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Effect of Photodeposition Time on the Concentration of Silver Nanoparticles on Core of Optical Fiber End

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Abstract
In this work an experimental study of deposited silver nanoparticles on the core of optical fiber end at different time based on photodeposition technique is presented. The results demonstrated that the concentration of silver nanoparticles deposited on the core of optical fiber end was effected by the deposition time. The photodeposition system was fabricated using multi-mode optical fiber and laser diode source. The results show that the silver deposition concentration increases linearly with the deposition time. The deposition rate was 3.25 (wt/ s)

Keywords: optical fiber, silver nanoparticles AgNPs, photodeposition.

تاثير زمن الترسيب الضوئي على تركيز جسيمات الفضه النانوية المترسبه على قلب ليف ضوئي عند نهايته

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الخلاصة
في هذا البحث تم تقديم دراسة تجريبية لترسيب جسيمات الفضة النانوية على قلب ليف ضوئي عند نهايتة باستعمال تقنيه الترسيب الضوئي وبازمان مختلفه. اوضحت النتائج ان تركيز جسيمات الفضة النانويه المترسبه على قلب الليف الضوئي تعتمد على زمن الترسيب.منضومة الترسيب الضوئي استعمل فبها ليف ضوئي متعدد الانماط وليزر بلوري ثنائي كمصدر ضوئي.اظهرت النتائج ان تركيز الفضة المترسبه يزداد خطيا مع زمن الترسيب وبمعدل ترسيب 3.2 (wt/ s).

1. Introduction

During the last few years, Nanoparticles have drawn major attention because of their unique features of optical, chemical and mechanical properties as compared with those of the indistinguishable bulk material. These features can be adjusted via their shape and size [1, 2]. Metallic NPs are particularly stimulating due to their ultrafast optical response [3], surface plasmon resonance SPR [4, 5], and large optical nonlinearities [6, 7]. Among others NPs optical manipulation has come to be a significant research area for its potential applications in medicine and other technological fields. Manipulation and trapping of dielectric NPs present an additional challenge more than trapping of dielectric micro-particles by means of the optics diffraction limit [8], the small volume of the nanoparticles and the high intensity of beam [9]. NPs of metals are even harder to trap due to the presence of resonant excitation of allowed electrons in the particle of metal coupled to light. The metallic particles optical properties change drastically round the plasmon resonant frequency. Thus, for instance, metal nanoparticles optical trapping is probable far from plasmon resonance [10], even so, particles and near plasmon resonance absorption controls are prevent from the ray [11]. But then,

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optical manipulation and trapping of NPs by pigtailed single optical fiber has discerned to be an attractive choice due to its stability and simplicity [12]. Usual optical fibers can be a simple and useful device for coating organic nanostructures on the end of optical fiber. Depositing particles on the end of an optical fiber can be utilized as saturable absorption in the laser cavities of optical fiber [13]. Fiber optical tweezers have been utilized not only for coating but also for growing gold and Ag NPs by a self-assembly [14]. To fabricate an optical fiber sensor based on LSPR, there are some methods to immobilize nanoparticles on the optical fiber, such as photodeposition technique [15], electron-beam lithography [16], self-assembly of polyelectrolyte [17], and self-assembly [18]. In this article, an experimental study of photodeposition of AgNPs onto a multi-mode optical fiber is presented. A near infrared light is used, where the scattering and absorption forces are much larger than the gradient force even for very small NPs and hence deposition of metal particles should not happen. even so, in this subject, the laser beam stimulates convection current movement (due to the heat transmission from hot Ag NPs) of the liquid absorbed near the end of optical fiber are displayed, and the scattering and absorption forces incompletely reimburse the Stokes force for convinced particle size. Since absorption, Stokes forces and scattering are all dependent on the laser power beam and particle volume, A mechanism for choosing the particle size deposited on the core of the optical fiber end is set through the interaction of these forces.

