ISSN 2229-5518

Production of Au NPs via PLAL Technique for Optoelectronic Application

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Abstract— In this paper, Au nanoparticles by pulsed laser ablation in liquid (PLAL) was prepared.Various affecting parameters were studied such different laser energy (100, 300, and 500 m J) with different number of pulses (100, 300, 500, and 700 pulse), at wavelength 1064 nm, and repetition rate of 1Hz. The structural , morphological and optical properties were discussed. XRD spectra showed the very strong diffraction peak at 37.8° is considered to be of (111) plane facet of the face centered cubic structure, while the diffraction peaks of other Au peaks are found to be much weaker compared to standard Au NPs. AFM showed the average diameter increase with the increase of the energy and number of shots. The optical properties showed decrease absorption spectra at decrease energy and number of shots.

Index Terms— Au nanoparticles, laser ablation , absorption spectra, AFM, XRD.

1 INTRODUCTION

The first metallic nanoparticles were prepared by Faraday in 1857. He discovered the optical properties of Au nanoparticles in solution and set the start for the growing interest in Au nanoparticles and their properties **[1].** Today the method created by Turkevich et al. in 1951 **[2]** is one of the most used procedures to synthesis Au nanoparticles in solution.

Au nanoparticles have many different interesting applications due to their properties such as Surface Plasmon Resonance (SPR), biocompatibility, chemical stability and easy surface functionalization or bioconjugation **[3].**Au nanoparticles are not a new concept. In fact, medieval glass workers unknowingly created Au nanoparticles when they made red stained glass by mixing gold chloride in molten glass **[4].** Although Au nanoparticles are colloids, the properties at the nano scale differ greatly from their larger bulk Au counterparts**[5].**

The first observation of photoluminescence in bulk Au, in the visible range of electromagnetic spectrum, was described in (1969) , and its quantum efficiency was very low (10^{-10}) [6]. Later, when more researches were devoted to nanometer dimensional samples, it was shown that Au nanostructures have significantly enhanced fluorescence, compared to the bulk Au, up to 6-7 orders of magnitude, Photoluminescence studies of Au nanoclusters [7], nanoparticles [8], These reports mostly concentrate on size and aspect ratio dependent properties, but also on a crucial influence of the closest surrounding, like capping agents or employed matrices[9].

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In this work, Au nanoparticles was prepared utilizing PLAL. The structural, morphological and optical characteristics of Au NPs have been study.

2 EXPERIMENTAL SETUP

The experimental setup for laser ablation of gold target immersed in pure deionized water as show in Figure1. The outputs of an Nd:YAG laser are 1064nm, and repetition rate 1 Hz with pulse duration 10 ns . Gold target was placed on the bottom of a 3-mL-glass vessel filled with pure deionized water, glass vessel was placed on a metal disk up small rotator holder moving two cycle in minute, even pulses distribution on all surface gold target.

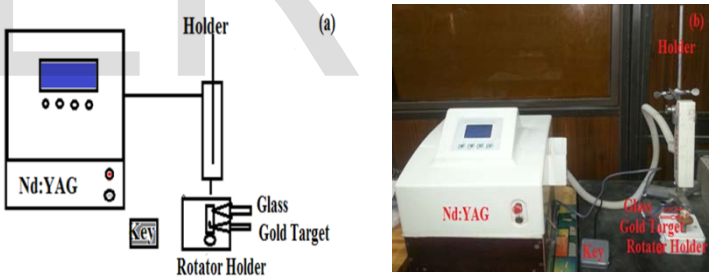

Figure (1) (a) Schematic diagram of laser ablation process (b) Image of laser ablation process set up.

ISSN 2229-5518

Q-switch Nd:YAG laser, the name scientific for Nd:YAG is neodymium-doped yttrium aluminum garnet; ($Nd:Y_3Al_5O_{12}$). Q-switched Nd:YAG laser providing pulses with wavelength 1064nm, and repetition rate 1 Hz. Parameters wear only for different laser energy(100, 300, and 500 m J) and different pulses (100, 300, 500 and 700 pulse). From laser source and laser ablation process we wear obtains on samples as in show Figure 2.

