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Structural, Morphological and Optical Properties of Gold Nanoparticles Using Laser Ablation in Liquid for Sensor Applications

Zainab H. Tawfiq [1,2], Sallah A. Adnan [1,a], Makram A. Fakhri [1,b], Rihab K. Hamad[1]
[1,2,3]*Laser and Optoelectronic department, University of technology, Baghdad, Iraq.*
[4]*Al esraa university college, Computer engineering techniques department, Baghdad, Iraq.*
Salahadnan9999@yahoo.com, mokaram_76@yahoo.com, 140017@uotechnology.edu.iq

Abstract*— The impact of laser wavelength on gold nanoparticle (Au NPs) creation is accounted by the extraction of gold atoms from the gold specimen immersed in ethanol. Pulsed Laser ablation in fluid procedure of the gold target was carried out by employing Nd:YAG laser (nanosecond pulses). Characterization of accomplished gold NPs was achieved by Atomic Force Microscopy AFM), X-Ray Diffraction (XRD) and Ultraviolet-Visible (UV-VIS) absorption and transmission spectroscopy. The outcomes demonstrated the attributes of the prepared NPs, contingent upon XRD, AFM. NPs gotten by 532 nm laser have preferred properties over that accomplished by 1064 nm laser as indicated by the highest values of intensity of shorter wavelengths.*

Index Terms*— Laser ablation in liquid; optical preparation; gold nanoparticles; Refractive Index Sensors.*

I. INTRODUCTION

Nanoparticles (Nps) of respectable metals have, as of late turned out, to be intriguing materials in light of their properties and imperative applications in numerous scientific fields [1]. The manufacture of metallic nanoparticles (NPs), for the most part gold and silver, has pulled in much enthusiasm because of their surface plasmon resonance related properties that are conceivably valuable for their biological applications [2].

The most significant issues in AuNP creation are the control of size, shape, and surface functionalization [3]. Because of their chemical stability and conspicuous optical properties, gold nanoparticles (Au-NPs) have been at the focal point of consideration in nanomedicine [4].

Au-NPs can likewise give the difference to malignant growth imaging through photoacoustic or light dispersing, just as structure versatile surface-upgraded raman dissipating based labels for disease focusing on and conclusion.Nanotechnology stresses materials in 10-9 meter scales, including biotechnology, material sciences, PC sciences, prescriptions, drug store and designing. Nanotechnology initially appeared in ninth century by Mesopotamian individuals for giving glossy impact in pots.

In 1857, Michael Faraday for the first time found the ruby gold nanoparticles (AuNPs), which turned into the establishment for the advanced nanotechnology [5]. Different structural and morphological characters of the created NPs can be constrained by laser fluence, spot estimate, wavelength, pulse width, and repetition rate of laser pulse [6].

The laser removal of a strong target inundated in a fluid milieu has turned into an inexorably imperative "top down" strategy for manufacturing nanostructured materials[7].In this strategy, NP creation results from removal of a strong target put in a fluid medium. Changing the laser parameters and the idea of the encompassing fluid medium empowers control of size, focus, chemical composition and utilitarian properties of the NPs.Numerous laser types have been

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proposed for this reason, including nano, pico and femtosecond lasers at different wavelengths running from infra-red (1064 nm) to ultraviolet (248 nm) [8].Another technique dependent on laser removal in fluid of the mass metal showed up over the most recent couple of years for the amalgamation of gold nanoparticles [3]. Mafune' et al. have demonstrated that it is likewise conceivable to get great control of the elements of the nanoparticles by utilizing the second harmonic of a Nd:YAG laser (532 nm) and a surfactant like sodium dodecysulfate (SDS).Uhlirand Turner was the first who labelled the construction of porous silicon coating (PSLs) on silicon electrodes in hydrofluoric acid electrolytes under anodic bias.

The diameter of PSL pores or channels was found to extend from 1 up to 100 nm related with porosities of 20-80% [9]. Since permeable silicon can be effectively manufactured legitimately from a similar single-crystal silicon wafers utilized in the microelectronics business, it appeared to be perfect for a Si-based optoelectronic innovation (the mix of optics and light emanation with standard silicon-based microelectronic gadgets). The benefit of a silicon-based EL gadget is that it would preferably be well matched with well-known strong state advancements that utilization silicon, and stay away from the cost and perils related with the treatment of III±V semiconductors. Porous silicon is an all-around described, flexible inorganic material created through a galvanostatic, synthetic, or photochemical drawing methodology within the sight of HF. Contingent on the carving conditions, Porous silicon by and large has an intricate, anisotropic nanocrystalline architecture of high surface area [10, 11].