2. Experiment Work

In order to reach the Ag deposition on the core of fiber, a laser diode source coupled with a multi-mode optical fiber was utilized. This laser works in continuous-wave of about 532 nm wavelength by Gaussian profile beam and output power 100mw.The diameter of the optical fiber core and its cladding are ~50μm and ~ 125 μm, respectively. The optical fiber has two ends, the first end was coupled to laser where the coupling was done using micro-lens SMA adapter coupled with SMA fiber optics adapter as shown in Figure-1 This configuration is connected to the laser diode by a homemade micro connecter

The second end of optical fiber is was prepared through take away the coating and cleaving it, and then putting it into a solution mixture of ethanol and silver NPs. The solution was prepared by mixing 27 mg of Ag powder and 30 cc of ethanol then homogenized using an ultrasonic bath of ultrasonic to for 15 minutes. The aqueous medium container was a cylindrical cell of 1.5 cm in diameter and 30 cm height is utilized to putting aqueous media. The container It was filled to ~90% of its capacity. The usual distance from solution free surface to fiber end was approximately 2 cm and the distance from the optical fiber end to the container bottom was around 28cm as shown in Figure-2. Laser diode source was turn on to deposit Ag NPs on fiber end via photodeposition technique. So that Ag NPs are close to the core of the optical fiber and are adhered to it via laser power .b By this process, it is possible to select the maximum size of NPs adhering on the optical fiber end bydue to the laser power. Furthermore, the amount of NPs amount relies on the time of the optical fiber is immersed in to the solution and the power of laser. The optical fiber coupled with diode laser and was immersed in the colloidal solution for different time (1, 12, 24) hours.

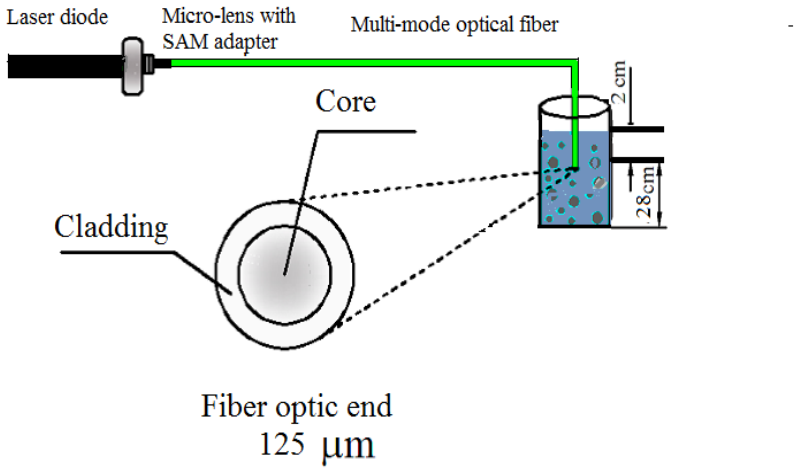


Figure1-The Setup for depositing Ag NPs onto optical fiber end

3. Results and Discussion

3.1Atomic Force Microscopye for of Silver nanoparticles

Figure-2 shows the Atomic Force Microscope images of the silver nanoparticles which was were prepared by the explosive wire system as raw material. The average particles average size as determined fromwith the atomic force microscope is 45.43 nm.

