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Test the Optical and Structural Characteristics of Nano PbO Produced by Plasma–Jet Technique

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ABSTRACT

The induced plasma technique was used in the current investigation to create lead oxide nanoparticles from bulk structures at various bombardment periods (4,6,8,10) min. The process will be carried out in the presence of argon gas that flows at a constant rate (3 L/sec). These nanoparticles were created as thin layers on various thicknesses of glass substrates prepared at different times of shelling. After that, they were analyzed with an x-ray spectrum, scanning electron microscope (SEM), atomic force microscope (AFM) and UV-visible spectrophotometer. Where the optical characteristics and constants were examined, the energy gap of the films varied with bombardment periods (2.1 ~1.98 eV). The SEM and AFM images clearly display a structure that varies with bombardment duration due to the fluctuation in the diameter of the nanoparticles. Finally, the layers entire amorphous nature is revealed by the x-ray spectrum.

اختبار الخصائص البصرية والتركيبية لأوكسيد الرصاص (PbO) النانوي التي أُنتجت بواسطة تقنية البلازما المحتثة(Plasma –Jet)

عمر عادل جدعان، كاظم عبدالواحد عادم، خالد حمدي رزيج

الملخص

تم استخدام تقنية البلازما المستحثة في هذا البحث لتكوين جزيئات أكسيد الرصاص النانوية من تركيب معدني في فترات القصف المختلفة (4،6،8،10) دقيقة. تم تنفيذ العملية في وجود غاز الأرجون الذي يتدفق بمعدل ثابت (3 لتر / ثانية). تم إنشاء هذه الجسيمات النانوية كطبقات رقيقة على سماكات مختلفة من ركائز زجاجية محضرة في أوقات مختلفة من القصف. بعد ذلك، تم تحليلهم باستخدام طيف الأشعة السينية (XRD)، ومجهر المسح الإلكتروني (SEM)، ومجهر القوة الذرية (AFM) ومقياس الطيف الضوئي المرئي للأشعة فوق البنفسجية (UV). حيث تم فحص الخصائص والثوابت البصرية ، اختلفت فجوة الطاقة للأغشية مع فترات القصف من (2.1 ~ 1.98 الكترون فولت) صور SEM و AFMتوضح البنية التركيبية التي تختلف باختلاف مدة القصف بسبب التغيرات في قطر الجسيمات النانوية. أخيرًا، الطبقات غير متبلورة تم فحصها بأكملها بواسطة طيف الأشعة السينية.

الكلمات المفتاحية: البلازما المستحثة؛ الخواص البصرية؛ الخواص التركيبية؛ فجوة الطاقة؛ الخشونة؛ اوكسيد الرصاص النانوي

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Introduction

Plasma physics has played an important role in much of the development of contemporary physics, the study of problems in the fields of astrophysics, atomic physics, chemistry, life sciences, molecular physics, magnetic and dynamic energy generation, and atmospheric physics [1]. Laser-induced plasma technology uses an ionized gas consisting of approximately equal numbers of positively charged ions and negatively charged electrons [2]. Plasma may contain neutral atoms. In this case, the plasma is said to be partially or incompletely ionized. Otherwise, the plasma is considered fully or completely ionized [3]. Through the inter disciplinary study of nanotechnology, we are able to create new materials with novel, intriguing, and practical features. These modern resources are nanoparticles used to create nano materials.Ultra-small particles called nanoparticles have outstanding qualities that can influence medication's direct delivery to the areas that the human body requires they have the ability to strengthen materials and better conversion of solar energy [4]. Lead is a chemical element, with the symbol Pb and atomic number 82, located in the carbon group “group XIV; also group IV by major group number” in the periodic table. Lead is a heavy, high-density metal, usually bluish-silver, that quickly turns a dark gray color when exposed to air. Lead is included in the composition of many alloys [5,6]. It is also a stable metal. Its three isotopes are at the end of the decay chain of radioactive heavy elements. Lead is one of the oldest metals used in human history. Along with arsenic and antimony, it was one of the first bronze-age metals attempted to make bronze .until Tin was discovered. Fragments of the metal lead dating back to around (7000 BC) were found in the Anatolia region near Catalhoyuk and represent the oldest historical finds that have been smelted. Because of its fresh and perfect appearance, lead had no known application at that time [7]. The main factor behind its extraction was its association with silver in ores found in the Earth's crust [8]. Pure lead was found by pressing and temperature in the standard case. It is a solid metal with a bright silver color that is slightly tilted toward bluishness [9], and it is one of the inefficient metals, lead loses its luster and has a dull appearance when it comes into contact with moist air. The color of the paint depends on the surrounding environment; it leaves bluish-gray scratches on the paper, and it was previously used for writing. After that, a pencil got its name [10], which is now used, although the material currently used is graphite. The lead voltage value is (0.13 V) [11], it is an anti-magnetic metal that is ductile and malleable [12], and it also has corrosion resistance due to passivation [13]. The nanoparticles of PbO have a spherical shape [14]. Crystallographic unit cells of the PbO phases are displayed in Fig.1