II. EXPERIMENTAL WORK

In order to extract gold nanoparticles (NP), the first step, inundated 2mm diameter of circular Hugh purity gold alloy in 5 ml of ethanol. after that step irradiate the metal using pulsed Q-Switched Nd-YAG laser of 532 nm, by applying an energy of 1000 mJ/pulse and 100 pulses with a 12 cm lens (spot size:1 mm^2) onto sample in order to remove the NPs as illustrated in Figure 1. commonly the red coloration of the solution leads to the creation of gold NPs after few seconds of removal.

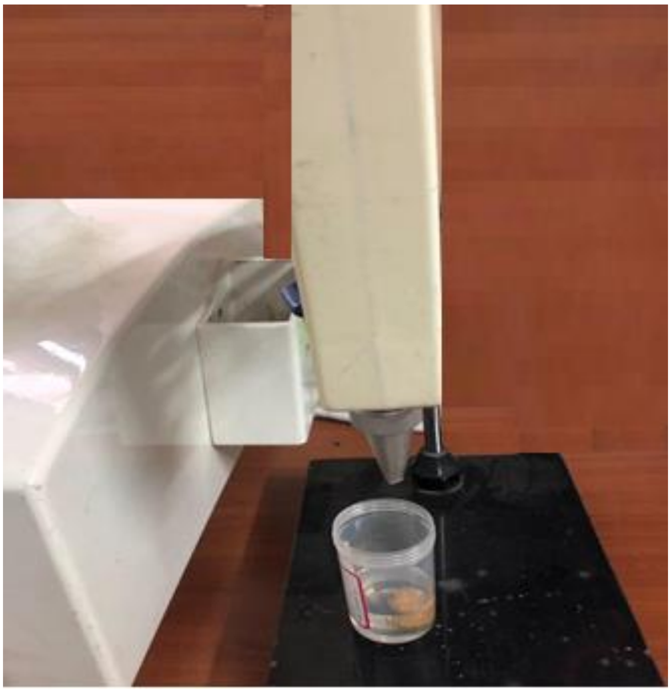

FIG. 1. EXPERIMENTAL SET UP FOR GOLD COLLOID PREPARATION BY LASER ABLATION IN SOLUTION.

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After the synthesis process, the prepared Ag NPs were considered utilizing UV-vis double beam spectrometer. The phase organization of the nanoparticles has been dictated by X-ray diffraction analysis utilizing a diffractometer system (x' pert pro MRD PW3040). Then again, Porous silicon was set up from silicon n-type and concentration 40% of hydrofluoric acid (HF) for 5 minutes engraving time and at 40 mA current. Finally, the gold blend has dropped on the porous silicon by drop casting technique which has subjected to heat so as to be dry.

III. RESULT AND DISCUSSION

Figure (2) demonstrates the XRD for the prepared gold NPs by PLA technique with 1064 and 532 nm, and 100 pulses. Drop-casting technique was utilized for the purpose of gold NPs deposition on the porous silicon. Figure (2) shows the XRD of 532 nm, three particular peaks were shown up at 2θ=34.05, 38.15, 44.3. Basically,each one of the three peaks corresponded to the standard Bragg reflections (110), (111) and (200) of (fcc) lattice. Peak of 34.15 alludes to the SiO2 which showed up because of silicon collaboration with ethanol. At 1064 nm, as appeared in Figure (2), two peaks showed up at 2θ=38.15 and 2θ= 44.3, compared to the standard Bragg reflection (111) and (200). Because of the laser power impact, this made two phases to be shown up for gold, one at 532 nm and the other at 1064 nm.

