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Influence of Exposure $Cd_{1-x}Mg_x Fe_2O_4$ Compound by RF Plasma

Alyaa Hefdhi Abbas Aziz[1*], Mohammed A. Al-Shareefi [2] and Abdulhussain Abbas khadyair [3]

[1]College of Science, University of Babylon, alyaahofdi.phy@gmail.com, Hilla, Province, Iraq.
[2]College of Science, University of Babylon, sci.mohammed.abdul@uobabylon.edu.iq,, Hilla, Iraq.
[3]College of Education, University of AL-Qadisiyah, abdulhussain.khadyair@qu.edu.iq.,, Diwaniyah , Iraq.
*Corresponding author email: sci.alyaa.hofdhy@uobabylon.edu.iq; mobile: 07803780309

تأثير التعرض لمركب $Cd_{1-x}Mg_x Fe_2O_4$ بواسطة بلازما RF

علياء حفظي عباس [1*]،محمد عبد الامير الشريفي[2]، عبد الحسين عباس خضير[3]

[1] كلية العلوم، جامعة بابل، alyaahofdi.phy@gmail.com ، الحلة , العراق
[2] كلية العلوم ، جامعة بابل، sci.mohammed.abdul@uobabylon.edu.iq ، الحلة، العراق
[3] كلية التربية ، جامعة القادسية ، abdulhussain.khadyair@qu.edu.iq ، الديوانية ، لعراق

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ABSTRACT

Background:

The work focuses on enhancing the structural properties, where the Cd_{1-x} Mgx Fe_2O_4 products prepared by sol-gel solution were characterized. Auto ignition approach using several automated equipment, as FESEM, XRD, for concentrations (x=0.0,0.8 and 1), post-synthesis plasmas were exposed in a low-pressure chamber using the RF Magnetron Sputtering System and the results compared. by X-ray diffraction analysis, confirms the configuration to the FCC cubic structure of the studied samples. Plasma treatment did not affect the crystallization but the crystal size (D) of the particle size decreases after exposure to plasma from (32.33- 27.083)nm . Morphological studies confirmed surface shape changes and particle size reduction upon exposure to plasma.

Materials and Methods:

The sol-gel method common and old a chemical process for the production of a variety of nanostructures, most notably nanoparticles of metal oxide. In which The molecular feedstock is combined with water or alcohol and then subjected to moderate heating while being agitated. The basic principle pertaining to the sol-gel technology is to manufacture a homogenous solution created from raw materials also then gelatinized . The powders are ground and sintered in a refractory oven at 1100 ° C for 6 hours. The powder was then pressed by a hydraulic press at a pressure of 150 kN into molds to form a disc with a diameter of 20 mm. The work will take place in two phases: before exposing it to the plasma, and then when the samples are placed into the RF Magnetron Sputtering.

Results:

The X-ray measurements showed that the un-exposure and plasma- exposure samples have a cubic spinel structure, and that the variation of the structural parameters with the exposure is irregular, Consequently enhancing the atoms' ability to diffuse after being put onto the substrate and grain size of the sample. The morphological analysis of the as-prepared ferrite $Cd_{1-x}MgxFe_2O_4$ samples was performed using FE-SEM, which gives details on the size and structure of the particles that make up the nanocrystals. The surface exposed to the plasma shows a change in the positions of the crystals and their cohesion with each other , which may result from a decrease in supermagnetic effect and lattice defects in Ferrite nanocrystalline films.

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Conclusion:

The aim of this work is to synthesize $Cd_{1-x}Mg_x Fe_2O_4$ ferrite nanoparticles in spinel cube structure by sol-gel self-combustion method. Then, the synthesis of thermal plasma using Radio frequency (RF) plasma, where the structural properties, surface shape, and interpretation were studied properties of ferrite nanoparticles produced before and after plasma exposure. According to the conducted XRD investigations the validity of the cubic spinel structure of ferrite and that the irregular difference in the size of the crystals before and after the exposure, the particle size decreases after exposure to plasma from (32.33- 27.083)nm, and the capillary parameter they were reduced from (8.892 to 8.743)nm for plasma-treated samples. the results obtained from shaping cubic spinel phase in both iron nanoparticles before and after plasma exposure supported by the XRD results. The morphological study revealed irregularity grain distribution and dominant agglomeration in ferrite before and after exposure.

Key words:

RF Magnetron Sputtering; $Cd_{1-x} Mg_xFe_2O_4$ component; FESEM; XRD spectra; .