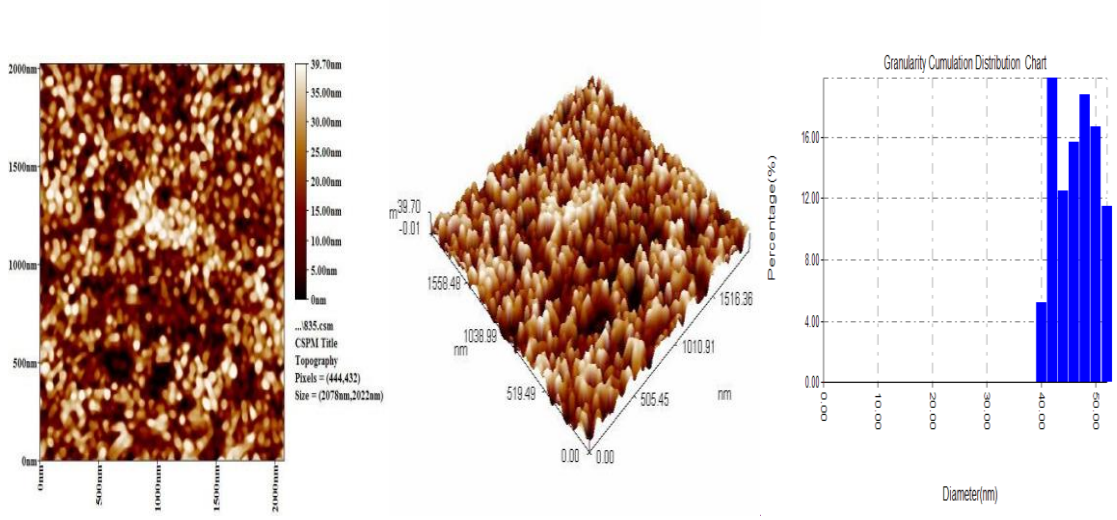
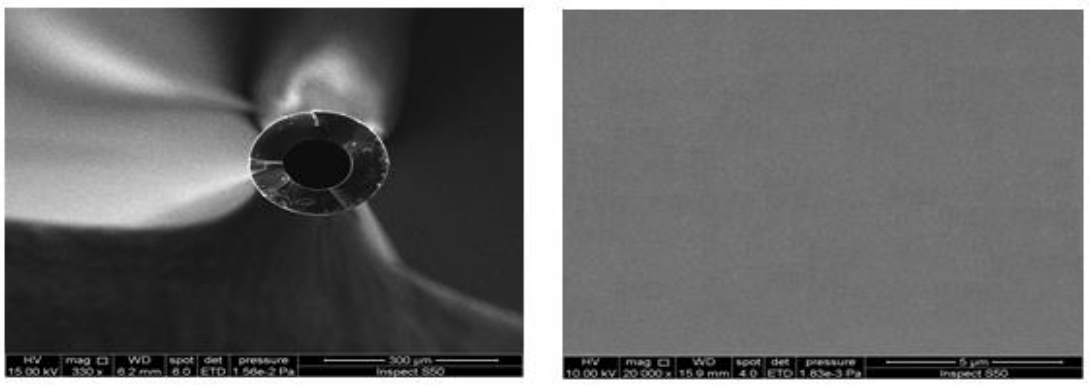


Figure 2- The AFM images of Ag NPs

3.2 Scanning Electron Microscope (SEM) for Optical Fiber End

The deposition set-up which had been mentioned in section (3), a An image of the optical fiber end before and after depositing silver NPs (using the deposition setup mentioned in section 3) at different times as shown in Figure-3

Figure-(3a) illustrates the optical fiber preparation (cutting and cleaving) before the deposition process. Figure-(3b) shows that no practically no NPs is were achieved when the laser diode is was off even if the optical fiber was submerged for a long time up to 1hour. However, when the fiber was submerged for time (1, 12, and 24 hour) and the laser diode was operated on , and can be noticed clearly that the deposition of silver NPs can be clearly noticed occurs as shown in Figures-(3c, d and e). The amount of deposited NPs increased when the end of optical fiber the immersion time of the end of optical fiber in to the colloidal solution i was increase,. and t The silver NPs arewere preferably deposited preferably about the fiber core, though some nanoparticles are deposited on the cladding of the optical fiber. Figure-(3F) reveals a magnification of the optical fiber core with 1μm that shows silver NPs were agglomerated and disagglomerated.



(a) (b)

