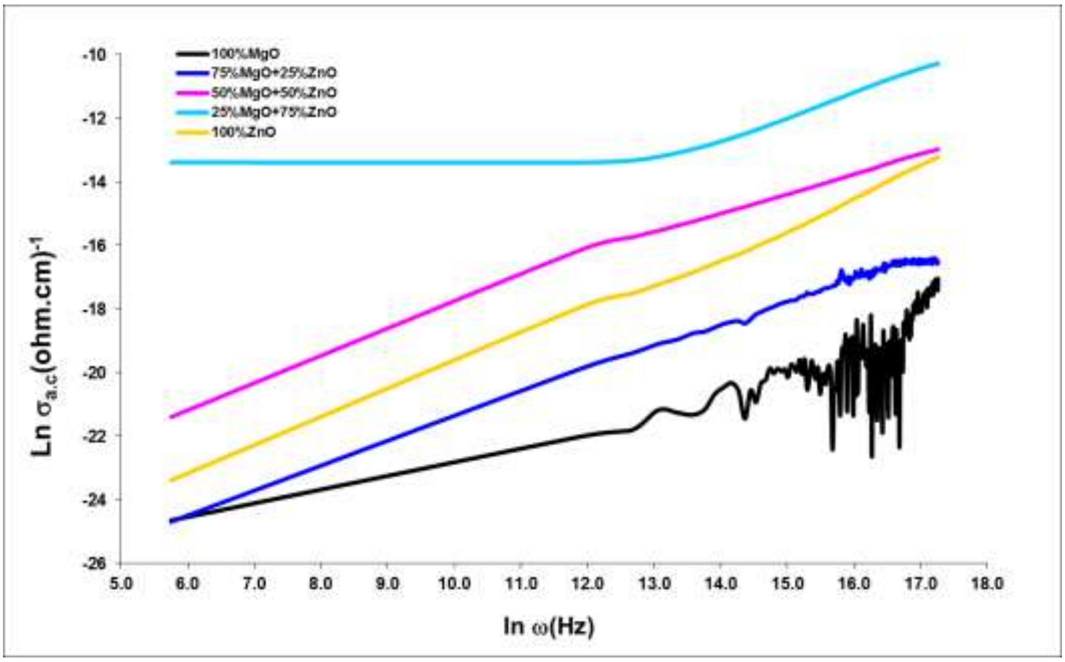

Figure 2: ln $\sigma_{a.c}(\omega)$ against Ln (ω) of MgO:ZnO composite of different ratios

The relative permittivity is the permittivity of a material expressed as a ratio with the electric permittivity of a vacuum. A dielectric is an insulating material, and the dielectric constant of an insulator measures the ability of the insulator to store electric energy in an electrical field.. The real part of the dielectric constant ε_1 is related to the energy store within the material meanwhile one cycle which supplied from the subjecting alternating electric field. Figure 3 and 4 shows variation of the dielectric constant ε_1 and the dielectric loss ε_2 with Ln (ω)of MgO:ZnO with different ratios 90/10,80/20,70/30 60/40 and 50/50).

The growing of ε_1 and ε_2 at low frequencies is due to two phenomena: electrode polarization and space charge effects [35]. The long distance travelled by the charge carriers at low frequencies results in high value of dielectric loss ε_2. The manifestation of small peaks for the composites samples with low ZnO ratio is ascribed to the relaxation phenomena where the dipoles are cable to stratify themselves according to the direction of the applied electric field giving rise to participating in the polarization process. Whereas at high frequencies, the dielectric constant ε_1 and dielectric loss ε_2 reach constant values. As the frequency increases the variation of the applied electric field become more fast that the charge carriers cannot pursue it, the participation of ε_1 and ε_2 to the polarization reach a small value [36,37]. It can be seen from Figure 3 and 4 that the value of ε_1 and ε_2 increased by increasing ZnO up 75% and then fall again; ε_1 increased from 1.23, to 287.68, by increasing ZnO from 0 to 75% and then decreased to 6.24 when ZnO ratio increased to 100 %. This is ascribed to the increase in number of charge carriers with increasing the amount of ZnO ratio. On the other hand, ε_2 increased from 0.717 to 55168 and the decreased to 2.52 when ZnO changed in the mentioned range.

