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Gold Nano Particles Produced by Laser Induced plasma Spectroscopy

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Abstract : Gold nanoparticles (Au NPs) have been more attractive in use in many fields because of their simple synthesis, tunable optical properties as well as good biocompatibility practicable for clinic settings. In this work, the glow of plasma produced by pulse laser (λ=1064nm) on gold samples in distilled water were analyzed by studying of the atomic lines and making comparison with strong standard lines for gold. The effect of laser energies at the range (400, 500, 600, 700and 800 mJ) on gold nanoparticle, produced by laser ablation, were investigated by XRD, AFM and UV-visible absorption. AFM and XRD results indicate that the gold particle size decrease with increasing laser energy. Absorbance spectra shows that the plasmon peaks shifted from 537 to 490 nm when laser energy increase from 400mJ t0 800 mJ as a result of decreasing particles diameter.
Keywords : LIPS; pulse laser; spectroscopy; Nano particles; Plasmon.

Introduction

In recent years, Metal nanoparticles are being extensively used in various applications. Gold nanoparticles are first choice in many applications due to their stability, simple synthesis, tunable optical properties as well as good biocompatibilitypracticable for clinic settings[1]. In the last decade,prepared of Au NPs with differentshapes were done, [2] such as gold nanorods [3], silica/gold nanoshells and hollow Au NPs, which allshow red-shifted properties [4]. The absorption properties, scattering and plasmonic phenomina make them more useful in many applications [5].

Plasmon is a dipole electron oscillations bounded by the nanoscopic particle occur when the a specific frequency of incident light scattered with nanoparticles with small metal sphere (comparable with the wavelength of incident light). There are two types of plasmons, plasmoncaused by the surface of thin metallic layers, and plasmon in metal particles with sizes in range of sub wavelength [6]

Aplasmonin a nanoparticle for metals has to be notable from a reaction between electromagnetic wave with metal free charges. These charges oscillation results resonant enhancement at specific frequency. This resonance leads to linear and nonlinear materials properties. The particle-size dependence and hostmatrix dependence of the absorption spectrum have been discussed in many scattering systems theory[7].

Recently, the controlling of size of metal nanoparticle has much care due its electrical and optical properties are depend on their size [8].

Pulsed laser-induced plasmas (LIPs) have several important applications making it an impotent tool, e.g. material processing, thin film deposition and metal analysis in solid samples[9]. Itis broadly used to study elemental content of a sample[10].

The broadening of a peaks in XRD patterns is a criterion to calculatethecrystalline size of solid using Scherrer equation formula [11].

$$G.S = \frac{0.9\,\lambda}{FWHM\,.\cos(\theta)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where λ is the x-ray wavelength=1.5406 Å for Kα transition for Cu target, FWHM is the beak breadth at half maximum in radian and θ is diffraction angle.

2. Experimental Part

The LIPs spectra for high purity gold sample in distilled water were recorded using LIPs experimental system, using of 1064 nm Nd:YAG pulse laser with 9 ns duration, 10 Hz pulse repetition frequency at different energies (400, 500, 600, 700 and 800 mJ). The sample located at the focal length of lens which focus the laser beam in the bottom of distilled 20 ml water container. Emitted light translated by optical fiber locates at 45° with beams in 3 cm distance from generated plasma to the spectroscopy connected with computer to analyze its spectra.

The water consist of gold particles were analyze by UV-visible spectroscopy from 200 to 800 nm in quarts cell and using cell filled with distilled water as reference. Then the gold particles dried on glass substrate by drop it and take it dry in room temperature to study the films morphology (by atomic force microscopy AFM) and structural properties (by x-ray diffraction) to study the effect of increasing laser energy on gold particle size.

