A Simple New Method for Purifying Grain Size by Pulse Laser Ablation

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Abstract

We present a new method to prepare collide with fine grain or (quantum dots) in solutions by changing the function of laser used, between ablation and irradiation by this can be obtained changing the location of the focal plane of the focusing lens and hence changing the fluence, which leads to the fragmentation of the large grains to smaller grains size. Repeating the changing process several times can lead to obtaining quantum dots or very small grain size.

Key Words: New Method, Quantum Dot, Nano Collide, Laser Ablation, Aqueous Solution.

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Introduction

The main reason for using laser ablation in liquids is the possibility of the transfer of energy from the laser-induced plasma to the liquid medium. This leads to the formation of bubbles. In addition, the possibility of absorbing the laser energy by the nanoparticles generated in the solution increases the kinetic energy of nanoparticles and thus the occurrence of Nano laser ablation [1]. Laser ablation in liquids is more effective, as the aggregation of nanoparticles can be avoided by using dispersions and ultrasonic vibrations as well as changing the PH value of the solution [2]. Laser ablation is characterized by the production of a nanomaterial at very low temperatures, as well as the production of more than one substance at the same time, in addition to the alloys of metals [3].

Interestingly and surprisingly, the effect of particle size leads to a change in the optical properties of matter, including dispersion or photo dissociation, of the material surface.

For example, the color known as pure gold nanoparticles. Which is more than 200 nanometers in diameter, is the golden yellow color. However, is reduced. It does not make any sense reducing the size of the gold nanoparticles is reflected in the ability of these particles to resist photo luminescence and their combination between short-range spectral emission and a wide spectrum of excitation [4]. The field of electronics and optics is one of the most important applied fields for nanomaterial applications. Combining optical properties and high conductivity, these materials are used in the manufacturing of ultra-high resolution and color-sensitive screens, such as TVs and new computer screens. The distribution of nanoparticles size can be controlled by choosing the laser irradiation parameters and the properties of the medium [5].

The preparation of Au and Ag nanoparticles under the ablation of solid target by pulsed Nd: YAG laser has been reported in many works, e.g. [4][6]. Many papers [1][2][7][8] have shown that the 40-60 nm silver particles prepared by the citrate reduction method in aqueous medium undergo fragmentation when subjected to 355 or 532 nm laser-pulse excitation[9].

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Theory

Laser ablation is the process of material removal from a surface by the action of laser-intense laser radiation. Laser ablation has attracted attention in many areas of technology and science and has been applied in several fields such as nanoparticles generation [10], pulsed laser deposition[11], laser surface cleaning, and microelectronic device fabrication[12].

The process of the localization of waves has been observed in many physical phenomena, such as for exactions in semiconductor nanostructures. Fabrication of nanoparticles by laser ablation of solids either in gas or in a vacuum has been extensively explored during the last decade. The pulsed laser ablation (PLA) technique has become a promising method for the synthesis of nanoclusters for the photonics, electronics, and medicine.

It provides a possibility for chemically clean synthesis of nanoparticles. In addition, the distribution of cluster size could also be controlled by carefully choosing the laser irradiation parameters and the properties of the medium. Furthermore, PLA allows for easy production of colloidal metal nanoparticles [13].

Experimental Procedure

The principle of the method depends on changing the location of the focus point of laser with accurate distance control ranging between 1 and 7 cm. This action can lead to a change of the laser function from ablation to irradiation and vice versa. In the case of complete focusing, when the focus of the laser beam exactly falls on the target surface the fluence will be at its highest value. This will guarantee the occurrence of the laser ablation process lead which to the generation of nanoparticles. The spectrum of particles sizes that generated using this method of which may contain types of clusters or aggregations. Therefore, by switching the ablation process to an irradiation process, by changing the focal plane position, the aggregations, the cluster, or the large particles will be crashed into smaller size particles. This will lead to the generation of particles much smaller than those obtained by laser ablation only.

Changing the focusing leads to fluence changing the laser. This transforms the work of laser from the ablation process (particle generation) to the irradiation process (fragmentation or atomizing of large particles). Continuously changing of the fluence can lead to a significant decrease in the particle sizes this could be due to the following three important effects:-

First: The direct effect of the bombing by the broad laser beam, which gives exposure possible for a large number of particles with standard sizes in comparison to the width of the laser beam.

Second: The collision effect between the particles as a result of the continuous collisions resulting from the acquisition of the particles a very high kinetic energy as a result of bombardment by laser pulses.

