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The Effect Of Laser Pulses On Synthesis Of Al Nps Stabilized In Polyvinyl Chloride Matrices

Ban Rasheed Ali

Department of physics, Collage of science, AL-Mustainsiryah University, Baghdad, Iraq.

Corresponding author: ahmed_naji_abd@yahoo.com

Abstract— **Pulsedlaser ablation in liquid on Al:PVC target with various number of pulses was employed to achieve Al:PVC NPs .XRD and AFM for the deposited thin films were used for characterization all the prepared samples.The optical properties has been studied and it was shown that the optical band gaps of Al:PVC NPs are increased with increasing laser pulses.**

Keywords—laser ablation, Polyvinyl chloride, AFM, XRD, Optical properties,

1. Introduction.

Nowadays thin films get more interest because of its enlarged applications and uses in many industries to improve quality for their products [1].Al. and it's alloys thin films (~100 nm)has been widely used for interconnections in both bipolar and metal oxide ,semiconductor ,integrated circuit devices [2,3]. Al is now the second most widely used metal after iron [4] because of its specific properties that make it used to exceed all over the world .The properties of Al. includes; low density with specific mass of 2700 kg/m^3.So Al. is the lightest of all ordinary metals [5], high strength, superior malleability, easy machining and good thermal and electrical conductivity.

In this work we have study the Al. alloy which is composed of 80% Polyvinyl chloride (PVC), and 20% Al.

PVC is produced by polymerization of of the Vinyle chloride monomer (VCM). This Polymer are linear and strong [6], chemical resistant to acid , salts ,fats . PVC relatively low costs, biological and chemical resistance and workability have resulted in it being used for a wide range of applications [7].Atomic force microscope (AFM) traces the topography of samples with extremely high – up to atomic resolution by recording the interaction forces between the surface and a sharp tip.

2. Experimental.

Al. 20%, PVC 80% (AL-PVC)billet was prepared by composing Al and PVC powder under (20 ton) pressure for 10 minutes .The billet was placed in a bottom of quartz vessel which is fill with 5 ml of methanol solution, which is works as a container for the product particles . Then the immersed billet irradiated by Nd: YAG laser (λ=1064 nm , E= 500mJ) to produced Al:PVC nanoparticles (Al:PVC NPs) . The laser ablation to produce NPs is shown in figure (1).

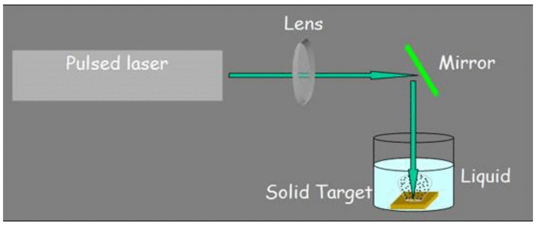

Fig.1 Laser ablation system

Different number of pulses (200 to 350 step 50 pulses) was used to be achieved (4) nanoparticles solution for each number of pulses that is shown in figure (2).

Fig.2 Nanoparticles solution with different laser pulses

Thin films of Al:PVC prepared using drop casting method (5 drops) for each solution which are deposited on a glass substrate (1*1)cm .The optical properties for the thin films were investigated by (UV-VIS spectrophotometer from VARIAN). Figures (3, 4, 5, 6, and 7) illustrate the optical properties.

X- Ray diffraction (XRD) analysis of the thin films and of the ablated target was done using (XRD– 6000 shimadzu X-ray diffraction.). The analysis shown in figure (8).3D AFM images for the thin films and granularity accumulation distribution were explained in figure (9) and table (1) respectively.

Results and discussion.

Figure3 display UV-VIS transmission spectra of Al-PVC 20% thin films at wavelength range (200-900nm) with different laserpulses. From the figure we can recognize two essential areas. The first area is for wavelength range (200 – 400 nm) which represent an absorption area for the prepared thin films and it is opaque for these range . the second area (400-900) is a stable area and it is transparent for this range plasmone point in wavelength (450 nm)due to the quantum effect for the nanoparticles (quantum conferment theory)and there are a semi fringes as a result of the energy oscillation between Al. and the polymer Also it is clear from the figure that the transmittance was increasing with increasing laser pulses .For laser pulses (200,250) it is noticed that there are a small variant in transmission spectrum within visible range, this variant are increased when we reached (300, 350 pulses) because of the production of the nanoparticles with high transparency which it could be useful in window applications.