The dielectric loss provided information about the amount of energy dissipated from charge carriers transporting and electrode polarization. The former sources of loss resulted from carriers precipitation at electrodes which are forced to oscillate in the same frequency of the applied field as soon as it was applied giving rise to dipolar relaxation as a peak in the dielectric loss spectra [38]. Stevels[39] explained this, that the increase in dielectric loss as the relaxation phenomenon resulted from many sources of losses like conduction, dipole and vibration. The increase of temperature results in an increase of conduction losses, which gives rise to an increment of the dielectric loss values.

Debye proposed that the relation between log ε_2 versus Ln (ω) forms curves which are symmetrical around angular frequency named ω_D which corresponded to maximum absorption according to the relation $\omega=1/\tau$, where τ is value of relaxation time which is defined as the reciprocal of frequency for jumping from one site to another. It can be seen that the only composites samples with low ZnO ratios i.e. (0, and 25%) declare absorption peaks.

The relaxation time increases but in a non- regular sequence by increasing the MgO ratio, see Table 1. The deduced values of relaxation are 8.58×10^{-6} sec decreased to 2.87×10^{-6} sec by increasing the ZnO ratio from 0 to 25%. The reduction of relaxation time with increasing ZnO is due to prompt movement of charge carriers that are concurrent with the direction of the applied electric field [40,41]