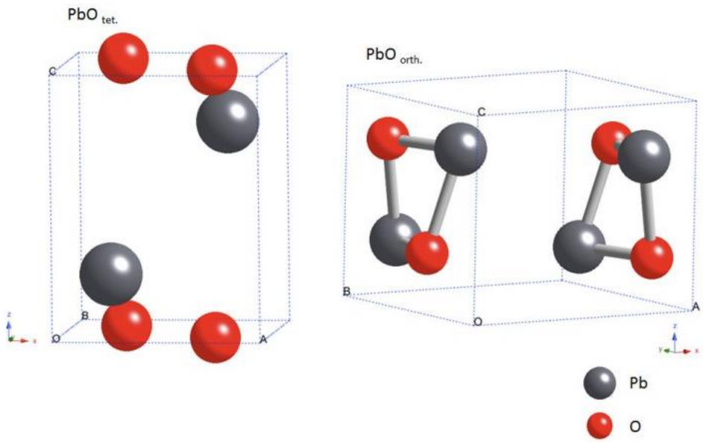

Fig. 1 A diagram displaying the PbO crystal structure [15]

2. Process of Preparation

Using the induced plasma deposition technique, solutions containing nanoparticles were created across various preparation times (4, 6, 8, and 10 min). Lead has been obtained from (99 %) pure lead metal foils. The foils were cleaned with polishing paper and then washed with ethanol alcohol to get rid of any impurities on the metal's surface. The induced plasma deposition process

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consists of a device with a voltage supply (power supply) and a bottle of Arcon gas in addition to a gas regulator with a holding holder, as well as glass beakers (10 ml) and also a needle with a diameter of (1 mm). A tube for transporting gas. Before being put in the glass beaker, the lead metal had dimensions of around (10 cm) in length and (10 cm) in width. After being chopped into about (1.5 cm^2), it will be placed in a (10 ml) glass beaker with (7 ml) of distilled water.

If a needle nozzle is located at a distance of (7 cm^2) from the target and the needle nozzle is directed in the middle of a metal lead oxide, then the metal of the lead oxide foil will be connected to the positive electrode while the negative electrode will be connected to the needle nozzle in order to generate a spark in the form of a scattered blue flame .The process will be carried out in the presence of argon gas that flows at a constant rate (3 L/sec).