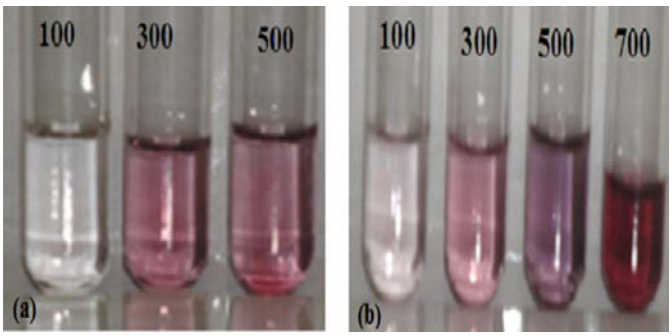

Figure (2) Imaging samples Au NPs, (a) Au NPs at laser energy 100, 300, and 500 m J and number of pulses 500 pulse, (b) Au NPs at number of pulses 100, 300, 500, and 700 pulse. and energy 700 m J.

3 Results and Discussion

Structural properties has been performed using XRD analysis and the typical XRD pattern for gold nanoparticles is shown in Figure (3), at energy (700 m J) and number of pulses (700 pulse) . Bragg's reflections observed in the diffraction pattern could be indexed on the basis of fcc-type crystal arrangement. The strong diffraction peak at 37.8° is ascribed to the (111) facet of the fcc-metal gold structure. The other peak can be attributed to (200) facet at 43.9°. We can note that as in table (1). those results agree with Srivastava et al.**[10].**

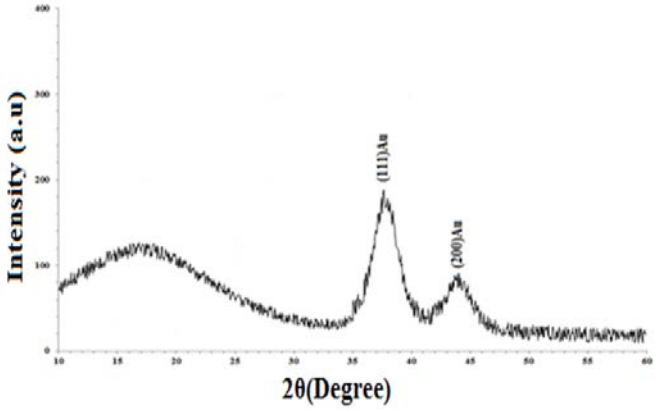

Figure (3) X-ray diffraction of Au NPs prepared by laser ablation at Energy 700 m J, and number of pulses 700 pulse.

Table (1): Show two different peaks (111) and (200), and FWHM.

2θ (deg.)	FWHM (deg.)	d_{hkl} Exp. (nm)	G.S (nm)	d_{hkl} Std. (nm)	hkl	phase
37.812	2.5207	23.773	3.33	23.908	(111)	cub. Au
43.975	2.6340	20.574	3.25	20.705	(200)	cub. Au

The surface morphology of synthesis Au NPs was investigated using atomic force microscope (AFM). We have studied the surface morphology properties of the Au NPs prepared by pulsed laser ablation in liquid for pure gold. The surface morphology of Au NPs samples that prepared with different energy pulses (100, 300& 500 m J), at constant number of pulses 500 pulse. The images in Figure (4) showing shape Au NPs from graphical 3D image at deposited on glass slides.

