Synthesis of Gold Nano Particles via Thermal Decomposition of $HAuCl_4$ on Glass Substrate

Uttam R. Kande[1] and Bhaskar S. Munde[2*]
[1]Department of Physics, Vaidyanath College, Parli-Vai.,Dist.Beed-431515 INDIA
[2] Department of Physics, KKM College, Manwat, Dist.:Parbhani-431 505 INDIA

Abstract

Thermal decomposition process was used to synthesize gold nanoparticles on glass slides at very low temperature condition. The particles with average sizes between 70 to 90 nm were observed on the glass surface and are due to thermal reduction of HAuCl4 at low temperature of sintering. These free standing gold nanoparticles prepared by this method are free from contamination and are suitable for use in semiconductor industry.

Keywords - *Gold nanoparticles, thermal decomposition.*

I. INTRODUCTION

Nano sized materials have extraordinary physical and chemical properties, which are different from those of the bulk material. Moreover, metals nanoparticles have recently been an important focus of research due to its unusual electrical, optical and thermal properties. Recent emerging field of nano-engineering, nano-electronics and nano-bioelectronics are searching for metal nanoparticles for various applications. Nanoparticles of silver and gold have electrons moving freely in close lying conduction and valance bands, which results in highest electrical and thermal conductivity among all metals. In addition to this, the free electrons give rise to a surface plasmon absorption band, which depends on both the particle size and chemical surroundings.

Synthesis of well defined metal nano sized material is a major goal now a day. Numerous reports are available on the synthesis of metal nanoparticles in solution by various ways such as photochemical reduction, electrochemical techniques and chemical reduction. Synthesis of gold (Au) nanoparticles is a significant area of research, because Au nanoparticles have potential applications in various fields such as biochemistry, environment, medicine, catalysis, electronics and optics [1–4].

In the present work, Au nanoparticles were synthesized on glass substrate via thermal decomposition of $HAuCl_4$ at two different temperatures. The synthesized Au nanoparticles have been characterized by X-ray diffraction (XRD), UV-Vis absorption spectrscopy, Scanning electron microscope (SEM) and Energy dispersive X-ray (EDX) analysis techniques.

II. EXPERIMENTAL

For synthesis of Au nanoparticles, solution was prepared by mixing 0.004 M $HAuCl_4$ in distilled water. A thin film of this solution was formed on clean glass slide of size 2.5 x 2.5 x 0.2 mm. This thin film was kept for drying at room temperature in dark room to avoid photo-degradation of $HAuCl_4$. This film was sintered in muffle furnace at atmospheric condition at 100 and 150 ^oC for 1 hour. This procedure is similar our earlier published work [5]. The obtained film sample was then analysed by XRD, UV-Vis absorption, SEM and EDX techniques.

III. RESULTS AND DISCUSSION

Figure 1 show the XRD spectra of the Au nanoparticles thin film obtained via thermal decomposition of $HAuCl_4$ on glass substrate at 150 ^oC. The XRD peaks appeared at the same positions of the bulk Au are known to appear. Four distinct XRD peaks, as shown Figure 1, at 2θ values of 38.205, 44.42 and 64.65 represent the (111), (200) and (220) crystalline planes of the face centred cubic Au crystal structure [6,7]. The sizes of the particles were estimated by analyzing the XRD spectra using Scherrer's formula [8]. The average Au particle size distribution estimated from the XRD spectra are 70 to 110 nm for the sample sintered at 150 ^oC.

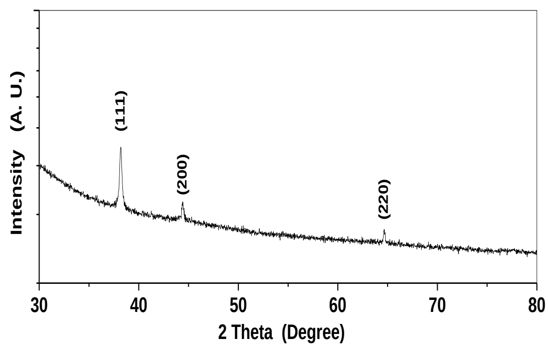

Figure 1: The recorded XRD spectra of the Au nanoparticles thin film obtained via thermal decomposition of $HAuCl_4$ on glass substrate at 150 ^oC.

Figure 2 shows, the optical absorption spectrum for the Au nanoparticles thin film obtained via thermal decomposition of $HAuCl_4$ on glass substrate at 100 and 150 °C. Sample sintered at 100 °C is dominated by a single absorption peak at ~ 512 nm, which corresponds to the surface plasmon absorption peak of the spherical Au nanoparticles [9]. It can be seen in Figure 2 that, the plasmon absorption peak appeared at ~ 512 nm for 100 °C sintered sample shifts to higher wavelength ~ 530 nm for the sample sintered at 150 °C. This shift of ~ 18 nm in the plasmon absorption peak reveals that the size of the Au nanoparticles increases with increase in the sintering temperature.