الخلاصة

يهدف هذا العمل على تحسين الخواص التركيبية ، حيث تم تحضير مركبات Cd_{1-x} Mgx Fe_2O_4 المحضرة بطريقة سول-جل للإشتعال التلقائي باستخدام العديد من المعدات الآلية ، مثل FESEM و XRD للتركيزات (x=0.0,0.8, 1)،. تم تعريض البلازما بعد التوليف في غرفة الضغط المنخفض باستخدام تقنية RF Magnetron Sputtering System ومقارنة النتائج. من خلال تحليل حيود الأشعة السينية ، يؤكد التكوين على الهيكل المكعب FCC للعينات المدروسة. لم تؤثر معالجة البلازما على التبلور ولكن الحجم البلوري (D) لحجم الجسيمات يتناقص بعد التعرض للبلازما من (32.33 - 27.083) نانومتر. أكدت الدراسات المورفولوجية تغيرات شكل السطح وتقليل حجم الجسيمات عند التعرض للبلازما.

مقدمة:

تدخل تقنية النانو في عدد كبير من المجالات التكنولوجية المختلفة ، حيث يكون النموذج الموحد للهيكل هو الجسيمات النانوية. تتميز الجسيمات النانوية النموذجية من نوع الامتداد ببعض الخصائص التي تميزها عن غيرها، بما في ذلك المقدار الكبير من المساحة المكشوفة لحجم النانو، ومغناطيس التشبع العالي والسلوك المغناطيسي المفرط النشاط [1]. بلورات فيريتس بتقنية النانو هي مواد عزل جيدة تختلف باختلاف التركيب البلوري وطريقة التحضير [2]. وتعتمد خصائص الجسيمات النانوية بشكل كبير على تكوينها ، وتشكلها، والحجم المرتبط بظروف تحضير هذه المواد، وهذا يعني أن خصائص تقنية النانو ، والتي يمكن هندستها أثناء عملية التصنيع [3]. هناك العديد من طرق التحضير، مثل الترسيب المشترك الحراري المائي، الانحلال الحراري، استخدام هلام محلول مائي ومزيل عكسي ،منها يمكن إنتاج جزيئات الفريت النانوية [4]. كان الفريت عبارة عن طبقات لينة تمت إزالتها بسهولة بسبب قوة قهرها المنخفض، وهو أساس تصنيفها كواحدة من فئتين على أساس المقاومة المغناطيسية ومغناطيسية القوة القهرية: صلبة وناعمة [5]. يحتوي الفريت الصلب على قوة قسرية عالية وهذا يؤدي إلى صعوبة إزالة المغناطيسية ويتم استخدامه في إنشاء أجهزة مغناطيسية دائمة مثل تلك المستخدمة في الثلاجات والمحركات الكهربائية ومكبرات الصوت الأخرى [6]. تم الإبلاغ أيضًا عن أن فريت المغنيسيوم يولد حرارة عالية ، مقارنة بالفريتات الأخرى، عندما يكون حجم الحبوب في نطاق نانومتر [7]

$MgFe_2O_4$ نظرًا لمقاومتها الكهربائية العالية ودرجة حرارة Curie ، فضلاً عن قيمتها العالية لمغنطة التشبع، لها العديد من الاستخدامات المهمة، وهي أيضًا مادة مغناطيسية ناعمة ولها مجموعة إسبنيل مقلوبة واحدة. مادة شبه موصلة لها تطبيقات في التكنولوجيا المغناطيسية وأجهزة الامتزاز وتكنولوجيا الاستشعار. [8] الكادميوم الفريت $CdFe_2O_4$ له هيكل شبيه بالمرحلة المستقرة، حيث تملأ أيونات الكادميوم والحديد رباعي السطوح (مواقع أ) وثماني السطوح (مواقع ب)، على التوالي (مواقع)، على التوالي، مع تعبئة مكعبة قريبة من

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أيونات الأكسيد [9]. على الرغم من المعرفة الواسعة بأن الإسبنيل العادي CdFeO يعمل كمغناطيس مضاد عند درجة حرارة Néel البالغة 13 كلفن، فإن التجميد الدوراني مع ارتباط قصير المدى يحدث فقط عند 13 كلفن، لا يوجد دليل على طلب بعيد المدى حتى 0.1 كلفن باستخدام القياسات التي تم الحصول عليها من تجارب نثر النيوترونات [10]. تستخدم بلازما التردد الراديوي (RF) بشكل شائع كعلاج سطحي أو تقنية ترسيب تستخدم البلازما ذات درجة الحرارة المنخفضة في مجموعة متنوعة من الصناعات، بما في ذلك الإلكترونيات والفضاء وعلم الأحياء [11]. تحتوي بلازما التردد الراديوي على أيونات عالية الطاقة وأنواع تفاعلية على نطاق واسع تستخدم في حفر السطح وترسيب أشباه الموصلات ذات الأغشية الرقيقة. بغض النظر عن ذلك ، فإن تشخيصه أمر بالغ الأهمية في تحديد العلاقة بين خصائص البلازما والمنتج النهائي [12].