3. Results and Discussion

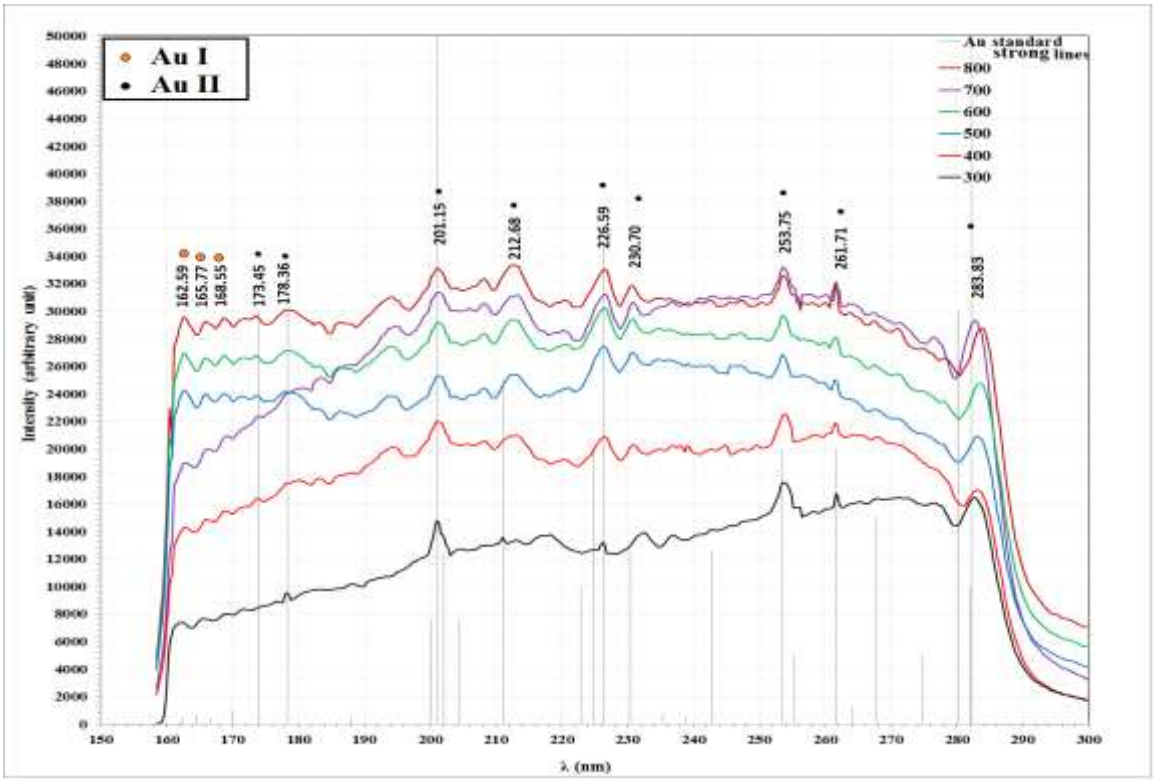

Fig (1) Comparison between light emission spectroscopy for plasma induced by different energy laser on gold sample in distilled water with standard strong lines of gold

Fig.(1)shows the spectroscopy patterns for laser induced on gold surface with differents laser energies 300-800 mJ and a comparison with strong lines for standard Au I and Au II data[12]. This figure show a good agree with standard lines.

Fig.(2)displays the photo for Au nano particles in distilled water samples. The color change from bright red to dark red with increasing laser energy caused as a result of changing Au nano particle size and the particle concentration in water. This result is in agreement with Huang et.al[13].

Fig (2) Water contain Au nano particles produced by pulls laser with different power

Fig.(3)illustrations AFM Image and itsgranulation distribution for Au particles samples deposited on glass slides produced by laser with different energies. This figure shows that the particle diameter decrease with increasing laser energy. The values of particles diameter, Table.1, give an indication about the behavior of particle size variation with laser energy.

Table (1)Average diameter and root mean square roughness for Au particles samples produced by laser with different energies

Laser energy (mJ)	Average diameter (nm)	RMS roughness (nm)
400	108.36	1.120
500	98.97	0.507
600	86.91	0.737
700	79.52	2.060
800	72.58	0.602