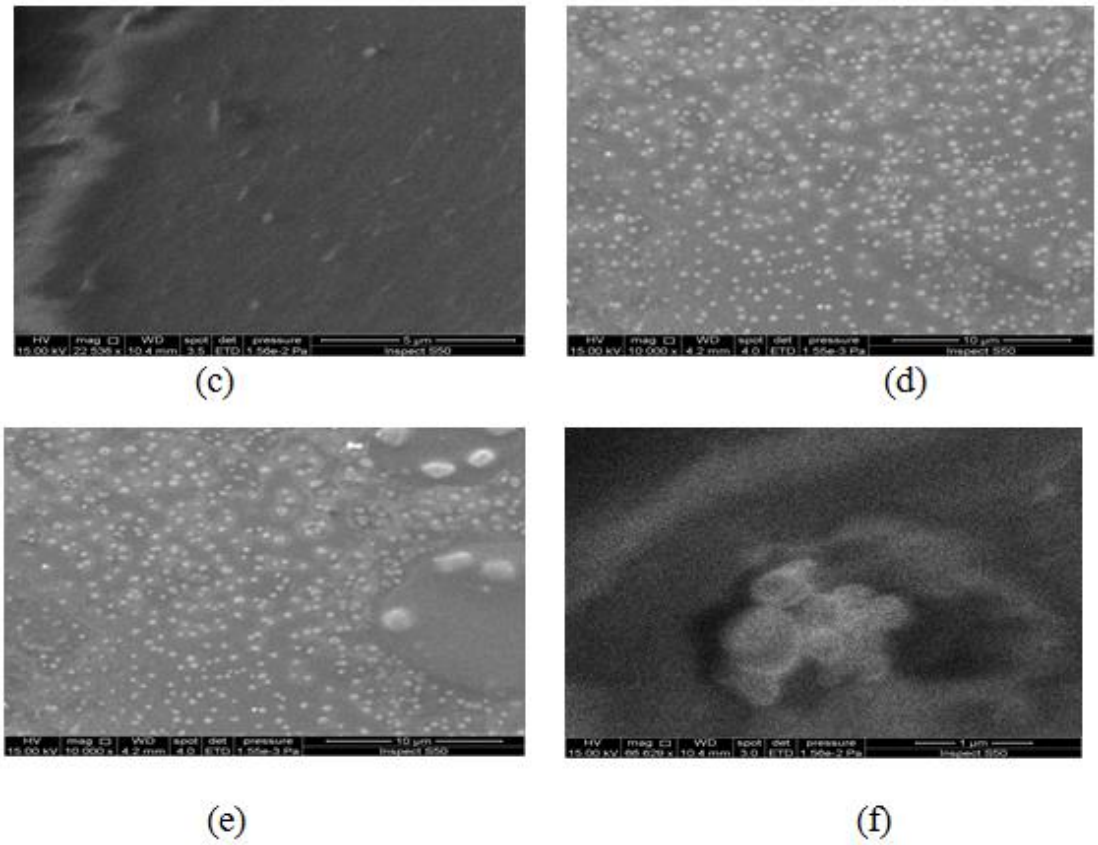


Figure 3-SEM images for an optical fiber end: (a)Micrograph after optical fiber cutting (b) immersed into solution for up to1h.without LD (c) Ag NPs deposition on the core when laser irradiated for 1h. (d) Ag NPs on the core when laser irradiated for 12 h. (e) Ag NPs on the core of optical fiber when laser irradiated for 24h. (f) Ag NPs on the core of optical fiber when laser irradiated for 24h. with magnification 1μm

3.3 EDX for an Optical Fiber End

The concentration of Ag NPs deposition was examined by EDX technique and the results are shown in Figures-(4a-4d). From Figure 4a, it can be shown the composition of optical fiber end can be seen which consists of silicon material which is represented s by the maximum peaks.