طرق العمل:

طريقة sol-gel شائعة وقديمة عملية كيميائية لإنتاج مجموعة متنوعة من الهياكل النانوية ، وأبرزها الجسيمات النانوية من أكسيد المعدن. حيث يتم دمج المواد الأولية الجزيئية مع الماء أو الكحول ثم تعريضها لتسخين معتدل أثناء التقليب. المبدأ الأساسي المتعلق بتقنية sol-gel هو تصنيع محلول متجانس تم إنشاؤه من المواد الخام أيضًا ثم تحويله إلى مادة هلامية. يتم طحن المساحيق وتلبيدها في فرن حراري عند 1100 درجة مئوية لمدة 6 ساعات. تم بعد ذلك ضغط المسحوق بواسطة مكبس هيدروليكي بضغط 150 كيلو نيوتن في قوالب لتشكيل قرص بقطر 20 مم .سيتم العمل على مرحلتين: قبل تعريضه للبلازما ، ثم عند وضع العينات في RF Magnetron Sputtering.

الاستنتاجات:

أظهرت قياسات الأشعة السينية أن عينات عدم التعرض والتعرض للبلازما لها هيكل إسبنيل مكعب ، وأن تباين المعلمات الهيكلية مع التعرض غير منتظم، وبالتالي تعزيز قدرة الذرات على الانتشار بعد وضعها على الركيزة وحجم الحبوب للعينة .تم إجراء التحليل المورفولوجي لعينات الفريت المحضرة $Cd_{1-x}MgxFe_2O_4$ باستخدام FE-SEM، والذي يعطي تفاصيل عن حجم وهيكل الجسيمات التي تشكل البلورات النانوية. يظهر السطح المعرض للبلازما تغيرًا في مواضع البلورات وتماسكها مع بعضها البعض، والذي قد ينتج عن انخفاض في التأثير المغنطيسي الفائق وعيوب الشبكة في أفلام الفريت النانوية.

الكلمات المفتاحية:

RF الاخرق مكنترون للترذيذ . مكون Cd_{1-x} $MgxFe_2O_4$,FE-SEM. أطياف XRD .

INTRODUCTION

Nanotechnology enters a vast number of different technology domains, where the uniform model is the nanoparticles of the structure. Model nanoparticles of the type of spanne have some characteristics that distinguish them from others, including the substantial amount of exposed space to the nanopolitan size, high saturation magnet and hyperactive magnetic behavior. Nanotechnate Verits crystals are good insulation materials that have a difference depending on the crystal composition and the method of preparation. The characteristics of the nanosomic particles of the highly dependent on their composition, morphology, and the size associated with the conditions of preparing these materials, this means that the characteristics of the nanotechnitus, which can be engineered during the synthesis process. There are several preparation methods, such as hydrothermal co-precipitation, pyrolysis, Using sol-gel and reverse micelle, ferrite nanoparticles may be produced[1-4].

Ferrite was Soft layers are readily demagnetized owing to their low coercion, which is the basis for their classification as one of two categories based on magnetic resistance and compulsive

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force magnetism: hard and soft. Hard ferrite has a high coercive force and this leads to the difficulty of demagnetization and is put to use in the creation of lasting magnetic devices such such as those used in refrigerators, electric motors, and other loudspeakers. Magnesium ferrite has also been reported to generate high heat, compared to other frites, when the grain the size is in the range nm [5-7].

MgFe$_2$O$_4$ because of its high electrical resistivity and Curie temperature, as well as its high value of saturation magnetization, has many important uses, and it is also a magnetic substance that is soft and has one inverted spinel groups .MgFe$_2$O$_4$ is an additional n-type semiconductor substance that has applications in magnetic technology, adsorption devices, and sensor technology. Cadmium ferrite CdFe$_2$O$_4$ has a regular-like structure as a stable phase, with Cd and Fe ions filling tetrahedral (A sites) and octahedral (B sites), respectively(B sites), respectively, with close cubic packing of oxide ions[8 and9].

Despite widespread knowledge that ordinary CdFe$_2$O $_4$spinel acts as an antimagnetic at a Néel temperature of 13 K, spin freezing with short-range correlation really takes place only at 13 K, there is no evidence of long-range ordering up to 0.1 K. Using measurements obtained from neutron scattering experiments. Radio frequency (RF) plasma is commonly used as a surface treatment or precipitation technology low-temperature plasma is used in a variety of industries, including electronics, aerospace and biology. Radiofrequency plasma contains high-energy ions and widely reactive species that are used in surface etching and thin-film semiconductor deposition. Regardless and its diagnosis is critical in determining a relationship between plasma properties and the final product [10-12].