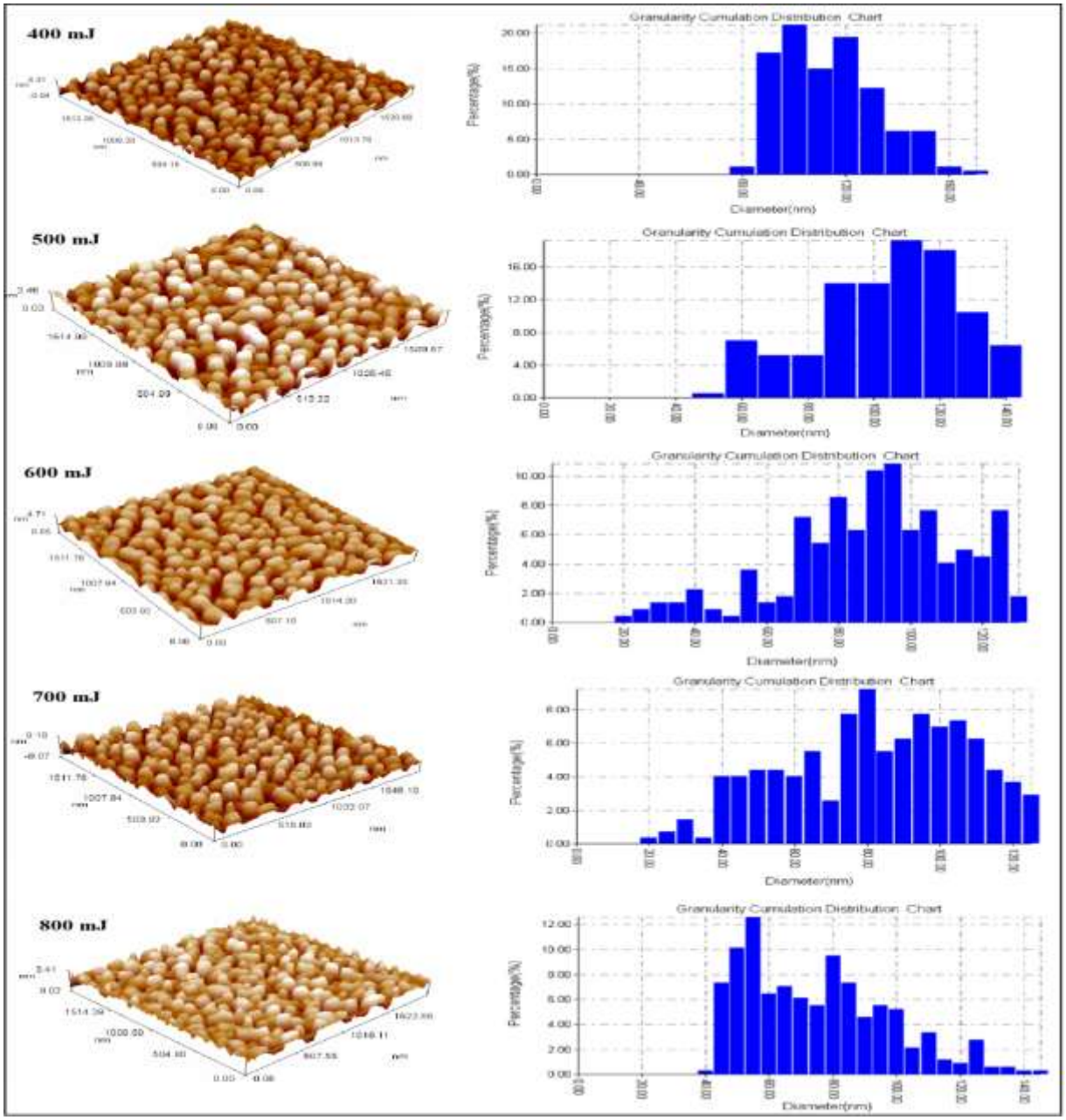

Fig (3) AFM image and the granulation distribution for Au particles samples produced by laser with different energies

Fig. (4)displays X- ray diffraction for Au particles samples on glass substrate. All patterns have three peaks located at 2θ about 38.35, 44.59 and 64.89 ^{0} corresponding to (111), (200) and (202) direction respectively for Au crystals. It can be seen that the full width of half maximum for observed peaks increase with increasing laser energy which indicate on decreasing the crystalline size from about 20 nm to 10 nm with increasing laser energy from 400 to 800 nm.This result is in agreement with N. Merghassemzadeh et al. [14].Table (2) shows all peaks observed in XRD and a comparison with standard peaks