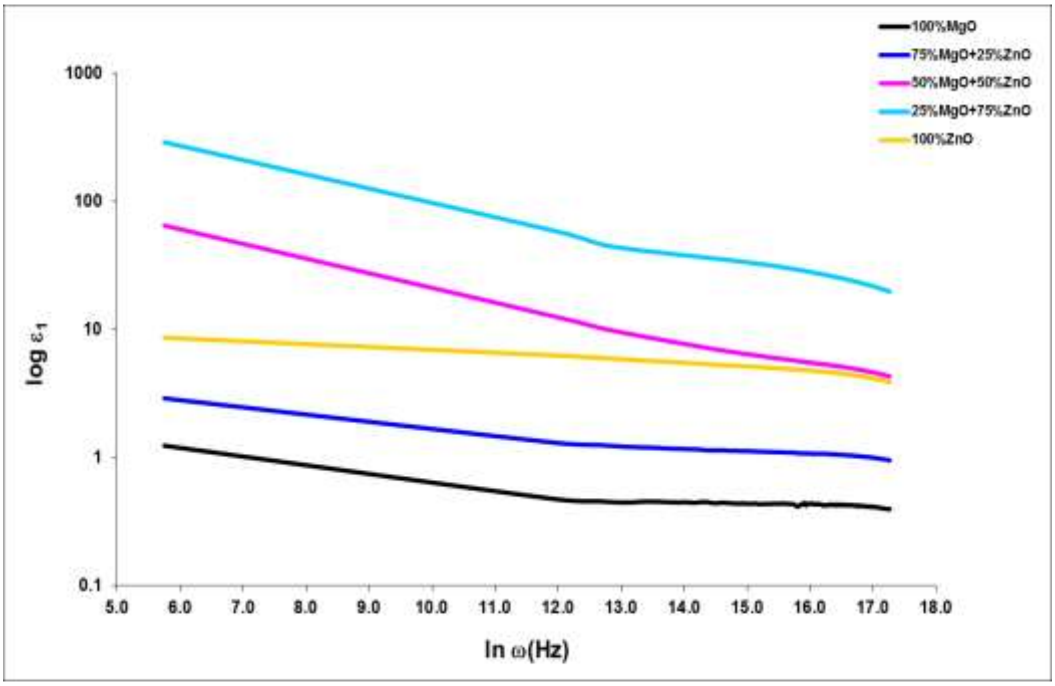

Figure 3: Variation of ε_1 against Ln ((ω) of MgO:ZnO with various ratios

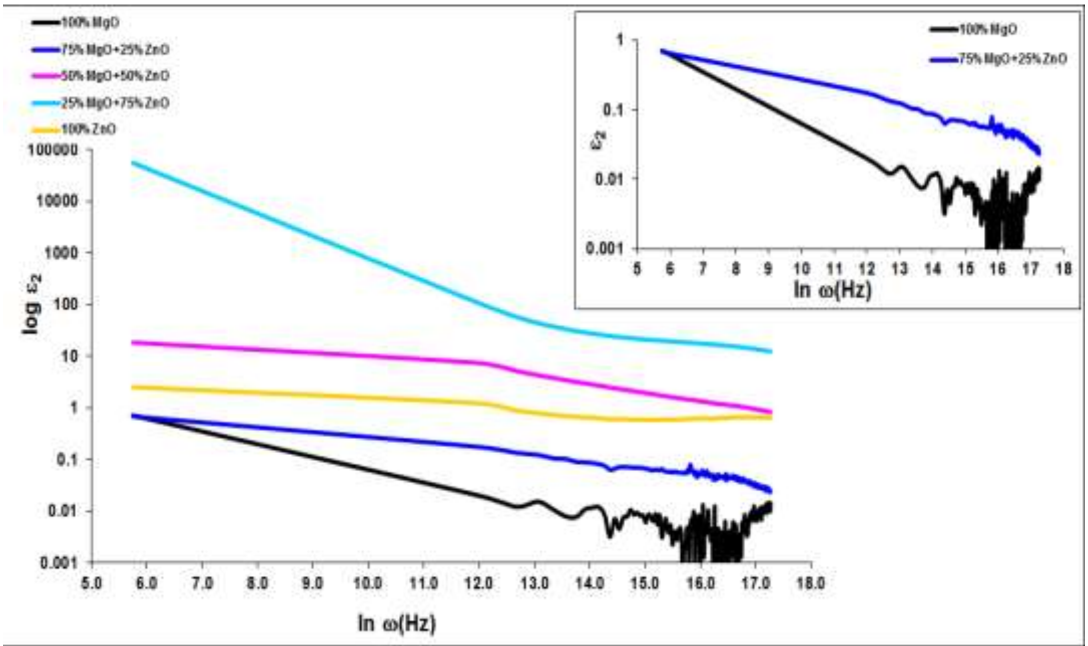

Figure 4: Variation of ε_2 against Ln ((ω) of MgO:ZnO with various ratios

The Cole-Cole drawing (ε_1 against ε_2) is the most important criteria for materials exhibiting one or more relaxation processes with analogous values and following the Cole-Cole formula. The plot equalization of the changing of dielectric loss ε_2 with dielectric storage ε_1 component at ambient temperature are shown in Figure 6. The semicircle figures are a proof of the existence of only one relaxation time. The polarizability can be measured from the relation $\theta = \alpha \frac{\pi}{2}$ where θ is the angle between the semicircle diameter and the dielectric storage axis .As can be seen from Table 1, the values increases as ZnO ratio increases from 0 to 50 % and then reaches a minimum value at 75% ZnO, then rises again for further increase of ZnO. On the other hand, the increase of the semicircle radius by increasing the ZnO ratio gives an indication that the continuous addition of ZnO reduced the relaxation time throughout making the movement of mobile charge carriers faster which is coincided with the conductivity values [42].