Third: As a result of moving the solution magnetically by magnetic stirrer, allowing the entire parts of the solution subjected to irradiation and several times, in addition to that the continuous stirring by different speeds, that generates extra kinetic energy, which increases the chance of vertical collisions that occur, whereby the greatest amount of energy transfer between the colliding grains and this factor, in turn, increases the efficiency of the process of getting more fine grains. (Towards quantum dots)

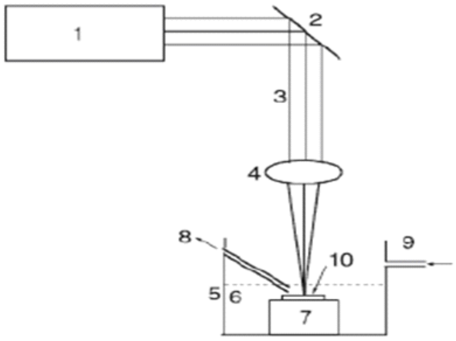
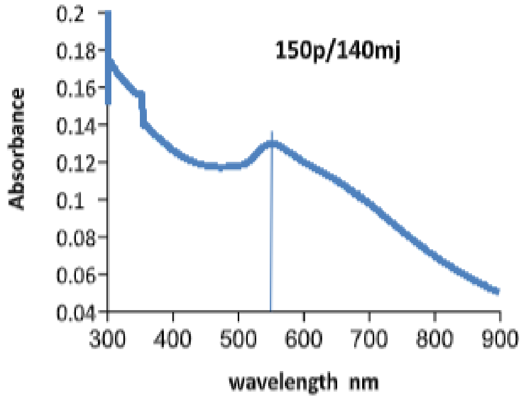


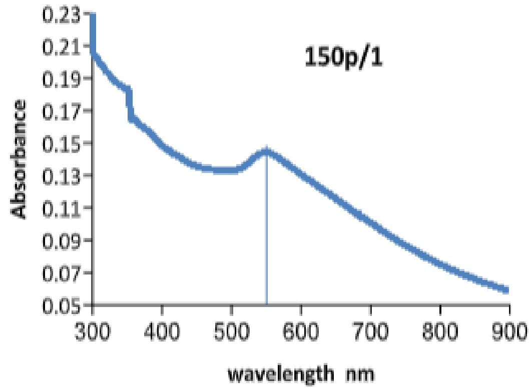
Figure 1. Schematic diagram of a typical LP-PLA setup: (1) laser Nd-YAG; (2) reflecting mirror; (3) laser beam; (4) focusing lens; (5) chamber; (6) liquid; (7) target (8) collecting pipe (9) effusion pipe (10) target reproduced from [14].

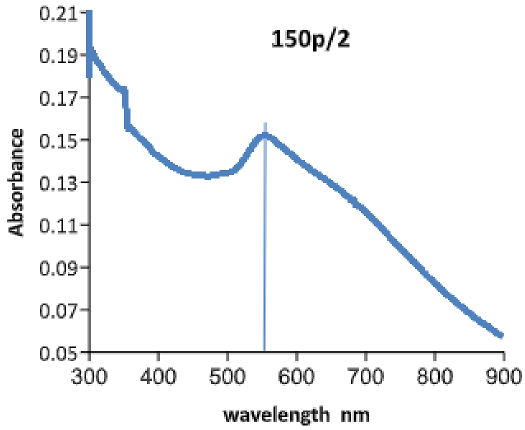
Results and Discussion

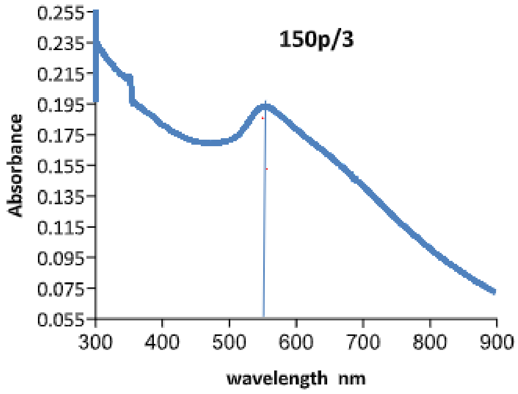
We showed that from the table (1) (**The first case**) when the distance between lens and target (Au) is changed by integer numbers from (15-19) cm, the (SPR) was (538) nm while the absorption will increase and the transmission will decrease. This effect is reflected in both the refractive index and the extinction coefficient.