Figure 4 shows the absorption spectra of the prepared thin films which shows an opposite behavior to the transmission spectra.

The maximum transmittance and minimum absorbance occurs in wavelength range between (300 -800 nm).

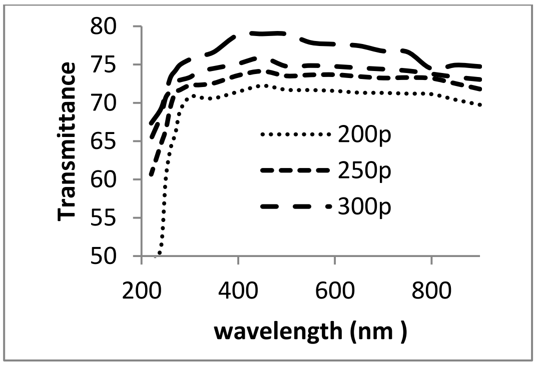

Fig.3 Transmittance Spectra for Al- PVC20% thin films

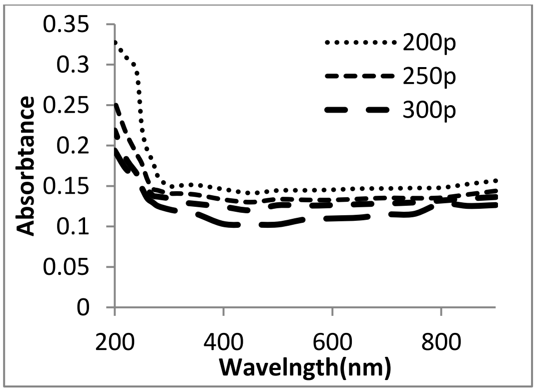

Fig.4 Absorbtance Spectra for Al- PVC20% thin film

Figure (5) shows the reflectance spectrum as a function of wavelength for Al-PVC20% NPs thin films which deposited on a glass substrate. The figure indicate a high reflectance due to the high energy of the incident wavelengths and it is about (0.2) within the UV- spectrum and it is decreased sharply and reached (0.14-0.15) at wavelength (300nm), beside a small reflectance within the range (400-900nm).Figure (6) have a similar behavior to the reflectance spectrum as explained in this formula.

$$\boldsymbol{n} = \mathbf{1} + (\boldsymbol{R})^{\mathbf{0.5}}/\mathbf{1} - (\boldsymbol{R})^{\mathbf{0.5}}$$