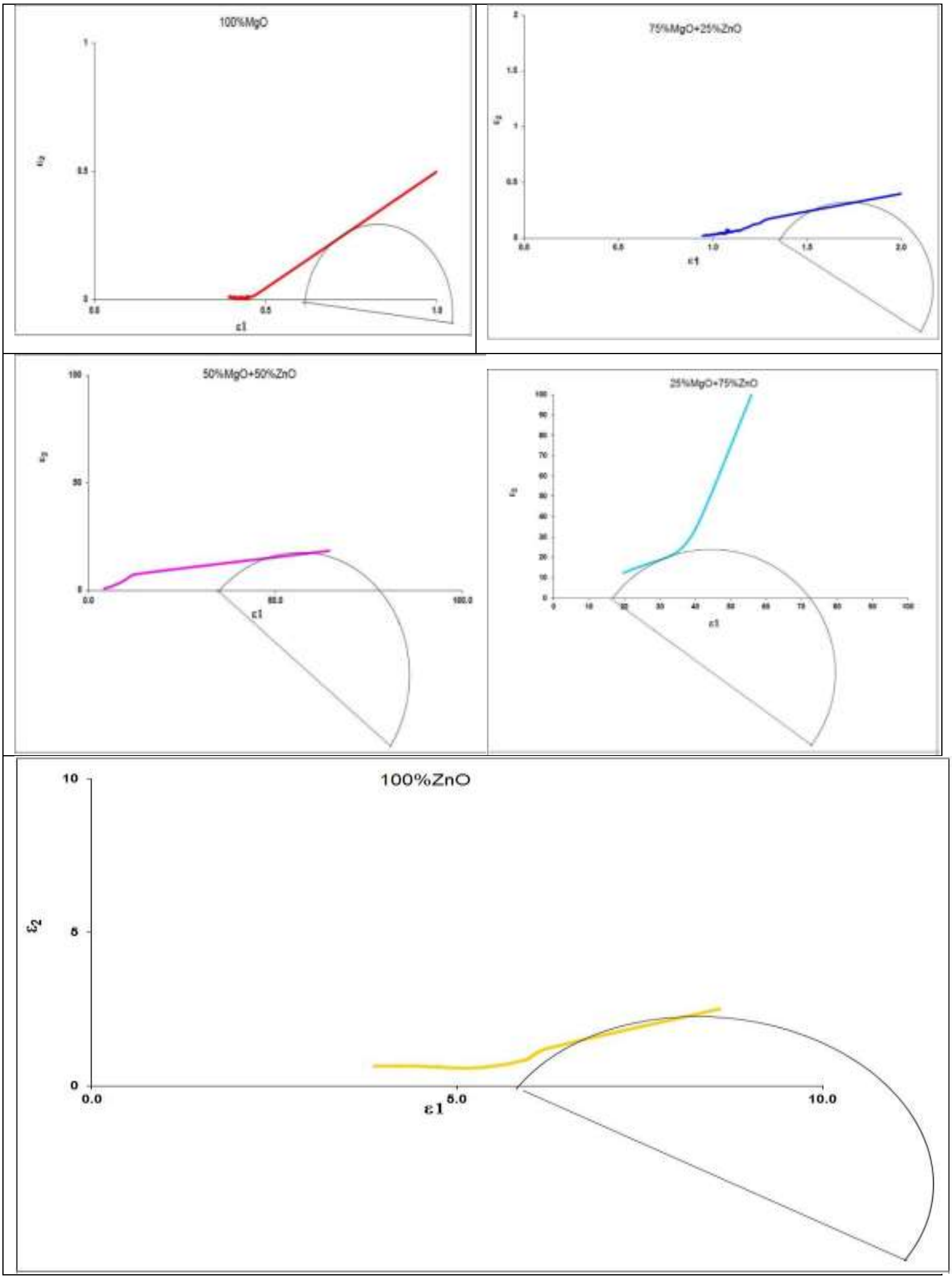

Figure 4: The plot of ε_1 versus ε_2 of MgO:ZnO with various ratios

Table 1: The values s, α, and τ for MgO:ZnO composites

Composites sample	The exponent factor (s)	Polarizability (α)	Relaxation time (τ) (sec)
100%MgO	0.748	0.1112	**$8.58x10^{-6}$**
75% MgO: 25%ZnO	0.628	0.4112	**$2.87x10^{-6}$**
50% MgO:50%ZnO	0.667	0.4667	**-**
25% MgO: 75%ZnO	0.540	0.3556	**-**
100%ZnO	**0.948**	**0.3777**	**-**

