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Research Article

Keywords: Nanoparticles, GLAD, SEM

Posted Date: October 11th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-961864/v1

Proceedings of the 2nd International Conference on Inventive Computation Technologies (ICICT 2017)
IEEE Xplore Compliant - Part Number:CFP17K52-ART, ISBN:978-1-5090-6697-1

Analysis of structural differences of Ag Nanoparticles generated using Thermal and E-beam process based on SEM image

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Abstract: The variation in applications of nanoparticles (NPs) comes from differences in their microstructures. This may be observed in the terms of variation in size, area fraction and even the morphology of the particles. It is mainly the size and topography of these particles which govern the Mechanical, Optoelectronics, properties and have a huge impact in Bio-medical engineering.

Keywords—Nanoparticles, GLAD, SEM etc.

1. INTRODUCTION

Nano range structures are formed by different methods for different applications such as optoelectronics, bio-medical purposes and many others. The size of nanoparticles mostly plays a critical role in the various application such as optics, electronics, data storage and anti-bacterial activity. [1]

Lots of techniques are induced to develop nanoparticles such as chemical process [2], RF sputtering [3] and by different physical routes etc. [4,5]. But glancing angle deposition gives some special advantage of mechanism to create nanostructures [6]. The morphology of the nanostructures depends on rate of deposition, deposition angle, substrate temperature [7] and rotation rate.

In this work we have shown the comparative study of research on morphological structure of Silver (Ag) nanoparticles (NPs) grown by Electron beam evaporator and Thermal Evaporator and further the structural calculation of Nanoparticles was done by Image processing in MATLAB- R 2017.

2. EXPERIMENTAL PROCEDURE

The Ag Nanoparticles were fabricated by both E-beam and thermal deposition methods keeping same condition.

a) Electron beam evaporator:

The GLAD technique has been carried out to synthesize the pure Ag (MTI, USA) NPs on n-type Si <100> substrate. The substrates were rotated azimuthally with constant speed of 460 rpm at an orientation of 85° with respect to the perpendicular line between the metal source and the planar substrate holder. The depositions were carried out at a base pressure of ~2 × 10^{-5} mbar inside the e-beam evaporator chamber. A deposition rate of 1.2 Å/s was kept constant. The Ag NPs patterned was checked by FEG: SEM measurement.

b) Thermal Evaporator:

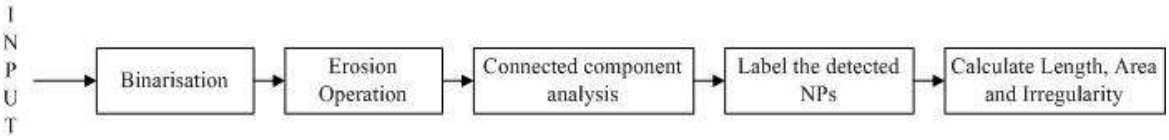
GLAD technique has been carried out to synthesize the pure Ag (MTI, USA) NPs on n-type Si <100> substrate. The substrate was azimuthally rotated with constant speed of 460 rpm at an orientation of 85° with respect to the perpendicular line between the metal source and the planar substrate holder. The depositions were carried out at a base pressure of ~2 × 10^{-5} mbar inside the thermal evaporator chamber. The dimmestar voltage was 25 mV and time was 3 minutes to deposit the particles over the substrate.

c) Methodology:

Here we have proposed for the first time the structural Nanoparticle Detection using image processing:

1) Binarize the image using a threshold value calculated using Otsu's method. [8]
2) Use morphological erosion operation on the binarised image.
3) Use connected component analysis to remove the small detected segments.
4) Label every selected nanoparticle. [9]
5) Calculate their boundaries and area. [10]
6) Calculate the irregularity of nanoparticles. [11]
7) Calculate the length of the detected nanoparticle

Flowchart:



Feature Calculated:

1) Length of the nano particles: Nanoparticles length was measured by calculating the distance between two farthest point in the nanoparticle boundary.
2) Irregularity in a shape: Irregularity in the shape of each nanoparticles derived by calculating the interior angles of the vertices of the detected nanoparticles boundary.
3) Area of the nano particles: The number of pixels inside a nanoparticle is giving the area of the nano particles. The area was converted in nm unit after multiplying with scaling factor.