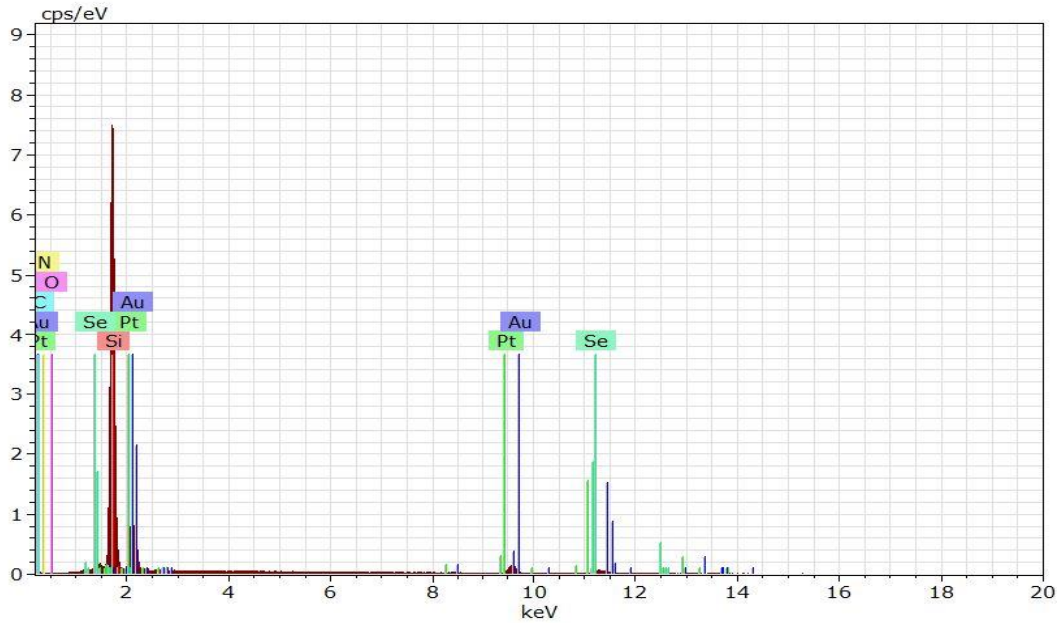


Figure 4a-Optical fiber end when laser diode turn is on

Figure-4b illustrates the optical fiber end has been coated by with silver nanoparticles for 1h. By comparison between Comparing Figure 4a and 4b the appearance of the silver nanoparticles peak is clearly noticed clearly show that the silver nanoparticles peak appear in Figure-4b and the silver nanoparticles concentration was 5.21% , This peak is not present while the silver nanoparticles cannot be shown in Figure 4a so. t This is good evidence that the optical fiber end was coated by with silver nanoparticles.

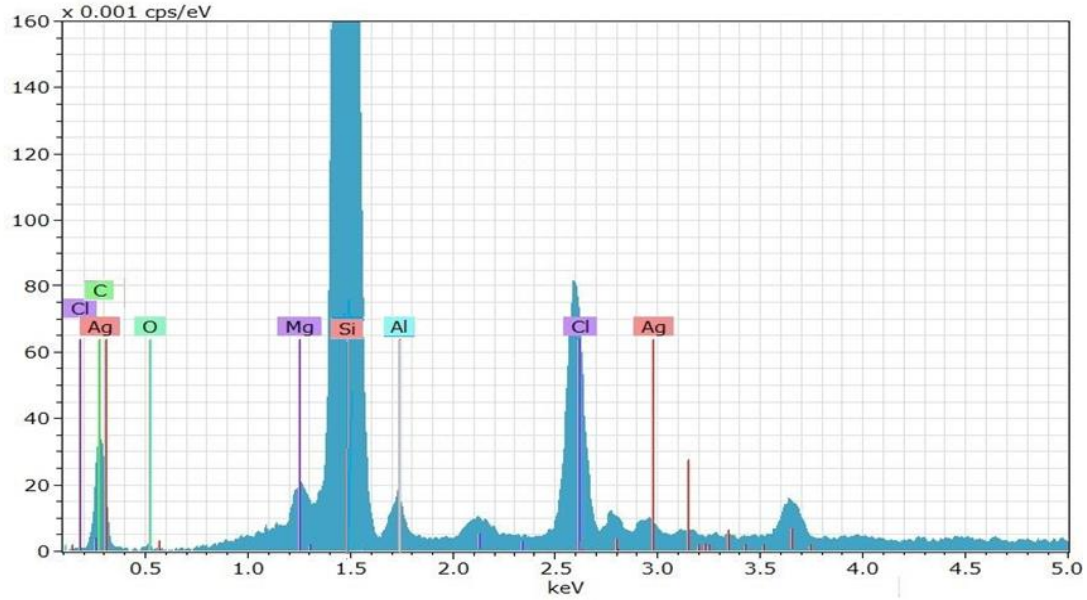


Figure 4b-Optical fiber end with deposition time of 1 hr.