Conclusions

The structural, and dielectric properties of MgO:ZnO composites prepared using solid state reaction were investigated. Analysis of X-ray diffraction spectra affirms the structural enhancement and increase of crystalline size with the continues addition of ZnO. A reduction of dielectric constant and dielectric loss was noted by increasing the frequency. High dielectric constant value was achieved for the composite with 75 % ZnO which coincide with the high value of the electrical conductivity. The dielectric spectra as function of frequency and maximum peaks loss confirms relaxation in composites where the peak shifts toward the high-frequency side proposed faster charge carrier's movements.

References

[1] K. Movlaee, M. R. Ganjali , P. Norouzi and G. Neri," Iron-Based Nanomaterials/Graphene Composites for Advanced Electrochemical SensorsIron-Based Nanomaterials/Graphene Composites for Advanced Electrochemical Sensors", *Nanomaterials*, vol. 7, pp. 1-33, 2017.

[2] N. Ajami, J. Ordoukhanian," Preparation and Characterization of POAP/Fe_2O3 Magnetic Nanocomposite in One-Step Method", *Int. J. Electrochem. Sci*., vol. 13, pp. 424 – 432, 2018.

[3] R. I Agool , A. Hashim," Preparation of Polyvinyl alcohol- Poly-acrylic acid- Cobalt Oxide Nanoparticles Nanocomposites and Study their Optical Properties", *International Journal of Science and Research*, vol. 3, pp. 1729-1732, 2014.

[4] M. I. Ikim, E. Yu Spiridonova ,T.V Belysheva,F.V. Gromov ,G.N. Gerasimov, L.I.Trakhtenberg ," Metal Nanocomposites: Synthesis, Characterization and their Applications" *Russian Journal of Physical Chemistry B*., vol. 10, pp. 543-6, 2016.

[5] S.Stankic , S.Suman , F.Haque , J.Vidic ," Pure and multi metal oxide nanoparticles: synthesis, antibacterial and cytotoxic properties" *Journal of Nanobiotechnology*., vol. 14, pp. 73, 2016.

[6] K. Pauporte, D. Lincot," Electrodeposition of semiconductors for optoelectronic devices: results on zinc oxide" *Electrochimica Acta*., vol. 45, pp. 3345–3353, 2000.

[7] K. Ramanujam, M. Sundrarajan," Synthesis and Characterization of ZnO and MgO Nanoparticles through Green Approach and Their Antioxidant Properties" *J Photochem Photobiol, B*., vol. 141, pp. 296-300, 2014.

[8] Y. Yang, H. Chen, B. Zhao, X. Bao, J. Cryst," Size control of ZnO nanoparticles via thermal decomposition of zinc acetate coated on organic additives" *Growth*., vol. 263, pp. 447-453, 2004.

[9] B.Q. Xu, J.M. Wei, H.Y. Wang, K.Q. Sun, Q.M. Zhu," Effects of Process Parameters on the Size of Nanostructure Magnesium Oxide Synthesized by a Surfactant and Ligand Assisted Wet Chemical Method" *Catal. Today*, vol. 68, pp. 217-225, 2001.

[10] M. Purica, E. Budianu, E. Rusu, M. Danila, R. Gavrila," Optical and structural investigation of ZnO thin films prepared by chemical vapor deposition (CVD)" *Thin Solid Films*., vol. 485, pp. 403–404, 2002.

[11] Y. Li, Y. Bando, T. Sato," Novel bulk synthesis of magnesium oxide nanobelts networks by microwave hydrothermal route",*Chem. Phys. Lett*., vol. 359, pp. 141-145, 2002.