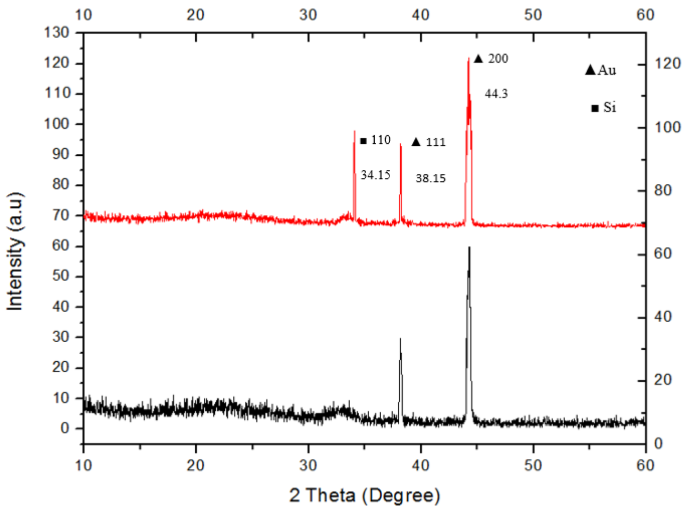

FIG.2. XRD ANALYSIS OF GOLD NANOPARTICLES

Figure (3.a.b) the morphological results are considered as a very interesting parameter for the photonics integrated circuits, optoelectronics and in the sensing applications. Both values of the root mean square and the grain size can be affected by the different wavelength of a pulsed laser. Fig. 3 (a and b) presented the topographic structure for gold NPs prepared at 532, 1064 nm. At a 532nm a small size of NPs was acquired, the surface roughness is (mean=18.034 nm, SD=12.807nm) and accomplished the good distribution and high smooth than that produced by 1064 nm which is (mean= 50.974nm, SD= 40.792 nm). This means that the gold interaction with 532 nm more than its ability of interaction with the other laser wavelength.

Figure (4.a.b) illustrated the SPR transmission and the absorption spectrum of the gold NPs as a function of wavelength for 1064 and 532 nm wavelengths. From this Figure one can observe that as the Au NPs size increase, the SPR band shifts to longer wavelengths. From Figure (4.a.), at 1064 nm, the gold NPs possess larger size than that obtained by 532 nm laser beam. As a result, the highest transmission peak has obtained by 1064, the transmission peaks obtained by 1064 and 532 nm where the transmission at 1064 nm about (89.07) and the effective transmission about 520 nm and the transmission at 532 nm are about (84.55) and the effective transmission about 513 nm, this value gives

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an indication that when minimizing the Laser wavelengths to ablated the gold nanoparticles, the result will be a blue shift and this means that the grain size will be less. From Figure (4.b.), the highest peak of absorption resulted by the application of 1064 nm laser beam and the effective absorption is about 0.49, while when using 532 nm laser , the absorption peak obtained at 530 nm and the effective absorption is about 0.70. The absorption of SPR of gold NPs depends on the size and shape of gold NPs when enlarging the volume , then minimizing the absorption in order to give maximum absorption from 500nm to the near infrared area of the spectrum, surface plasmon resonance can be tuned easily. For example, Cytodiagnostics spherical colloidal gold in the area between 515-570nm has the maximum absorbance as demonstrated above, however the irregular form particles like gold nanorods, and urchin form gold nanoparticles (also known as gold nanostars) have the maximum absorbance in the near-infrared area of the spectra This is similar to the results recorded by Nguyen Ngoc Long et al [12].