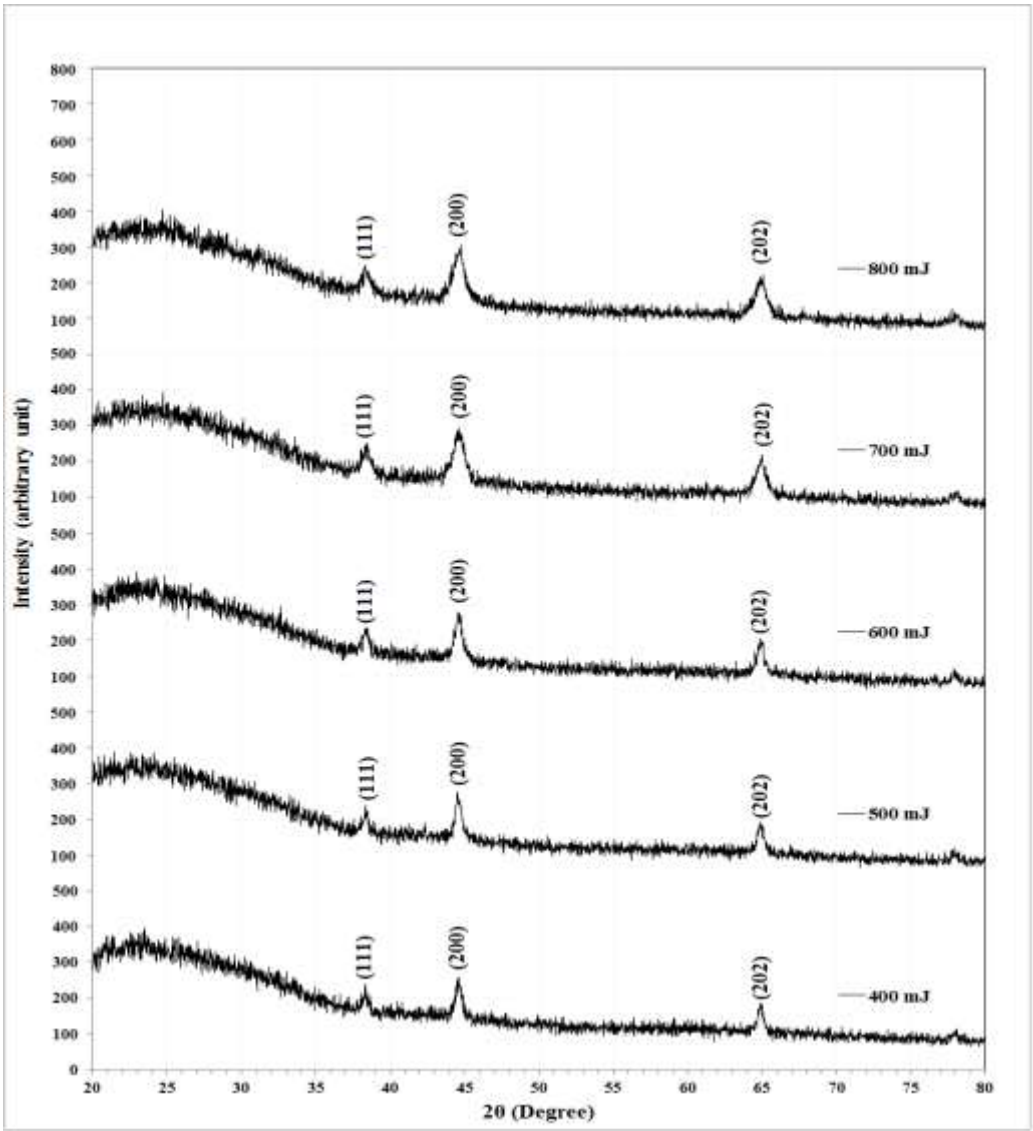

Fig (4) XRD patterns for Au particles samples produced by laser with different energies

Table(2) comparison between experimental and standard XRD peak and calculated crystalline size.

Power (mJ)	2θ (Deg.)	FWHM (Deg.)	d_{hkl} Exp.(Å)	G.S (nm)	d_{hkl} Std.(Å)	hkl	card No.
400	38.3550	0.4060	2.3449	20.7	2.3500	(111)	96-901-2431
	44.5970	0.4820	2.0301	17.8	2.0352	(200)	96-901-2431
	64.8970	0.4530	1.4357	20.8	1.4391	(202)	96-901-2431
500	38.3582	0.4507	2.3447	18.7	2.3500	(111)	96-901-2431
	44.6002	0.5350	2.0300	16.0	2.0352	(200)	96-901-2431
	64.9002	0.5028	1.4356	18.7	1.4391	(202)	96-901-2431
600	38.3614	0.5002	2.3446	16.8	2.3500	(111)	96-901-2431
	44.6034	0.5939	2.0299	14.5	2.0352	(200)	96-901-2431
	64.9034	0.5581	1.4356	16.9	1.4391	(202)	96-901-2431
700	38.3646	0.7053	2.3444	11.9	2.3500	(111)	96-901-2431
	44.6066	0.8374	2.0297	10.3	2.0352	(200)	96-901-2431
	64.9066	0.7870	1.4355	12.0	1.4391	(202)	96-901-2431
800	38.3678	0.7829	2.3442	10.7	2.3500	(111)	96-901-2431
	44.6098	0.9295	2.0296	9.2	2.0352	(200)	96-901-2431
	64.9098	0.8735	1.4354	10.8	1.4391	(202)	96-901-2431