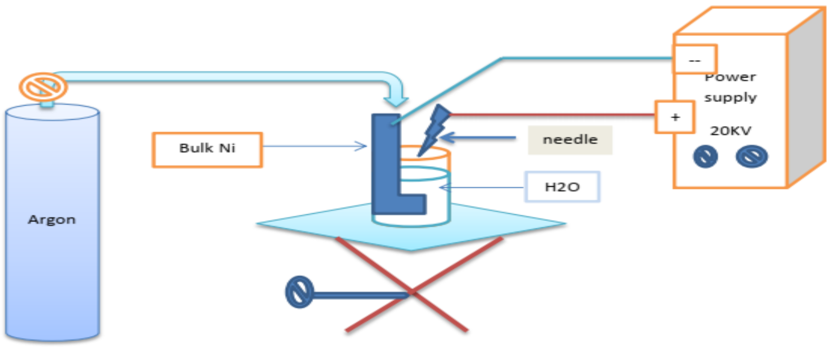

Fig.2 Explain the operation of the induced plasma -jet

3. The results and Discussion:

The plasma-jet approach has been used to create the lead oxide PbO particles for prep times (bombardment) ranging from (4, 6, 8, and 10 min). Each solution's PbO particles' optical characteristics were recorded. The optical characteristics and constants [16] for the solution created across various time periods are shown in figure 3. Over the wavelength range of (300–400 nm), the transmittance, absorbance, and reflectance rapidly changed before becoming extremely saturated for the longer wave lengths. The refractive index and the extinction coefficient both decline with wavelength in the range of (300–400 nm) and then become remarkably stable for the other longer wavelengths. This change also occurs similarly in the optical constants and for the same range of wavelengths .In table 3 and figure 6-f, the computed band gap for each solution changed dramatically. The band gap was (2.1 eV) for the particles prepared at (4 min), (1.9 eV) at 6 min, and subsequently increased to (1.92 eV) and (1.98 eV) for the particles prepared at (8 and 10 min), respectively. The variation in grain size is what causes the band gap to fluctuate, and as the grain size gets closer to the nanoscale, the energy gap widens as well with bombardment time as figure. 2-a.b .Tables 2 and 3 demonstrate the evolution of the energy gap and grain size over time.

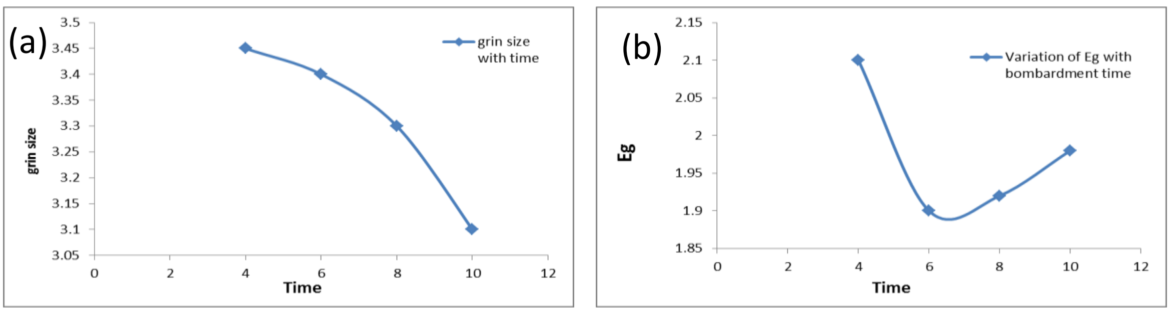

Fig.3 a- Variation of grin size with bombardment time, b- Variation of E_g with bombardment time

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grain size varies with preparation time and decreases with deposition time according to the atomic force microscopy images, which is consistent with an x-ray spectrum in which the peaks have shifted to the blue region. Additionally, the surface roughness variation with the bombardment time schedule (1) .