[12] J.H. Lee, K.H. Ko, B.O. Park," Effect of Camphor Sulfonic Acid Doping on Structural, Morphological, Optical and Electrical Transport Properties on Polyaniline-ZnO Nanocomposites" *J. Cryst. Growth*, vol. 247, pp. 119-125, 2003.

[13] K.F. Cai, E. Mueller, C. Drasar, A. Mrotzek," Synthesis and Characterization of Nanoparticles and Nanocomposite of ZnO and MgO by Sonochemical Method and their Application for Zinc Polycarboxylate Dental Cement Preparation" *Mater. Lett*., vol. 57, pp. 4251, 2003.

[14] H.S. Choi, S.T. Hwang," Sol-gel-derived Magnesium Oxide Precursor for Thin-film Fabrication" *J. Mater. Res*., vol. 15, pp. 842-845, 2000.

[15] T. Lopez, R. Gomez, J. Navarrete, E. Lopez- Salinas, " Evidence for Lewis and Brønsted Acid Sites on MgO Obtained by Sol-Gel" *J. Sol-Gel Sci. Technol*., vol. 13, pp. 1043–1047, 1998.

[16] R. Ayouchi, D. Leinen, F. Martin, M. Gabas, E. Dalchiele, J.R. Ramos-Barrado," Preparation and characterization of transparent ZnO thin films obtained by spray pyrolysis" *Thin Solid Films*, vol. 426, pp. 68-77, 2003.

[17] Y.Q. Zhu, W.K. Hsu, W.Z. Znou, M. Terrones, H.W. Kroto, D.R.W. Walton," STRUCTURAL AND OPTICAL PROPERTIES OF (ZnO/MgO) NANOCOMPOSITES" *Chem. Phys. Lett*., vol. 347, pp. 337-343, 2001.

[18] Y.C. Hong, H.S. Uhm," Synthesis of MgO nanopowder in atmospheric microwave plasma torch" *Chem. Phys. Lett*., vol. 422, pp. 174-178, 2006.

[19] Z.M. Dang, L.Z. Fan, S.J. Zhao, C.W. Nan," Synthesis of composite of ZnO spheres with polyaniline and their microwave absorption properties" *Sci. Eng. B*., vol. 99, pp. 386-389, 2003.

[20] A. Ohtomo, M. Kawasaki, T. Koida, K. Masubuchi, and H. Koinuma," Mg_x $Zn_{1-x}O$ as a II–VI widegap semiconductor alloy" *Appl. Phys. Lett*., vol. 72, pp. 2466, 1998.

[21] T. Minemoto, T. Negami, S. Nishiwaki, H. Takakura, Y. Hamakawa," Preparation of $Zn_{1-x}Mg_xO$ films by radio frequency magnetron sputtering" *Thin Solid Films*., vol. 372, pp. 173-176, 2000.

[22] S. Choopun, R.D. Vispute, W. Yang, R.P. Sharma, T. Venkatesan," Realization of band gap above 5.0 eV in metastable cubic-phase $Mg_xZn_{1-x}O$ alloy films" *Appl. Phys. Lett*., vol. 80, pp. 1529, 2002.

[23] K. Anandan1, D.Siva, K. Rajesh," Effect on Quality of Cement-Mortar by Inclusion of Nano Particle of Zinc Oxide" *International journal of engineering sciences & research technology*, vol. 7, pp. 8, 2018.

[24] N. Siregar, M. dan Johnny Panggabean, " The effect magnesium (Mg) on structural and optical properties of ZnO:Mg thin film by sol-gel spin coating method" *The 4th International Conference on Applied Physics and Materials Application Journal of Physics: Conference Series*, vol. 1428, pp. 012026, 2020.

[25] G. Dave and D. K Kanchan," Dielectric relaxation and modulus studies of PEO-PAM blend based sodium salt electrolyte system" *Indian Journal of Pure & Applied Physics*, vol. 56, pp. 978-988, 2018.