3. RESULTS AND DISCUSSION

Nanoparticles generated from Thermal and E-beam method are compared based on their length, area and irregularity in shape. Average size is smaller for thermally generated nanoparticles than nanoparticles generated using thermal (figure 1 and

2) and E-beam method (figure 3 and 4). Irregularity is almost same for all of them. Low standard deviation for length and area of nanoparticles generated from E-beam and thermal process proves the uniformity of nanoparticles. E-beam generated particles are more prominent.

TABLE 1. Mean and standard deviation of paricle sizes

Nanoparticle Generation method	Length(nm)		Area(nm^2)		Irregularity(^{o})	
	Mean	*Standard Deviation*	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*
Thermal	5.13	1.3571	9.259	2.8198	206.352	10.743
E-beam	10.609	1.5750	21.117	4.284	202.216	10.753

Comparison of the largest NPs generated using different methods concludes that ebeam generated nanoparticles are bigger and prominent compared to thermal process.

TABLE 2. Size of particles in terms of length and area occupied

Nanoparticle Generation method	Length(nm)	Area(nm^2)
Thermal	16.8280	35.609
E-beam	35.98	77.81

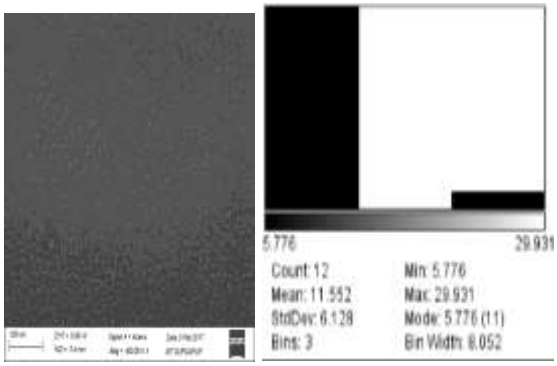


Fig. 1. FEGSEM image of Ag NPs prepared by thermal evaporator system and its particle histogram

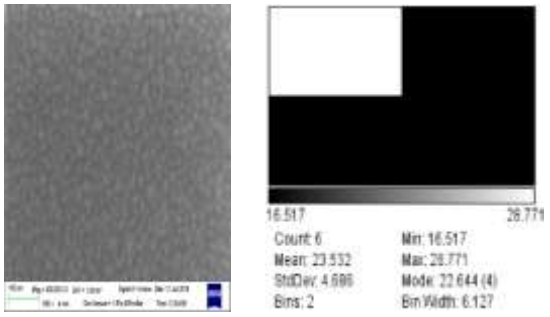


Fig.3. FEGSEM image of Ag NPs prepared by E-beam evaporator system and its particle histogram

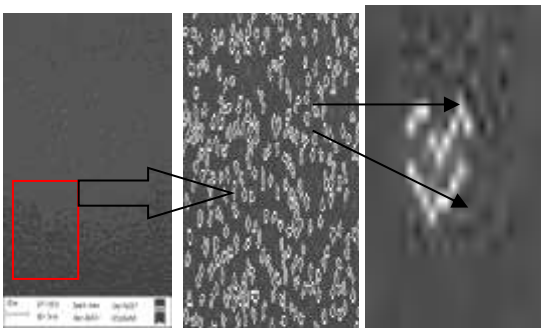


Fig. 2 (a) Original Image (b) Detection NPs from the marked area of original Image (c) The largest NPs in the sample.

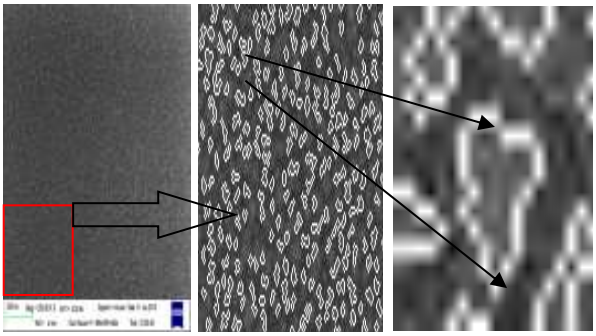


Fig.4. (a) Original Image (b) Detected NPs from the marked area of original Image (c) The largest NPs in the sample

4. CONCLUSION

In conclusion we have done the comparative morphological study of Ag nanoparticles fabricated by E-beam evaporation method and thermal evaporation method by Image processing technique. The results project that the particles grown by E-beam evaporator is most prominent than Thermal evaporation system.

5. ACKNOWLEDGEMENT

Authors are thankful to the Department of Physics, National Institute of Technology, Durgapur and Electronics and Communication Engineering, National Institute of technology, Agartala for using the laboratory facility and Aurora Engineering college and Jadavpur University for financial support.

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