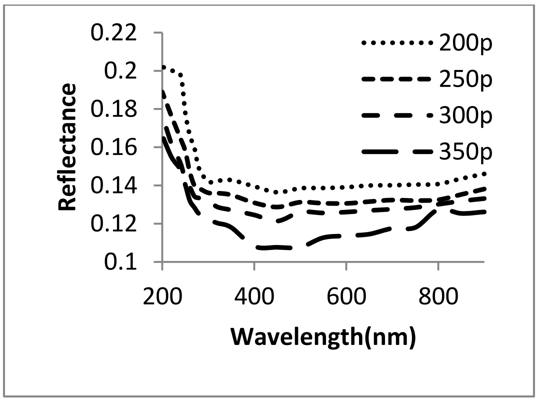

Fig.5 Reflectance Spectra for Al- PVCalloyThin film

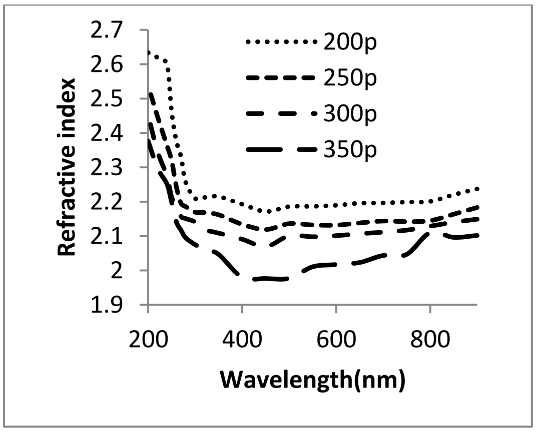

Fig.6 Refrectiveindix Spectra for Al-PVC 20%Thin film

From Figure 7 which represent the relation between $(\alpha h\nu)^2$ versus photon energy it could be found that the energy gap was (4.3 ,4.6 ,4.8 ,4.9) for laser pulses (200 , 250 ,300 ,350) respectively .It can be noticed that these results agree with the results obtained in figures 3,4,6,7.

From figure 7 we can notice also that the optical energy gap was increasing with increasing the number of pulses.

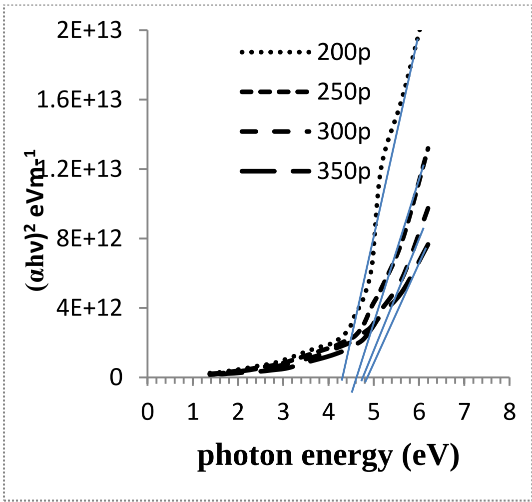

Fig .7 $(\alpha h\nu)^2$ *versus optical energy gap*

XRD analysis using for characterizing the bulk metal and all the samples prepared. Figure 8 illustrate the XRD spectrum for the bulk material and Al-PVC20% thin films which deposited on a glass substrate as a function to Braggs angle. It is noticed from the figure that there are four essential peaks for the bulk material due to the diffraction angles (2θ=38, 45, 65, 78) from the miller indices (111), (200), (220), (311) respectively which shows an agreement with the PDF card-Al-00-004-0787, from search and the surface of the material have a polycrystalline configuration. While for deposited thin films and for laser pulses (200, 250, 300, and 350)it can be noticed that most of the Al-peaks began to reduced or disappeared and it can still noticed a polymer peaks because of polymer particle size which consist most of the granular of the material is bigger than that for the Al-particles, and the material was converted from polycrystalline to amorphous material which indicates that these particles began to have a nanoparticles behavior due to Diby Scherrer formula [8].

$$D=\frac{0.9\,\lambda}{\beta\cos\theta}$$

Where D is the grain size, λ is the X-Ray wavelength,β is the full-width at half-maximum (FWHM), θ is half the angle between incident and scattered X-Ray beams .

From table (1) it is noticed that the particle size (D) was decreasing and the dislocation density (δ) microstrain (S)increasing with increasing laser pulses where (δ) and (S) can be calculated from the equations:

$\delta=1/D^2$ and $S=\frac{\beta\cos\theta}{4}$

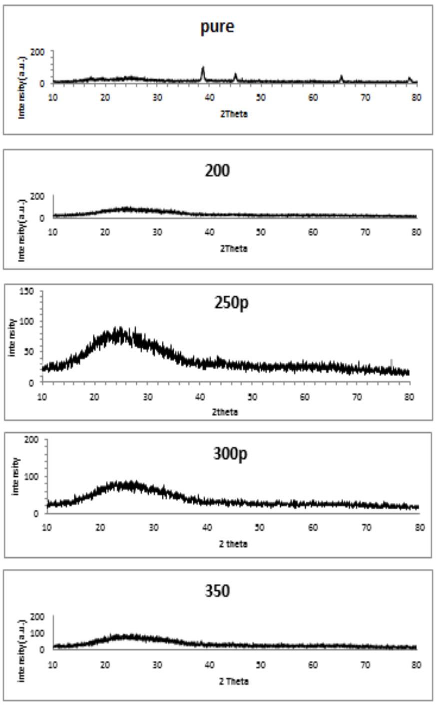

Fig.8 XRD analysis for the bulk metal and the thin films for different number of pulses