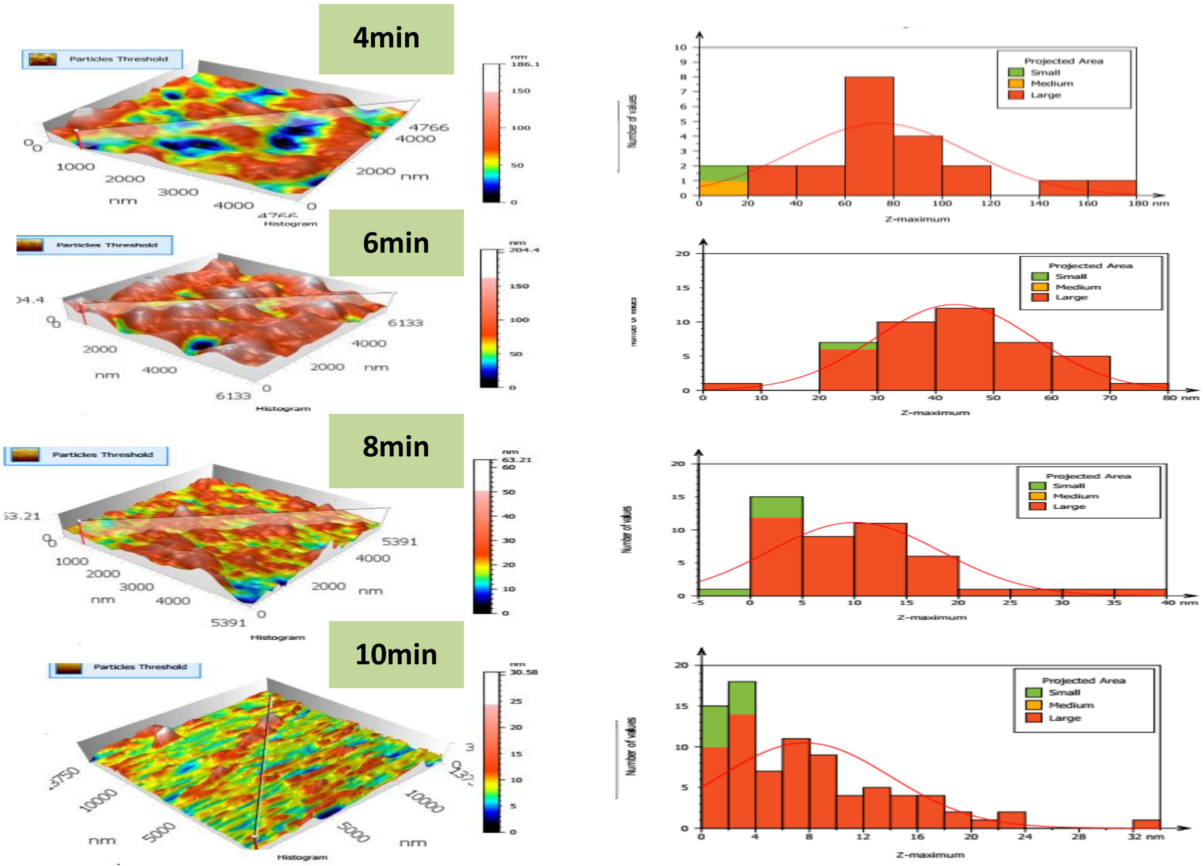

Fig.4 PbO's structural characteristics at different bombardment times (4, 6, 8, and 10 min)

Table 1. AFM readings and energy gaps for the ready samples at different bombardment times

Bombardment time (min)	Surface Thickness(nm)	Roughness Average (nm)
4	56.5	16.19
6	0.22	1,638
8	36.13	7,177
10	26.09	10.89

The X-ray spectra show that the layers are extremely crystalline with cubic structure for all bombardment periods; the peaks for all periods appear with small differences in 2θ and small differences in intensities, which are reflected in the calculated grain size; the grain size decreases with bombardment period as shown in Table 2; and this agrees with AFM images.