[26] B. A.Hasan, Ikhlas H.Shalal," AC ELECTRICAL CONDUCTIVITY ANALYSIS OF (PVC-PS) BLEND FILMS" *Iraqi Journal of Physics*, vol. 11, pp. 47-57, 2013.

[27] B. A.Hasan E. M. Nasir. " Structural Morphology and Electrical Properties of Vacuum Evaporated SnS Thin Films" *International Journal of Current Engineering and Technology*, vol. 5, 2015.

[28] B. A. Hasan and Hiba H. Issam " Dielectric properties and A.C electrical conductivity analysis of $(La_2O_3)_{1-x}(ZnO)_x$" *2nd International Scientific Conference of Al-Ayen University IOP Conf. Ser.: Mater. Sci. Eng.*, vol. 928, pp. 072003, 2020

[29] B. A. Hasan and Hiba H. Issa," Effect of thickness on the structure, morphology and A.C conductivity of Bi_2S_3 thin films" *Iraqi Journal of Physics*, vol. 15, pp. 87-95, 2017.

[30] S.Nasri, A. B. Hafsia, M. Tabellout, M. Megdiche." omplex impedance, dielectric properties and electrical conduction mechanism of La0.5Ba0.5FeO3−δ perovskite oxides" *RSC Advances*, vol. 6, pp. 76659, 2016.

[31] A. K. Jonscher." Analysis of the alternating current properties of ionic conductors" *Journal of Materials Science*, vol. 13, pp. 553, 1978.

[32] A.N.Papathanassiou,I. Sakellis, J. Grammatikakis," Universal frequency-dependent ac conductivity of conducting polymer networks" *Applied Physics Letters*, vol. 91, pp. 122911, 2007.

[33] K. W. Boerm and S. R. Ovshinsky," Electrothermal Initiation of an Electronic Switching Mechanism in Semiconducting Glasses" *J. Appl. Phys*., vol. 41, pp. 2675, 1970.
[34] M.Leon , G.Van Tendeloo and R. Diaz" The reconstruction of a three-dimensional structure from projections and its application to electron microscopy" *J. Microsc. Spectrosc. Electron*, vol. 13, pp. 99, 1988.
[35] P.Sharma ,D.K Kanchan and N.Gondaliya ." Effect of nano-filler on electrical properties of PVA-PEO blend polymer electrolyte" *Ionics*, vol. 19, pp. 777, 2013.
[36] S.Navaratnam , K.Ramesh , S.Ramesh , A.Sanusi , W.J .Basirun and A.K.Arof ," TRANSPORT MECHANISM STUDIES OF CHITOSAN ELECTROLYTE SYSTEMS " *Electrochim Acta*, vol. 175, pp. 68, 2015.
[37] R.Sathymoorthy." Structure, Dielectric, and AC Conduction Studies on Yttrium Fluoride Thin Films" *Phys.Stat.Sol. A*., vol. 117, pp. 495, 1990.
[38] R.Coelho, " Sur la relaxation d'une charge d'espace" *Revue Phys Appl*, vol. 18, pp. 137-146, 1983.
[39] J. M. Stevels and S. Flugge." *Universal low-temperature ac conductivity of macroscopically disordered nonmetals*" *Handbuch der physik, Edn,(Springer: Berlin*), vol. 350, 1957.
[40] P .Pradeepa, S.Edwinraj and Ramesh, " Synthesis and Characterization of a Hydrophilic/Hydrophobic IPN Composed of Poly(vinyl alcohol) and Polystyrene" *P M. Chin Chem Lett*, vol. 26, pp. 1191,2015.
[41] A.A. Hasan," Dielectric Study of PVC-LiF Composites Films", *Iraqi Journal of Science*, vol. 62, pp. 861-870,2021.
[42] A. Arya, A. L. Sharma," Transition metal dichalcogenide (TMDs) electrodes for supercapacitors: a comprehensive review" *Journal of physics :Condensed Matter*, vol. 33, 2021