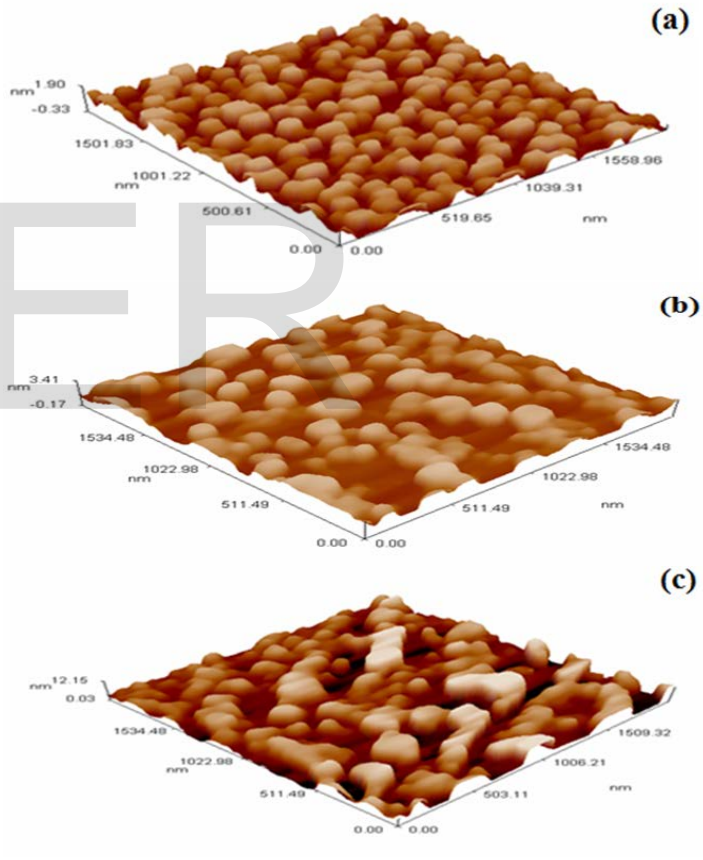

Figure (4) 3D AFM image of Au NPs with (a) 100, (b) 300, and (c) 500 m J, number of pulses 500 pulse.

From Figure (4) it can be observed that the average diameter of Au nanoparticles prepared by 1064nm, and 1Hz with different energy at (100, 300 , and 500 m J) were found to be equal to (102.52 nm, 106.61 and127.66)

ISSN 2229-5518

respectively. So the average diameter and size distribution increases with the increase of the energy as shown in table (2).

Table (2): The calculated morphology characteristics of Au nanoparticles prepared with different energy.

Number of pulses	Energy (mJ)	Diameter Avg. (nm)
500	100	102.52
	300	106.61
	500	127.66

Also the surface morphology of Au NPs samples that prepared with different number of pulses (100, 300, 500& 700 pulse), at constant energy 700 mJ. The images in Figure (5) showing shape Au NPs from graphical 3D image at deposited on glass slides.

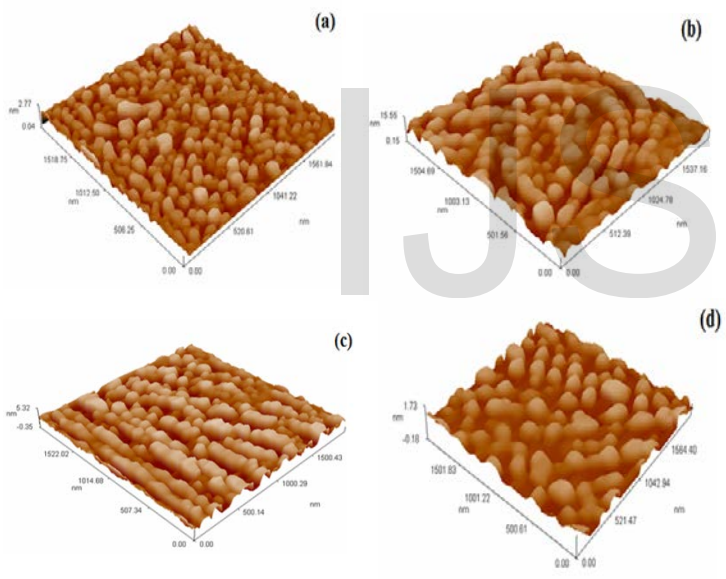

Figure (5) 3D AFM image of Au NPs (a) 100, (b) 300, (c) 500, and (d) 700 pulse , and energy 700 m J .

The result from the Figure (5) show that, the average diameter increases with the increase of number of pulses. The average sizes increases and the distribution broadens with increasing the number of pulses, the particles become much closer to each other. the particles density becomes greater as compared with lower number of pulses. These result agree with A. Mushtaq & Michael J **[10].** as shown in table (3).

Table (3): The calculated morphology characteristics of Au nanoparticles prepared with different number of pulses.