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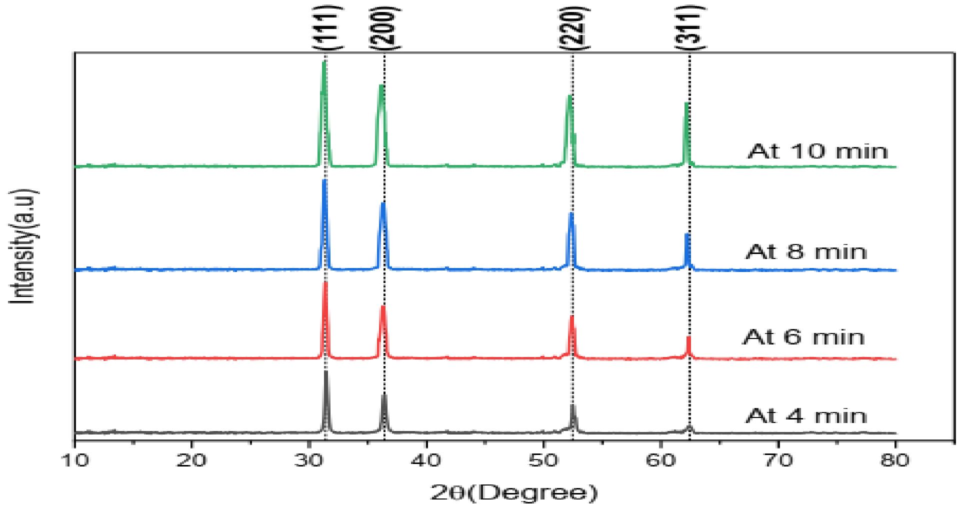

Fig.5 displays the induced plasma bombardment-induced X-ray diffraction of PbO metal oxide after various times of preparation.

Table 2. The average grain size After various bombardment times.

Bombardment time	Average grain size nm
4min	**3.45**
6min	**3.4**
8min	**3.3**
10min	**3.1**

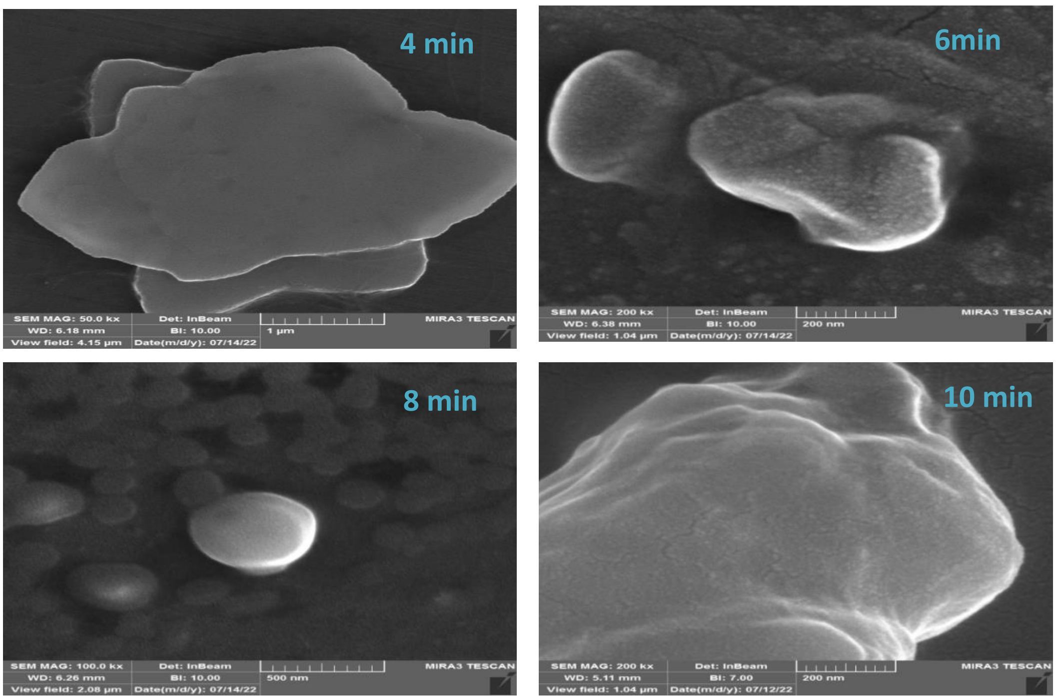

Fig.6 SEM images of PbO prepared at different bombardment periods (4,6,8,10 min)