Optical fiber end which has been coated by with silver nanoparticles during a period time of 12 hours a is shown in Figure- 4.c.and t .The concentration of silver nanoparticles deposited were increased up to 35.21% This is because the concentration of the deposited silver nanoparticles is directly proportional to the immersion time within the times adopted in the experiment.

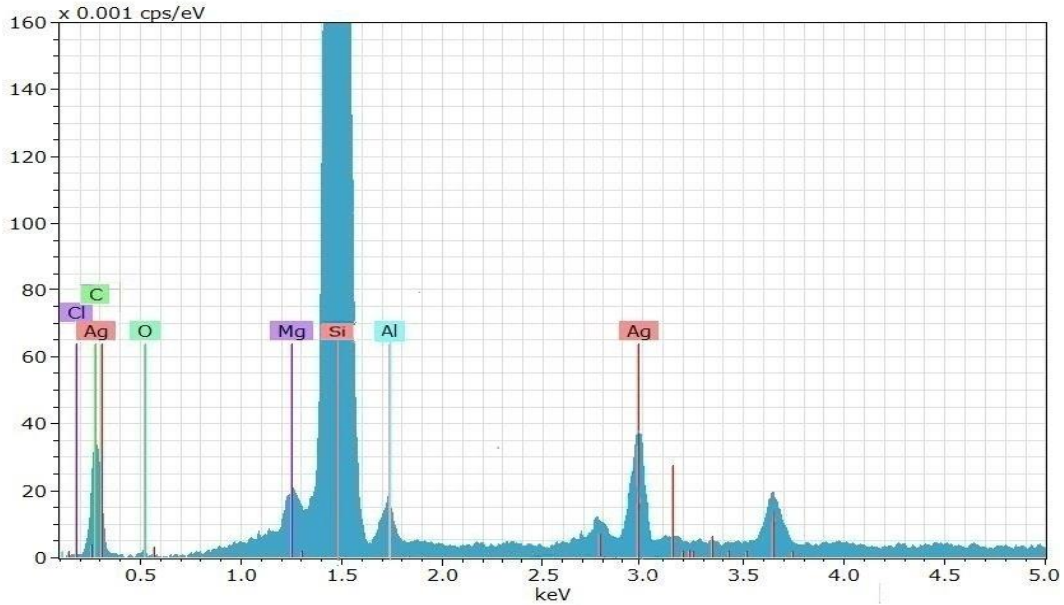


Figure 4c-Optical fiber end with deposition time of 12 hr.

But when the coated optical fiber end was coated with silver nanoparticles for 24 hours, the deposition concentration of silver nanoparticles were was increased up to 80% as shown in Figure- 4d . It is clear that the relationship between time and concentration is still direct ly proportionality.