Table (1): X-Ray analysis for Al-PVC 20% NPs

Pulses number	2θ	β (deg)	D (nm)	δ (nm)$^{-2}$	S (line^{-2}.m^{-4})
Bulk metal	38.76 45.03 65.4	0.007676 0.006106 0.005059	17.79925 21.91274 24.09367	0.003156 0.002083 0.001723	0.00181 0.00141 0.001064
200	22.24 23.29	0.010816 0.013956	13.13851 10.1636	0.005793 0.009681	0.002653 0.003417
250	21.55 22.57 24.84	0.009071 0.015351 0.011513	15.68338 9.251404 12.28408	0.004066 0.011684 0.006627	0.002228 0.003764 0.002811
300	22.91 22.017 21.359	0.009071 0.00628 0.011862	15.64689 22.63604 11.99696	0.004085 0.001952 0.006948	0.002223 0.001541 0.002914
350	22.187 21.329 23.374	0.012909 0.005931 0.008373	11.00894 23.9951 16.93677	0.008251 0.001737 0.003486	0.003167 0.001457 0.00205

We can get detailed information about the size distribution of Al-PVC 20% was obtained using AFM images and granularity accumulation distribution. AFM provides spatial information parallel and perpendicular to the surface of the thin films in addition to topographic high resolution information. The samples are scanned under the tip using a piezo-driven and the results are displayed as images in figure 9. From this figure it is noticed that the nanoparticles have a semispherical or ball shaped and are prepared in a matrices with some peaks. Also it is clear that at laser pulses (200, 250) the surface of the thin films was more amorphous and there are cracks due to the differences of the diameters and particles size between Al. and polymer particles. With increasing laser pulses the surface of the thin films become more uniformity and the cracks decreased. These results agree with the XRD analysis.

Imager 4.62 system palette program was using for computing the particle size , rephrence density and root mean square for the prepared samples . The computing results were illustrated in table 2.From this table it is noticed that the grain size, root mean square and surface roughness was decreasing with increasing laser pulses.

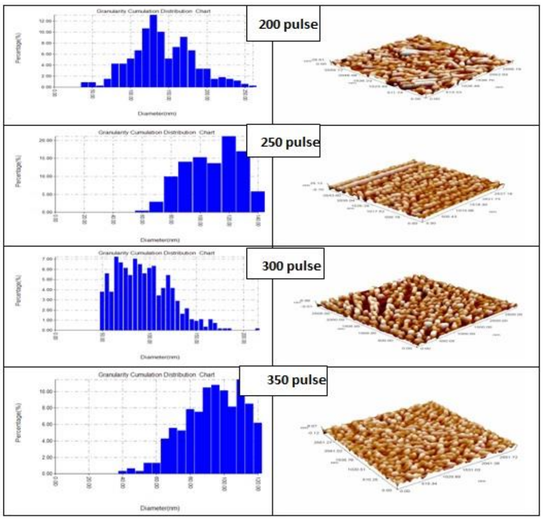

Fig.9 AFM images for Al-PVC 20% Thin films

Table (2).Grain size of Al-PVC 20% for different number of pulses.

No. of pulses	average Grain size (nm)	Roughness average (nm)	Root mean square (nm)
200	137.16	6.55	7.52
250	103.83	5.23	6.11
300	91.79	1.75	6
350	91.09	1.5	1.81

Conclusions.

Producing 0f Al nanoparticles And controlling the size of nanoparticles is one of important promising studies because of their many applications in various field such as pyrotechnic , propellant , explosive industries , rocket fuel, alloy powder metallurgy parts of automobiles , aircrafts and many other important applications . There are many techniques for synthesizing Al nanoparticles.Pulsed laser ablation is an attractive method in producing nanoparticles due to its ability to produce nanoparticles with a narrow size distribution and a low level of impurities.

The studies have been shown that the size, morphology, stability and properties of nanoparticles materials are strongly affected by experiments conditions.

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