Fig.(5)shows the absorption spectrum for Au nanoparticles in distilled water. In general the absorbance increase at all range with increasing laser energy as a result of increasing number of produced particles in water.Peaks appear in all samples in the range 490 to 537 nm caused from plasmon effect (light passing gold particles in range of nano-size loss its intensity by scattering). The absorption maximum moves from 537 to 490 nm when laser energy increase (from 400, 500, 600 , 700 and 800 mJ) , i.e. with decreasing particle diameter from 20 to 10 nm this result is in agreement with thesis have reported in nano range diameter particle size effects on plasmon absorption peaks, perhaps slightly changing resonance effects[15].This result is in agreement with Sardar et.al. [16] And Huang et.al[14].

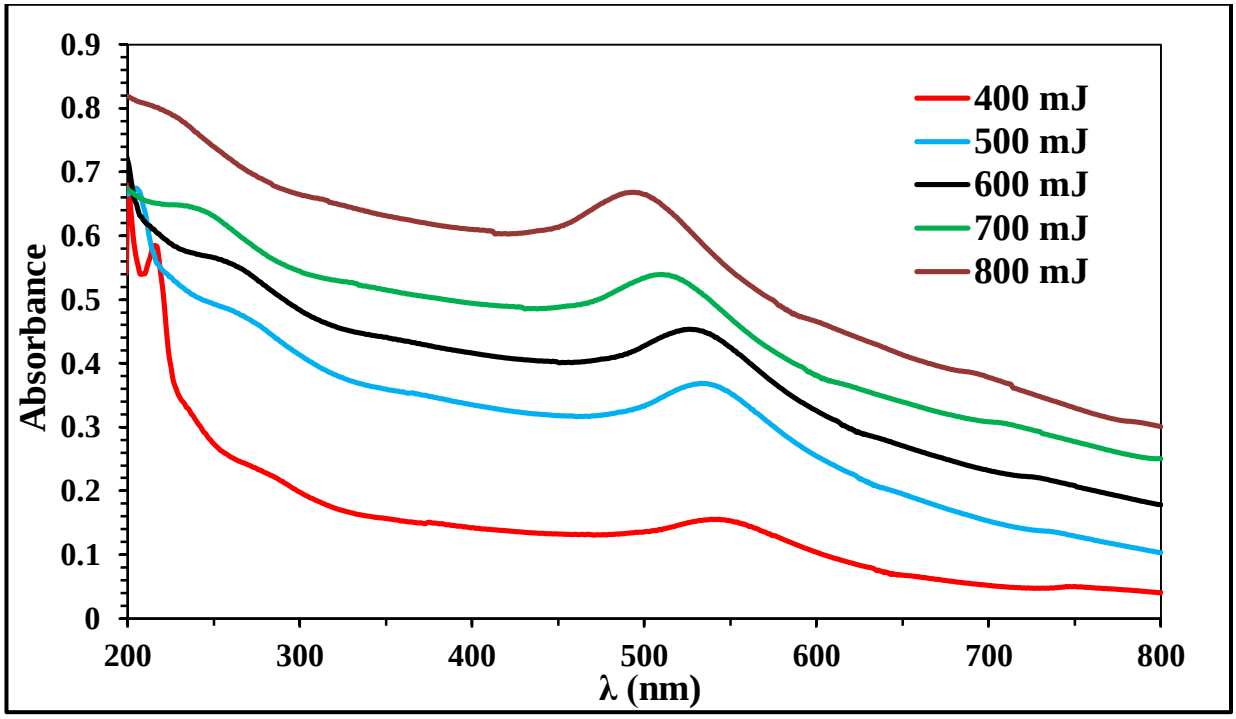

Fig. (5) Absorbance spectrum of Au nano particles produced by pulls laser with different power in distilled water.

Conclusions

Our results, confirm that the varying of laser energy is a good tool to control the nanoparticles size. It was noted that the particle size decrease with increasing laser energy,so that the plasmon peak position shifted toward blue region.

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