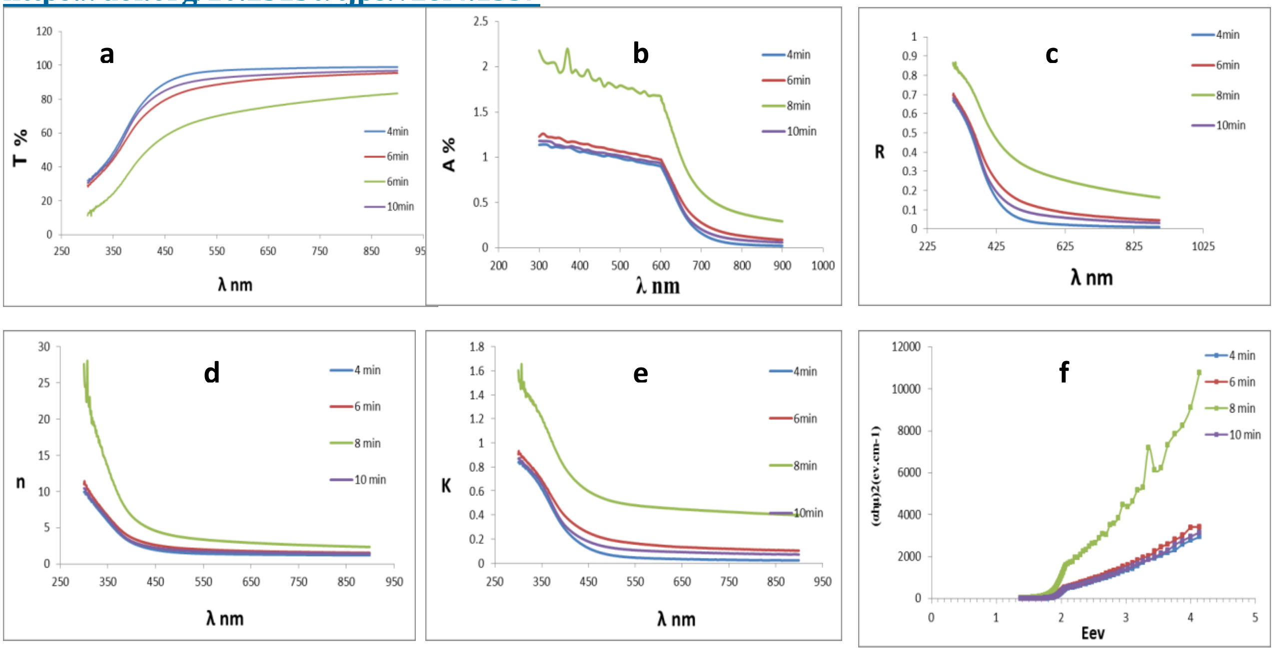

Fig.7 period of the bombardment's impact on the optical characteristics a. transition, b. absorption, c. reflective, d. refractive index, e. extinction coefficient, f. energy gap

Table 3. PbO band gap prepared at various bombardment times

Bombardment time (min)	Energy gap (eV)
4	2.1
6	1.9
8	1.92
10	1.98

4.Conclusions :

Using the plasma-jet technical, lead oxide nanoparticles have been created for various bombardment times. The surface roughness and thickness are seen to decrease with bombardment periods in AFM images, which is consistent with SEM images and the X-ray spectrum. The peaks for all periods occur at the same 2θ with varying intensities in the X-ray spectrum, demonstrating that the layers are entirely crystalline. The predicted grain size also gets smaller with time, from (3.45 nm) to (3.1 nm). The energy gap changed from (2.1 eV) to (1.98 eV) and optical characteristics visibly with the duration of the bombardment. That is, these films can be used in the applications of solar cells and photodiodes.

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