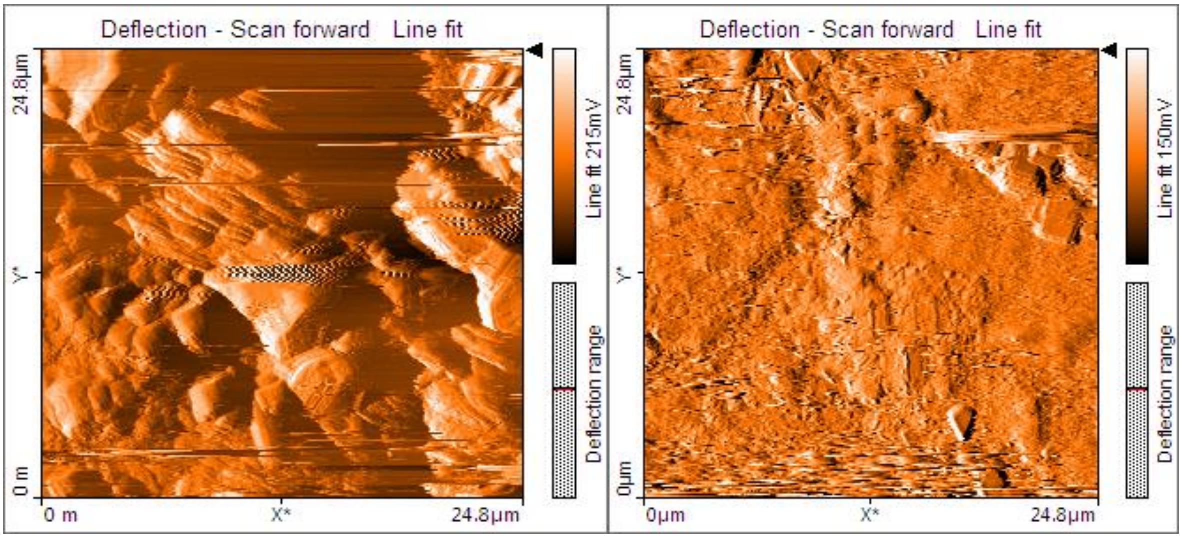

FIG.3.A. AFM ANALYSIS OF GOLD NANOPARTICLES AT 532 NM, (B) AFM ANALYSIS OF GOLD NANOPARTICLES AT 1064 NM

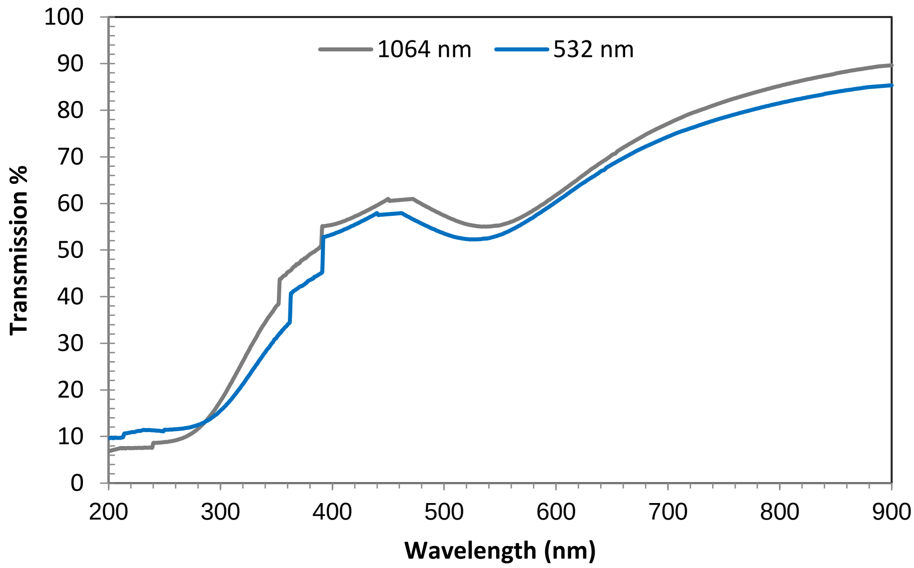

FIG.4.A..UV-VIS TRANSMISSION SPECTRUM FOR 1064 AND 532 NM LASERS ON THE GOLD NPS EMBEDDED IN ETHANOL.

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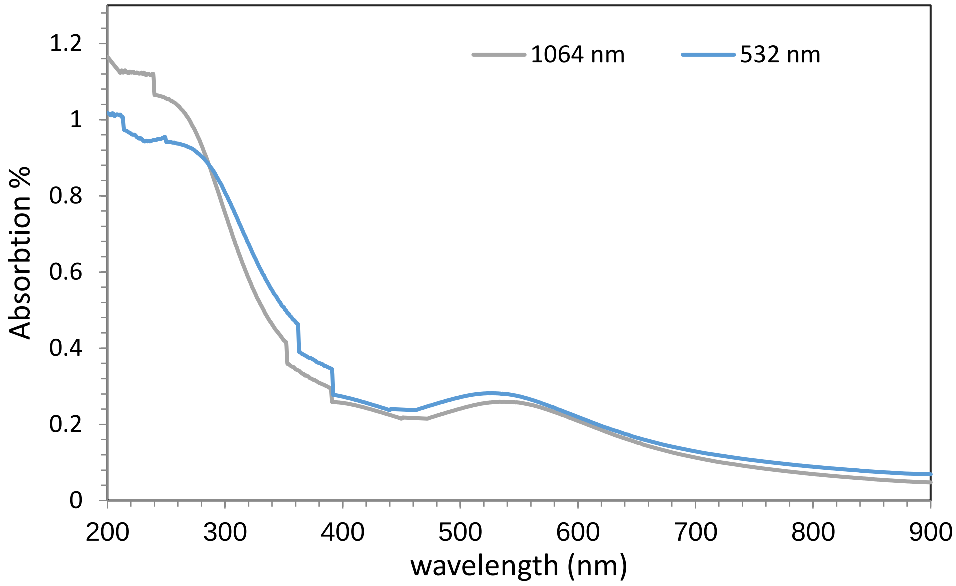

FIG.4.B. UV-VIS ABSORPTION SPECTRUM FOR 1064 AND 532 NM LASERS ON THE GOLD NPS EMBEDDED IN ETHANOL.

IV. CONCLUSION

Gold NPs mixed in ethanol were prepared by PLA technique utilizing a nanosecond Q-switched Nd:YAG pulsed laser at 1064 nm and 532 nm laser. Drop casting technique was utilized to sedimentation the gold NPs on the permeable silicon. The results have demonstrated characteristics of prepared NPs, contingent upon XRD, AFM.NPs acquired by 532 nm laser own better properties over that accomplished by 1064 nm laser as indicated by the most intensity of shorter wavelengths. As result, the gold NPs interaction increases, as the number of laser pulses increases. From AFM results, two phases of gold were shown up at 532 nm, while only one phase was shown up at 1064 nm. One can conclude that as the Au NPs size increased, the SPR band shifts to longer wavelengths.

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