Number of pulses	Energy (mJ)	Diameter Avg. (nm)
100	700	84.48
300		92.01
500		96.08
700		123.97

The Au nanoparticles were prepared at wavelength 1064nm and 1Hz of a pulsed Nd:YAG laser. Four samples were prepared using number of pulses of (700, 500, 300 and 100 pulses), while energy constant (700 m J). Figure (6) show absorbance spectra of gold nanoparticles prepared PLAL. The absorption peak of gold nanoparticles prepared by (700, 500, 300 and 100 pulses) were found equal to (0.575, 0.446, 0.295, and 0.114) respectively with peak position at wavelength nearly 527nm. We can note decrease absorption spectra at decrease number of pulses, and constant energy . These results agree with A. Mushtaq & Michael **[10].**

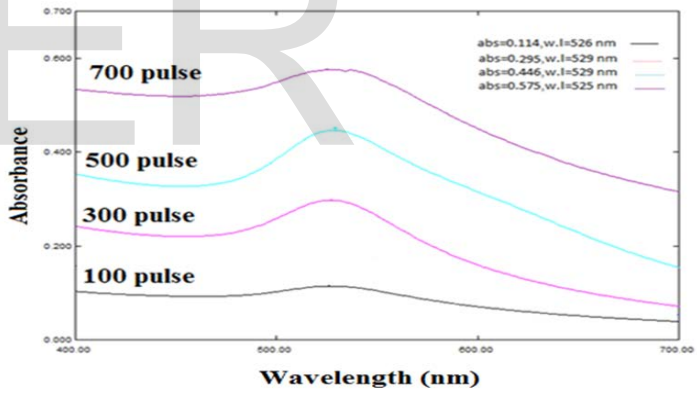

Figure (6) Absorbance spectra of the colloidal gold nanoparticles by laser ablation at wavelengths 1064 nm,1Hz, and number of pulses (700, 500, 300 and 100 pulse), and energy 700 m J.

From Figure (7) we can note the Au nanoparticles were prepared at wavelength 1064 and 1Hz of a pulsed Nd:YAG laser. Three samples were prepared using different energy (500, 300, and 100 m J), while number of pulses constant 500 pulse . Figure (7) show absorbance spectra of gold nanoparticles prepared PLAL. The absorption peak of gold nanoparticles prepared by (500, 300 and 100 m J) were found equal to (0.409,0.258, and 0.054) respectively with peak position at wavelength nearly 527nm. We note decrease absorption spectra at decrease energy, and constant

ISSN 2229-5518

number of pulses.

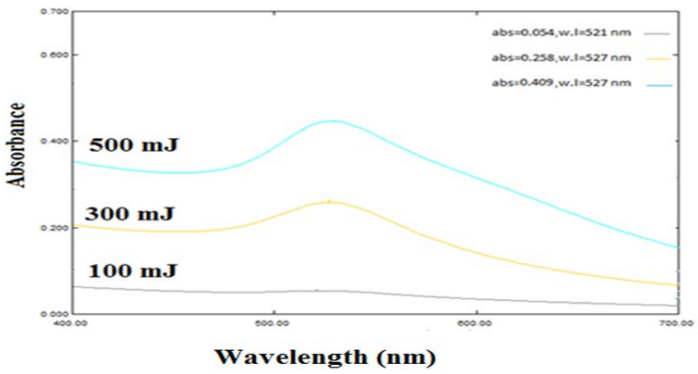

Figure (7) Absorbance spectra of the colloidal gold nanoparticles by laser ablation at wavelengths 1064nm, and energy (500 , 300 , and 100 m J) , and number of pulses 500 pulse.

4 Conclusions

The size, shape and size distribution of Au NPs can be controlled by varying the laser energy and number of pulses (preparation parameters). Increase absorption spectra for Au NPs at increase energy and number of pulses, which due to increase material surface area and this due to increase efficiency of cell. XRD spectra for Au NPs shows the very strong diffraction peak at 37.8° is considered to be of (111) plane facet of the face centered cubic structure, while the diffraction peaks of other Au peaks are found to be much weaker compared to standard Au NPs.

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