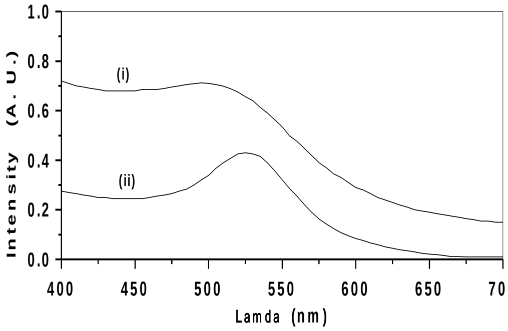

Figure 2: The Surface plasmon resonance spectra of Au nanoparticles thin film obtained via thermal decomposition of $HAuCl_4$ on glass substrate at 100 and 150 °C.

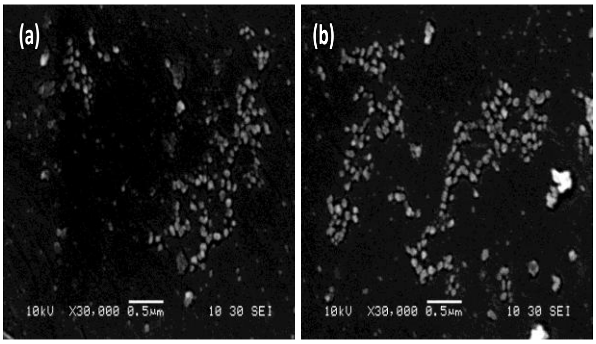

Figure 3: SEM images of the Ag nanoparticles thin film coatings on glass sintered at (a) 100 and (b) 150 °C.

Figure 3 show SEM images of the Au nanoparticles thin film coatings on glass sintered at 100 and 150 °C respectively. The sample sintered at 100 °C show that the Au particles of sizes in the range of ~ 70 to 90 nm and of sizes in the range ~ 100 to 120 nm for the sample sintered at 150 °C. These SEM results clearly reveal that, the rate of agglomeration of the Au particles on glass substrate increases with increasing sintering temperature.

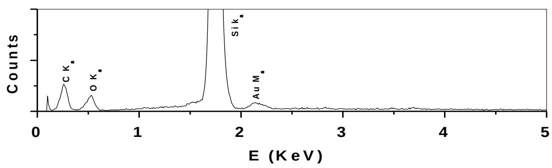

Figure 4: EDS spectra for the thin film coatings made via thermal decomposition of $HAuCl_4$ on glass substrate at 150 °C.

Figure 4 represents the presence of Au in the thin film coatings made via thermal decomposition of $HAuCl_4$ on glass substrate was confirmed using an elemental analysis technique such as Energy dispersive spectroscopy (EDS). The recorded EDS spectrum for the Au nanoparticles synthesized at sintering temperature of 150 °C is shown in Figure 4. The presence of Au in the thin film coating can be identified by the presence of Au line at E = 2.143 keV and from the substrate of Si a strong Si line at E = 1.739 keV. The observed core level x-ray line indicates that the thin coatings contain Au nanoparticles.

This study clearly indicates that the sintering temperature plays an important role in decomposing $HAuCl_4$ and controlling the size of Au nanoparticles. The surface plasmon peak is strongly depends on the particle size under identical conditions of the precursor. The increase in the nanoparticles size with increasing sintering temperature shift in the surface plasmon absorption peak position towards right side of spectra.

CONCLUSION

Au nanoparticles were prepared by decomposing thin film of $HAuCl_4$ coated on glass substrate on sintering. The optical study reveals that the surface plasmon peak of Au nanoparticles is affected by the sintering temperature. The XRD result reveals polycrystalline Au nanoparticles can be synthesizes on glass substrate via above method. SEM measurements shows that the Au nanoparticles synthesized in solution have spherical shape with size distribution in the range 70 to 120 nm.

REFERENCES

[1] P.S. Alegaonkar, A. B. Mandle, S. R. Sainkar and V. N. Bhoraskar, Nucl. Instr. and Meth. B 194 (2002) 281.
[2] M.K. Temgire and S. S. Joshi, Radiat. Phys. Chem. 71 (2004) 1039.
[3] Wei-Tai Wu, Yusong Wang, Lei Shi, Qingren Zhu, Wenmin Pang, Guoyong Xu and Fei Lu, Nanotechnology 16 (2005) 3017.
[4] Y.Sun and Y. Xia, Science 298 (2002) 2176.
[5] U.R. Kande and B. S.Munde, International Journal of Advanced Technology in Engineering and Science, 5 (2017) 407
[6] M.Kumar, L. Varshney and S. Francis, Rad. Phys. Chem. 73 (2005) 21
[7] I.Hussain, B. Mathias, A. J. Papworht and A. I. Cooper, Langmuir 19 (2003) 4831.
[8] B.D. Cullity, Elements of X-ray Diffraction (Addision-Wesley, New York, 1959).
[9] R.He, X. Qian, J. Yin and Z. Zhu, J. Mater. Chem. 12 (2002) 3783.