Materials and Methods

- **Sample preparation**

A process known as the sol-gel method common and old a chemical process for the production of a variety of nanostructures, most notably nanoparticles of metal oxide. In which The molecular feedstock is combined with water or alcohol and then subjected to moderate heating while being agitated in order to precipitate a gel via the process of hydrolysis/alcohol. The sol-gel technique is a synthetic approach that may be used to produce nanoparticles with a wide range of different chemical compositions. The basic principle pertaining to the sol-gel technology is to manufacture a homogenous solar solution created from raw materials also then gelatinized [13 and14]. In order to protect the qualities of the product from the influence of impurities of the prepared compound, a raw material of this research makes use of very pure materials. The purity raw materials material employed in the fabrication of sol-gel samples is between 99% and 98%.

In this research Cd$_{1-x}$ MgxFe$_2$O$_4$ this sample size for this work was adequate nitrate and citric acid for their synthesis. In a baker with a capacity of 400 ml, the raw ingredients were mixed with 200 ml of deionized distilled water, and the mixture was baked mixture was mixed with a homogenizer a heated the magnetic stirrer for continuous stirring (model JENWAY-1000). By adding ammonia to the solution and keeping it heated for two hours on a heater set to 60 degrees

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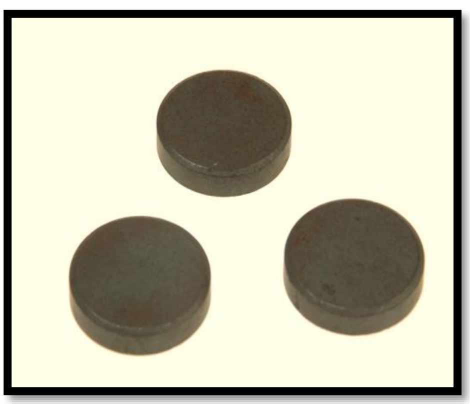
Celsius, the PH level of the solution was brought up to 8. The gels were dried for 2 hours at 120 °C and then spontaneously combusted to form a loose powder after ignition in air at room temperature. After that, the powders are ground and sintered in a refractory oven at 1100 ° C for 6 hours, and the grinding process is repeated until it becomes homogeneous. The powder was then pressed by a hydraulic press at a pressure of 150 kN into molds to form a disc with a diameter of 20 mm, Figure(1) . The work will take place in two phases: before exposing it to the plasma, and then when the samples are placed into the RF Magnetron Sputtering, pure argon gas (99.9% impurities) was used.

- **Composition of RF Magnetron Sputtering System:**

The system incorporated three main parts, the cavity (chamber) , control box, and RF power supply. The chamber covered by a upper surface with three magnetron targets built-in connected to RF power supply (single target connection each time), also the targets are connected to water chiller to keep the targets cooled. The second part is the control box which contains a touch screen to control starting of system, flowing of gas, sample rotation speed and stage temperature setting, in addition to inlet gas and air switch. As shown in Fig. (2).The third part is the RF power supply.



Figure(1): Molds a disc of ferrite.

Figure(2):Composition of RF magnetron sputtering system.

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Results and Discussion

X-ray diffraction studies

For a phased analysis of the order to control the formation Cubic and tetrahedral structures were used Powder X-ray diffract graphs. Figure (3) The XRD spectra of Cd $_{1-X}$Mg$_X$ Fe_2O_4 doped with various Mg^{+2} concentrations are reported. The XRD patterns revealed the pure crystalline nature of the prepared $Cd_{1-X}Mg_X$ Fe_2O_4 with no secondary phases/impurities, confirming the product's high purity of the Cubic spinel structure. This suggests when examining $Cd_{1-x}ZnxFe_2O_4$, the ferrite compound $CdFe_2O_4$ was identical to the card (No. 96-591-0006). It was discovered that the ferrite compound made of pure $MgFe_2O_4$ was contaminated with manganese ion is multi-crystallized in varying amounts and in the direction of preference (222) and identical to the card((No. 96-591-0006) . As shown in Figures (1a,b) that demonstrate the face centred cubic spinel phase (FCC) .

When the cadmium ion is substituted with a magnesium ion, the height of the peak decreases with increasing crystal size, We also see that the shift occurs to the right, towards $CdFe_2O_4$, and a decrease as a result of the increase in volume, there is a rise in the potency of the cadmium ferritic compound.