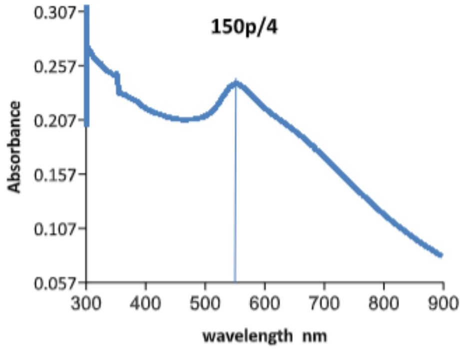
The refractive index was increased (1.337-1.497) while the extinction coefficient between (6.577 x 10^{-6} - 9.948 x 10^{-6}). As in Table (1), we showed that from the table (2) (**The second case**) when the distance between lens and target is changed by half-integer numbers, which appear the (SPR) at (541) nm while the absorption will increase and the transmission will decrease. This effect is reflected on both the refractive index and the extinction coefficient too. The refractive index was increased up to (2.07) while the extinction coefficient high increased up to (2.78×10^{-6}). Knowing that the first and second cases we used (140 mJ) and constant pulses equal (150 p). As in Table (2) and fig. (2).

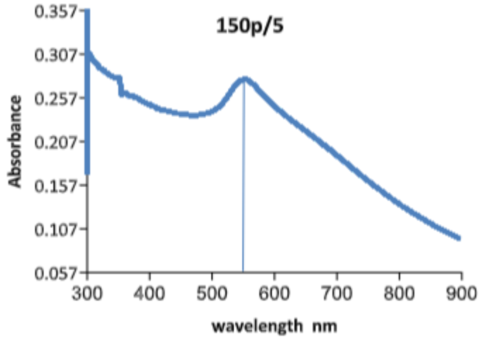


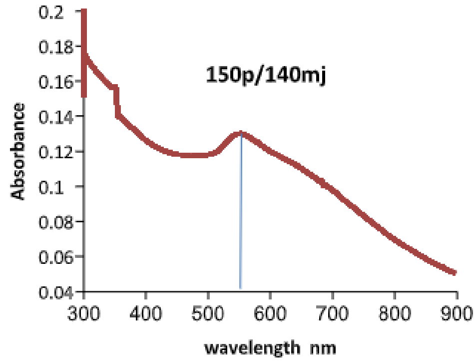


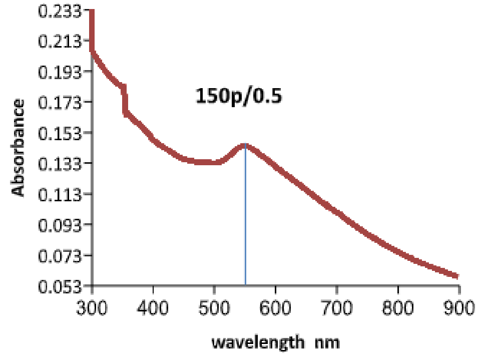


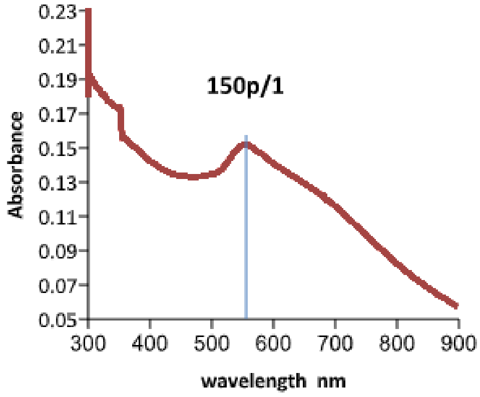


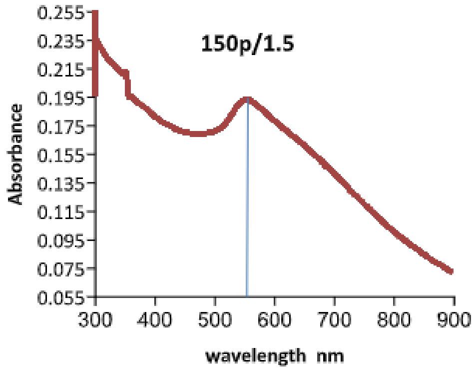


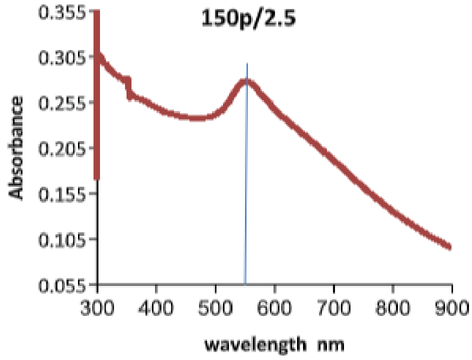












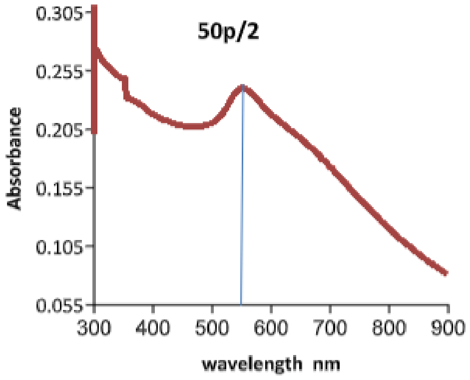


Fig. 2. Represent the Absorbance of all cases of Laser ablation

First State

Table 1. Summarize of optical constants at (538) Absorbance peak with (150 p and 140 mJ)

Lens–Target Distance /cm	Wavelength nm	A	T	K * 10^{-6}	N
15	538	0.066	0.852	6.577	1.337
16	538	0.0868	0.818	8.658	1.438
17	538	0.0864	0.818	8.658	1.439
18	538	0.0868	0.797	9.947	1.497
19	538	0.0992	0.795	9.948	1.497

Second State

Table 2. Summarize of optical constants at (541) Absorbance peak with (150 p and 140 mJ)

Lens –Target Distance /cm	Wavelength nm	A	T	K * 10^{-6}	N
15	541	0.128	0.74	1.30	1.629
15.5	541	0.142	0.71	1,44	1.690
16	541	0.149	0.709	1.540	1.714
16.5	541	0.192	0.642	1.950	1.867
17	541	0.237	0.578	2,423	2.00
17.5	541	0.274	0.531	2.78	2.07

From the optical properties calculations, which include absorbance, Transmittance, refractive index and extension coefficient in the first and second cases as shown in Table (1) & (2).