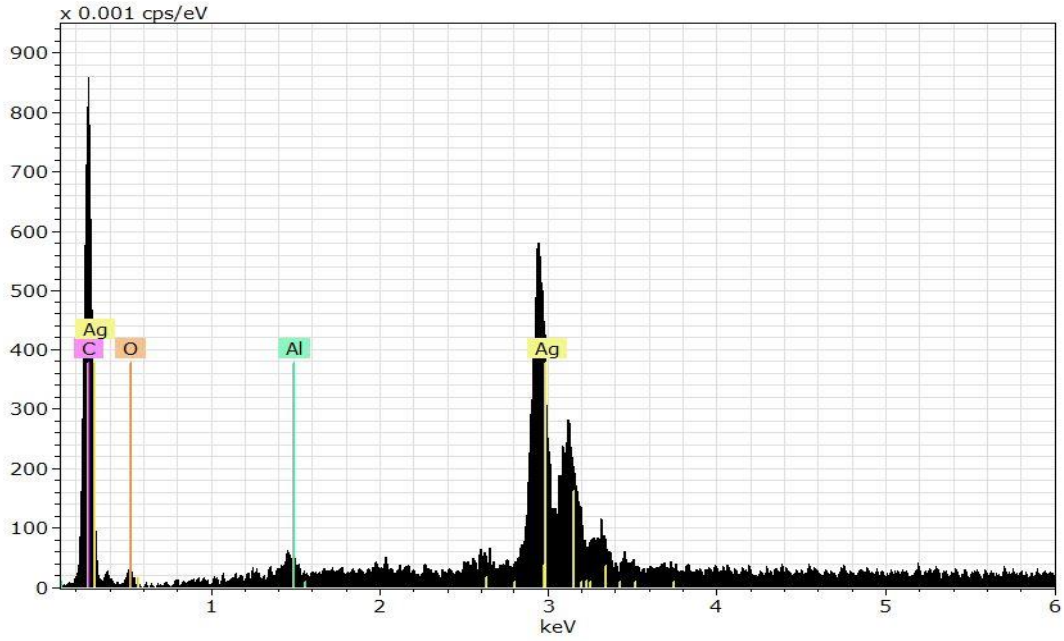


Figure 4d-Optical fiber end with deposition time of 24 hr.

3.4 The Relationship between Deposition Time and Deposition Concentration.

When the deposition period i wass increased the coating concentration is also increased. This can be shown in Figure-5 which is presenting presents the relationship between deposition times at and the concentration of the deposited Ag NPs concentration.

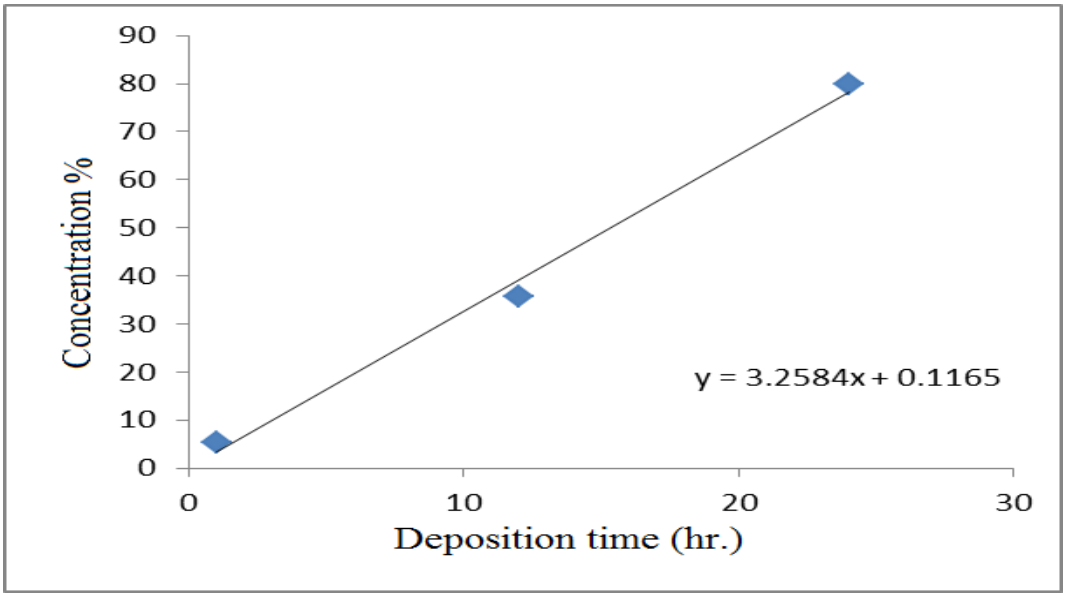


Figure 5-Ag NPs deposition concentration as function of the deposition time.

5. Conclusion

In this work, the photodeposition of silver NPs on the optical fiber core is possible by using a laser diode based by on the photodeposition methods was proved, and t The concentration of Ag NPs deposited on the core of optical fiber end was achieved proved to be directly dependent via on the deposition time. It is possible to deposit other types of metallic nanostructure so that since the photodeposition method has potential applications in this subject, and via Employing this method , it is possible to select the maximum size of NPs adhering on the core of optical-fiber end by means of changing the laser power. By c Controlling the increase of the concentration of silver NPs , it is possible to prevent the formation of NPs agglomeration ed. This deposition technique is simple and of

low-cost of deposition. The metallic NPs can be utilized in Raman sensors and refractive index measurement.

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