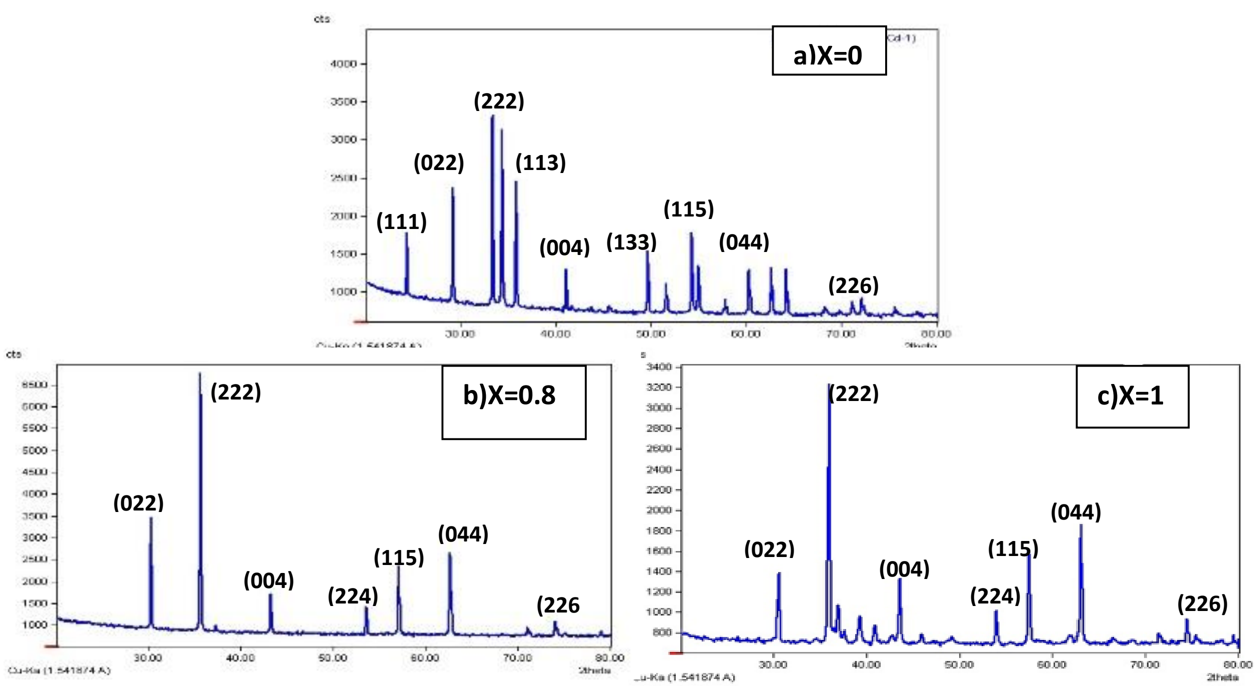

Figure (3): X-Ray patterns of Cd $_{1-X}$Mg$_X$ Fe_2O_4 with different ratio(x) Mg before plasma exposure .

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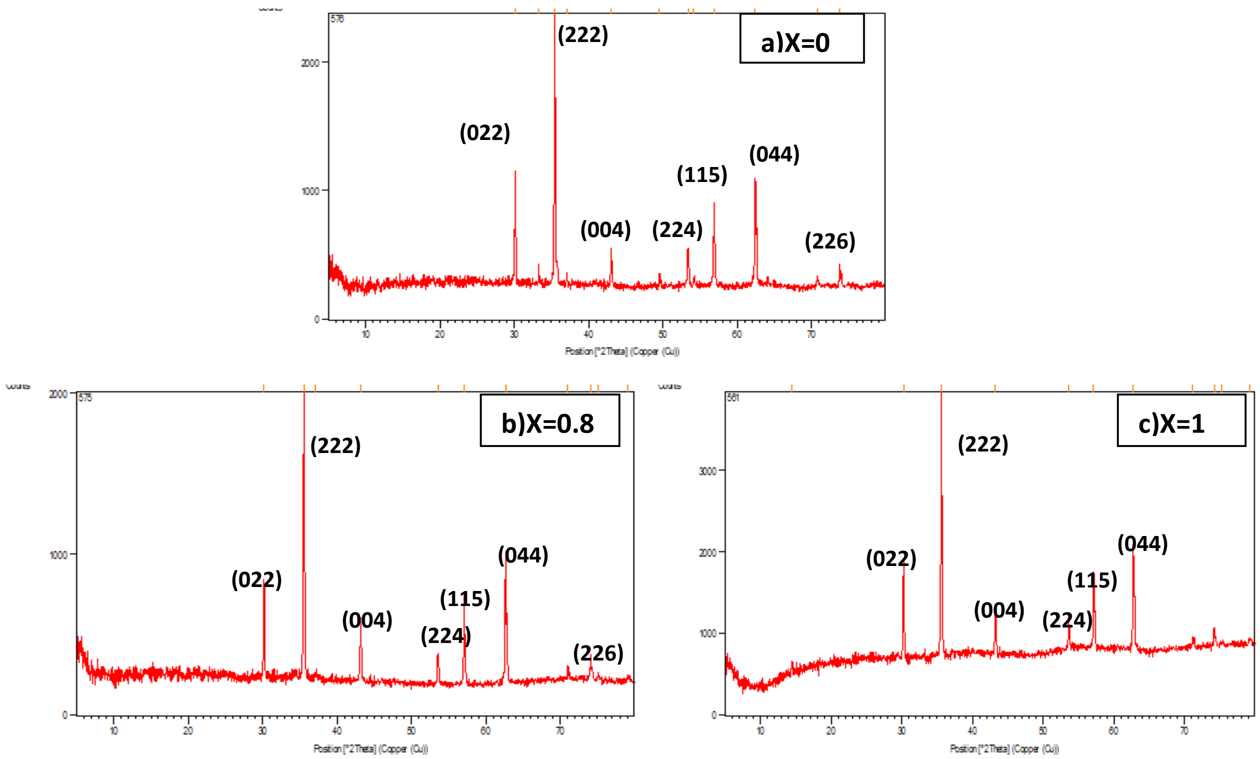