In the first case, we notice that when increasing the distance between the lens and the target, leads to a decrease of fluency, so that the peak of absorption becomes between (538 -541) with knowing that both the energy and the number of the pulses are constant at (140 mJ) and (150 p). This increases the absorption by increasing the distance (decrease of the flounce) Increasing the granular size, but by repeating the process and by reference to the initial state, the process of purification of grain size, lead to increases in absorption from (0.066) to (0.0992), this is reflected on the transmittance too. While for refractive index (n), we observe the increase of the refractive index from (n=1.337) to (n=1.497), this limits the optical behavior of the Nano solution. While for the absorption coefficient, we note to increase the absorption coefficient from ($6.577*10^{-6}$) to ($9.948*10^{-6}$). This behavior is determined in a specific range within the central visible range (500-700 nm). While In the table (2) we observe the same behavior, noting that the refractive index values increase to (n=2).

The relationships between the size of the Au NPs and the repeat process was an advantage to the purification of grain size.

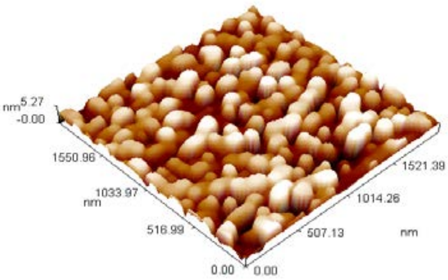


Fig. (3-a)

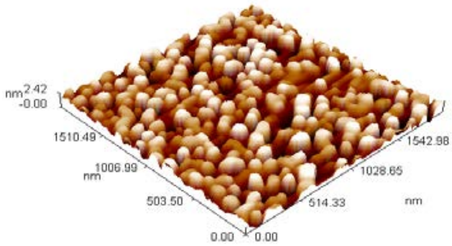


Fig. (3-b)

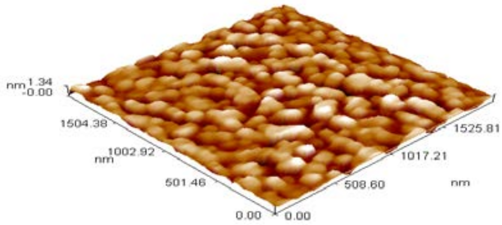


Fig. (3-c)

Fig. 3: AFM images with different cases.

Based on this method, the size of the NPs can be controlled using the Sequence of ablation and irradiation leads to the purification of grain size of nanoparticles which is showed in fig.3-a-b-c, this agreement with [15].

Conclusion

The process of conversion and sequencing of the work of the laser between irradiation and ablation by changing the focus of the lens of leads to the change of the laser fluence. This is a very new and efficient way of refining the particle size of nanoparticles produced by laser ablation in liquids.

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