Figure (4): X-Ray patterns of Cd $_{1-X}$Mg$_X$ Fe$_2$O$_4$ with different ratio(x) Mg after plasma exposure.

Crystal size (D), which can be taken as an indicator for the size of the granules, as shown in Table (1). It was observed that (D) decreased after plasma exposure. At x = 0, the value of(a) decreased, but the rest of the concentrations values the lattice parameter (a) increased after plasma exposure. Thus, the X-ray measurements showed that the un-exposure and plasma- exposure samples have a cubic spinel structure, and that the variation of the structural parameters with the exposure is irregular, Consequently enhancing the atoms' ability to diffuse after being put onto the substrate and grain size of the sample[15 and 16].

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Table (1): Structural parameters of Cd $_{1\text{-}X}$Mg$_X$ Fe$_2$O$_4$.

The Constituent	(hkl)	Peak-position (2theta)	Size of Crystallite D (nm)before plasma exposure.	Size of crystallite D (nm)after plasma exposure.	a(nm) before plasma exposure	a(nm) after plasma exposure
CdF_2O_4	*(222)*	*35.04*	*32.78025*	*36.35334*	*9.0923*	*8.76738*
$Cd_{0.2}$ $Md_{0.8}Fe_2O_4$	*(222)*	*35.52*	*36.49799*	*22.41938*	*8.8401*	*8.7466*
$MgFe_2O_4$	*(222)*	*35.58*	*27.64796*	*22.49516*	*8.7569*	*8.73205*

Surface morphology properties

The morphological analysis of the as-prepared ferrite $Cd_{1-x}Mg_xFe_2O_4$ samples was performed using FE-SEM, which gives clear details on the size and structure of the particles that make up the nanocrystals. Figure 5 shows the surface shape and size distribution. And from which Figure(7a) corresponding to the FESEM image in Figure (8c), It has been shown that the nanoparticles have a propensity to agglomerate, at least to some degree. This is most likely the result of the absence of a stabilizer that is both efficient and effective. Nanocrystals were found for each of the prepared compounds as shown in the figures, and the particles differ from each other in size, and the particle size increases as cadmium ions Cd^{+2} are replaced by magnesium ions.

After the exposure of the compound $Cd_{1-X}Mg_X$ Fe_2O_4 to plasma, we notice a change in the topography of the surface, also a clear change at the most concentration in the surface structure after exposure to the plasma Figure (8), and the surface exposed to the plasma shows a change in the positions of the crystals and their cohesion with each other after the plasma carries them away to most concentrations, which may result from a decrease in super magnetic effect and lattice defects in Ferrite nanocrystalline films [17and18].

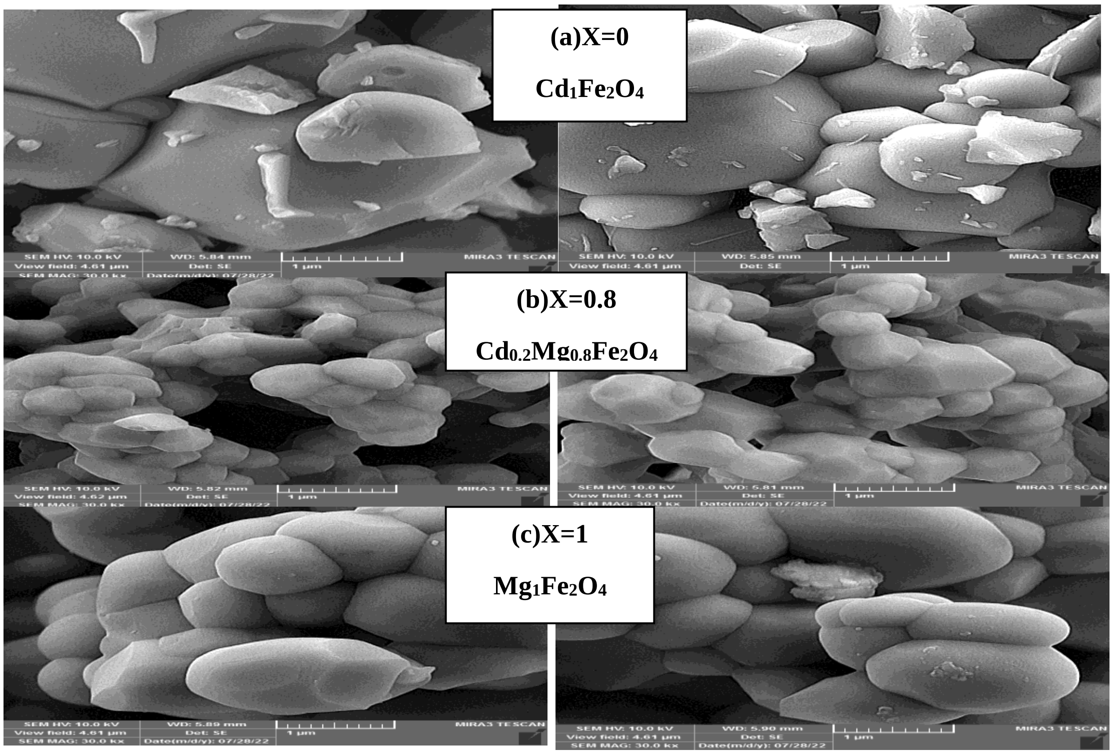

Figure (7). FESEM images of $Cd_{1-x}Mg_xFe_2O_4$ nanoparticles at different ratios of Mg^{+2} before plasma exposure.

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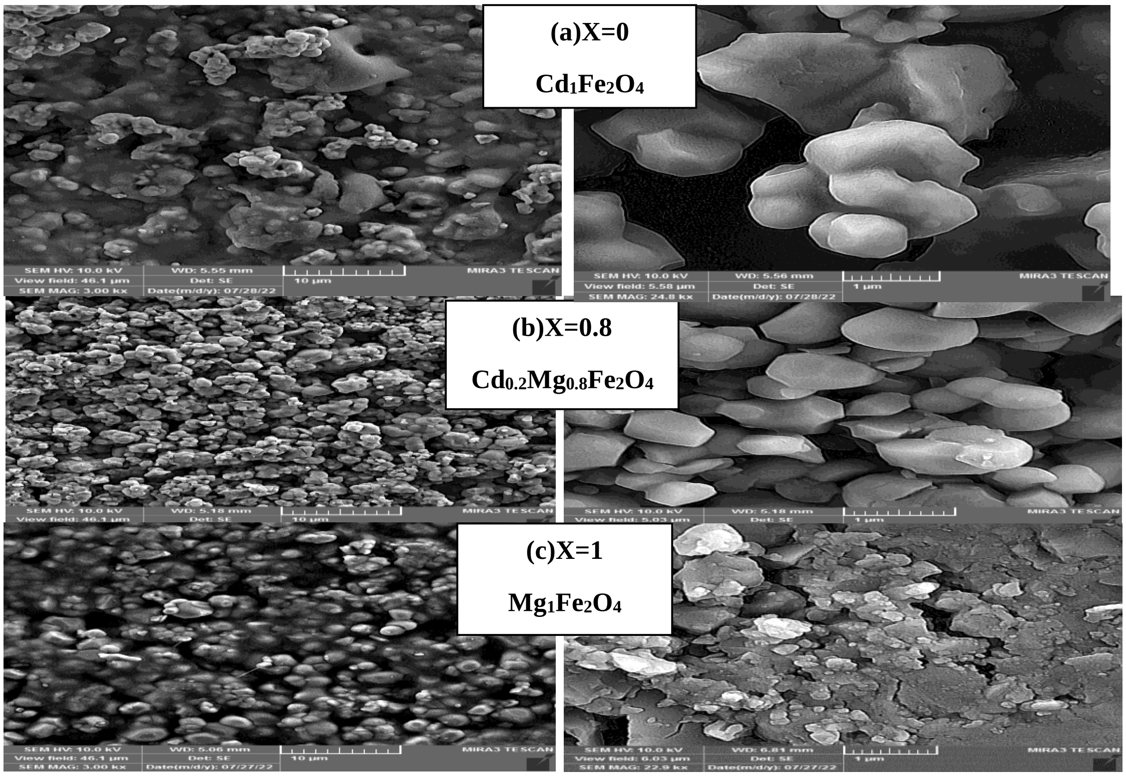

Figure (8): FE-SEM images of $Cd_{1-x}Mg_x Fe_2O_4$ with different ratios of Mg after plasma exposure.

Conflict of interests.

There are non-conflicts of interest.

References

[1] S. Pande , M. Islam, S. Mohanta and Nasiruddin, “Single-Step Synthesis of Manganese Ferrite Nanoparticles with Enhanced Magnetization via Chemical Co-precipitation Route”, Journal of Scientific Research, vol.11, no.2, pp.225-234, may 2019.

[2]S. Laurent, D. Forge, M. Port, A. Roch, C. Robic, L. Vander and R. Muller, “Magnetic Iron Oxide Nanoparticles: Synthesis, Stabilization, Vectorization, Physicochemical Characterizations, and Biological Applications”, American Chemical Society ,vol.108, no.6,pp. 2064–2110,2008.

[3] V. Awati, “Structural Dielectric and Magnetic Properties of Ni Substitution in Cu-Zn Nano Ferrite”, International Journal of Current Research, Vol. 5,no.12, 2013.

[4] P. Sakthivela, R. Murugana, S. Asaithambia, M. Karuppaiaha, G. Vijayaprasathb, S. Rajendrana, Y. Hayakawac, G. Ravia, “Radio Frequency Power Induced Changes of Structural, Morphological, Optical and Electrical Properties of Sputtered Cadmium Oxide Thin Films”, Thin Solid Films, vol. 654, no.6,pp. 85–92,2018.

[5] C. Carter and M. Norton, “Ceramic Materials Science and Engineering”, Springer, 2013.

[6] N. Kılınç, L. Arda, S. Ozturk, Z. Ozturk, “Structure and Electrical Properties of Mg-Dopedznonanoparticles”, Crystal Research Technol, vol.45, no.7.pp.27-31,2010.

[7] Q. Chen, A. Rondinone, B. Chakoumakos, and Z. Zhang, “Synthesis of Superparamagnetic $MgFe_2O_4$ Nanoparticles by Co-precipitation", Magn. Magn. Mater., Vol.194,no.3,pp.1-7 1999.

[8] A. Lu, E. Salabas and F. Schuth, "Magnetic Nanoparticles: Synthesis, Protection, Functionalization, and Application," Angewandte Chemie International Edition, vol. 46, no.8, pp.1222-44, 2007.

[9] H. Akamatsu, Y.Zong, Y. Fujiki, K. Kamiya, K. Fujita, S. Murai and Katsuhisa Tanaka, "Structural and Magnetic Properties of CdFeO Thin FilmsFabricated via Sputtering Method", IEEE Transactions on Magnetics, Vol. 44, no.2, pp.3-11,2008.

[10] K. Kamazawa, S. Park, S. Lee, T. Sato, and Y. Tsunoda, "Dis-sociation of Spin Objects in Geometrically Frustrated $CdFe_2O_4$" , Physical Review B, vol.70, no.7,pp.418-422,2004.

[11] H. Trong, T. Bui, L. Presmanes, A. Barnabe, I. Pasquet, C. Bonningue and Tailhades,"Preparation of Iron Cobaltite Thin Films by RF Magnetron Sputtering", Thin Solid Films, vol. 589,no.3, pp. 292-297,2015.

[12]A. Farheen and R. Singh, "Effect of Hydrothermal Annealing on Structure and Magnetic Properties of RF Sputtered Mn-Zn Ferrite Thin Films", Materials Research Express, Vol. 6,no.11,pp.11-14, 2019.

[13] D. Bokov, A. Turki Jalil, S. Chupradit, W. Suksatan, M. Ansari, I. Shewael, G. Valiev, and E. Kianfar, "Nanomaterial by Sol-Gel Method: Synthesis and Application", Hindawi Advances in Materials Science and Engineering, Vol. 22,no.2,pp.1-21,2021.

[14] A. Feinle, M. Elsaesser, and N. Husing, "Sol-Gel Synthesis of Monolithic Materials With Hierarchical Porosity" , Chemical Society Reviews, vol.45, no.12,pp78-86. , 2016.

[15] S. Nie, H. Geng, J. Wang, L. Wang, Z. Wang, R. Xu, G. Yue, Y. Chen, D. Peng," The Structure and Magnetic Properties of NiZn-Ferrite Films Deposited by Magnetron Sputtering at Room Temperature", Advanced Materials Research, vol.69, no.4,pp.323-329, 2013.

[16] G. Munish, G Manik., Anu, R. Mudsainiyan, B. Randhawa and B. Randhawa, "Physico-Chemical Analysis of Pure and Zn Doped Cd Ferrites ($Cd_{1-x}Zn_xFe_2O_4$) Nanofabricated by Pechini Sol-gel Method" , Journal of Analytical and Applied Pyrolysis, vol.116, no.6, pp.75-895, 2015.

[17] M. Naseri, E. Saion, M. Hashima, A. Shaari, H. Ahangar," Synthesis and Characterization of Zinc Ferrite Nanoparticles by a Thermal Treatment Method", Solid State Communications. vol.151, no.2, pp. 1031-1035,2011.

[18] F.Yasseen, M.Abdul Ammer , "Synthesis$Cd_{1-x}ZnxFe_2O_4$ Nanoparticles by Sol-Gel Combustion Method And Study It's Magnetic Properties", Journal of critical reviews,vol.7, no.5,pp.606-613, 2020.

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