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Preparation of Ag/Rgo and Ag/Rgo/Tio_2 Nanoparticles as Thin Films for Improvement the Reflection of Laser Mirrors

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Abstract

In this research, the preparation of thin films was done by using the Pulsed Laser Deposition technique, where the measurements studied of structure, morphological and optical properties, including (XRD) of Ag/rGO and Ag/rGO/TiO_2 films within pulsed energy varied from 600 to 1000mJ for each sample that deposited upon the substrate. At (XRD) pattern, the Ag peaks are more intense compared to the rGO peaks because the amount of rGO deposit particles is lower. Moreover, at Ag/rGO/TiO_2 the peaks have being decreased along with the incensement of energy. (FESEM) it can be seen that as the pulse energy increases, the amount of deposit particles increases, confirming the formation of Ag/rGO and Ag/rGO/TiO_2. The EDX results have proved the consistency of the films upon the silicon substrate as a result of high pulse energy that leads to more particles to deposits, (UV) Absorption Spectroscopy shows the sharper peak for Ag/rGO films which appears at 417nm have blue shift as energy pulse increased from 600 to 1000mJ, that proved the synthesis for Ag/rGO. However, the absorption peaks for (Ag/rGO/TiO_2) are broader, a more intense peak was around 400nm with pulse energy 1000mJ, and a blue-shift has been observed overall film layer which confirms the consistency for the Ag/rGO/TiO_2 multilayer thin films.

Keywords: Pulsed Laser Deposition, Ag thin Film, Nd:YAG Laser, Multilayer.

Introduction

Nanoparticles incorporated into thin films represent a dynamic area of research and application as Electronics, Medicine, Photocatalysis, and Environmental fields. Thin films are coatings or layers with thicknesses typically ranging from a few nanometers to micrometers. When nanoparticles are embedded in these films, they can significantly alter the film’s properties, offering unique functionalities that are not present in bulk materials. Silver nanoparticles (AgNPs), titanium dioxide nanoparticles (TiO_2NPs), and reduced graphene oxide nanoparticles (rGONPs) each have unique properties and applications, and they represent important areas of research in nanotechnology. AgNPs as thin film exhibit strong surface plasmon resonance, leading to unique light absorption and scattering properties. However, rutile is one of the three main crystal phases of titanium dioxide, known for its stability and high refractive index also a high UV light absorption makes it useful for photocatalysis and UV protection. On other hand, reduced graphene oxide (rGO) which is graphene oxide with some of its oxygen-containing groups removed, which improves its conductivity compared to graphene oxide (GO).

There are several methods to synthesis thin film as Physical Vapor Deposition (PVD), Chemical Vapor Deposition (CVD), Sol-Gel Process, and Pulsed Laser process. Pulsed Laser Deposition is one of pulsed laser process which is a physical vacuum deposition method used to produce thin films. PLD is regarded as a promising approach to depositing homogeneous nanoparticle thin films as the deposited thin films are structurally comparable with the material of the target. Other advantages include a superior rate of deposition, facilitated control over the growth and thickness of the film, lower roughness of thin film surface, as well as the ability to optimize the fabrication process by adjusting deposition parameters such as the energy of the laser, temperature, pressure of the chamber, and substrate-target distance[1,2].

PLD has several benefits over other thin film deposition methods, particularly the ability to control the rate of film deposition by adjusting the parameters of the laser [3], deposition duration, target-to-substrate distance [4,5], and background gas. The PLD's essential qualities include transferring the target material's stoichiometry to the substrate. The potential to deposit consecutive [6], and new coatings is achieved by irradiating consecutive targets with distinct materials [7,8]. Ag/rGO and Ag/rGO/TiO_2 was prepared to enhance the optical properties of laser resonator by using them as multilayer coating for the mirrors.

Experimental Details

Before beginning with the deposition process, a press powered by hydraulics was used to form a nanopowder pellet with 6g of each of the Ag, rGO, as well as TiO_2 NPs measuring approximately 1.5 centimeters in diameter and 0.5 millimeters in thickness. The nanopowder was subjected to twenty mega Pascal's of pressure over fifteen minutes. Unlike other methods, PLD has several advantages, including reliability and convenience over producing multilayered from varied materials. The thickness of the thin film is controlled by the amount of pulses generated through the 1064 nm Nd: YAG laser. The silicon wafers in this study were cut to typical dimensions about 10 x 20 mm. In the beginning one thin layer containing Ag pellets on the target has been created with varied pulse energy. All Samples have been settled in the upper part of the holder within the chamber. After that, the step involved depositing the rGO target onto Ag film, to create Ag/rGO film. In order to investigate the multi-layer characteristics, the final step entailed coating TiO_2 onto Ag/rGO to create a multi-layer comprising Ag/rGO/TiO_2. Moreover, the optical and structural features of thin Ag/rGO and Ag/rGO/TiO_2 films have being measured over pulse energies ranging from 600 to 1000 mJ for each films. All samples were formed in 5 min over the number of pulses about 500 with one Hz, at a base pressure equal to 2.0×10^{-5} mbar inside the chamber. To promote film uniformity and prevent fast drilling, the target was placed on a holder fifty millimeters from the substrate.

Results

X-ray Diffraction pattern (XRD)

The XRD data shows thin film structures that are synthesized with pulsed laser deposition method. In **Fig.1-a)** for Ag/rGO thin film over varied energy of pulses from 600 to 1000mJ, the panels (111), (220) and (331) correspond to presence of silver nanoparticles, these results agree with [9,10,11,12] and the peak of (100) and broad peak (002) appearance is due to reduction of graphene oxide nanoparticles which agree with [13], thus confirming the formation of Ag/rGO ,as shown in **Table(1)**. An intense peak of Ag was observed compared to the rGO peaks, this related to the lower particles number of rGO deposits upon Ag film.

The peaks intensity almost has a minimum decrease as the energy of the pulse increasing from 600 to 1000mJ. In **Fig.1-b)** for Ag/rGO/TiO_2 all the peaks were decreased when the pulse energy increased to 1000mJ except the peak of Ag at 37.46° reminds. However, within all patterns peaks of Ag were still more intense than peaks of rGO; also there is no appearance of TiO_2 peaks which might be due to its low content and small particle size in the films as reported in [14],shown in **Table(1)** .

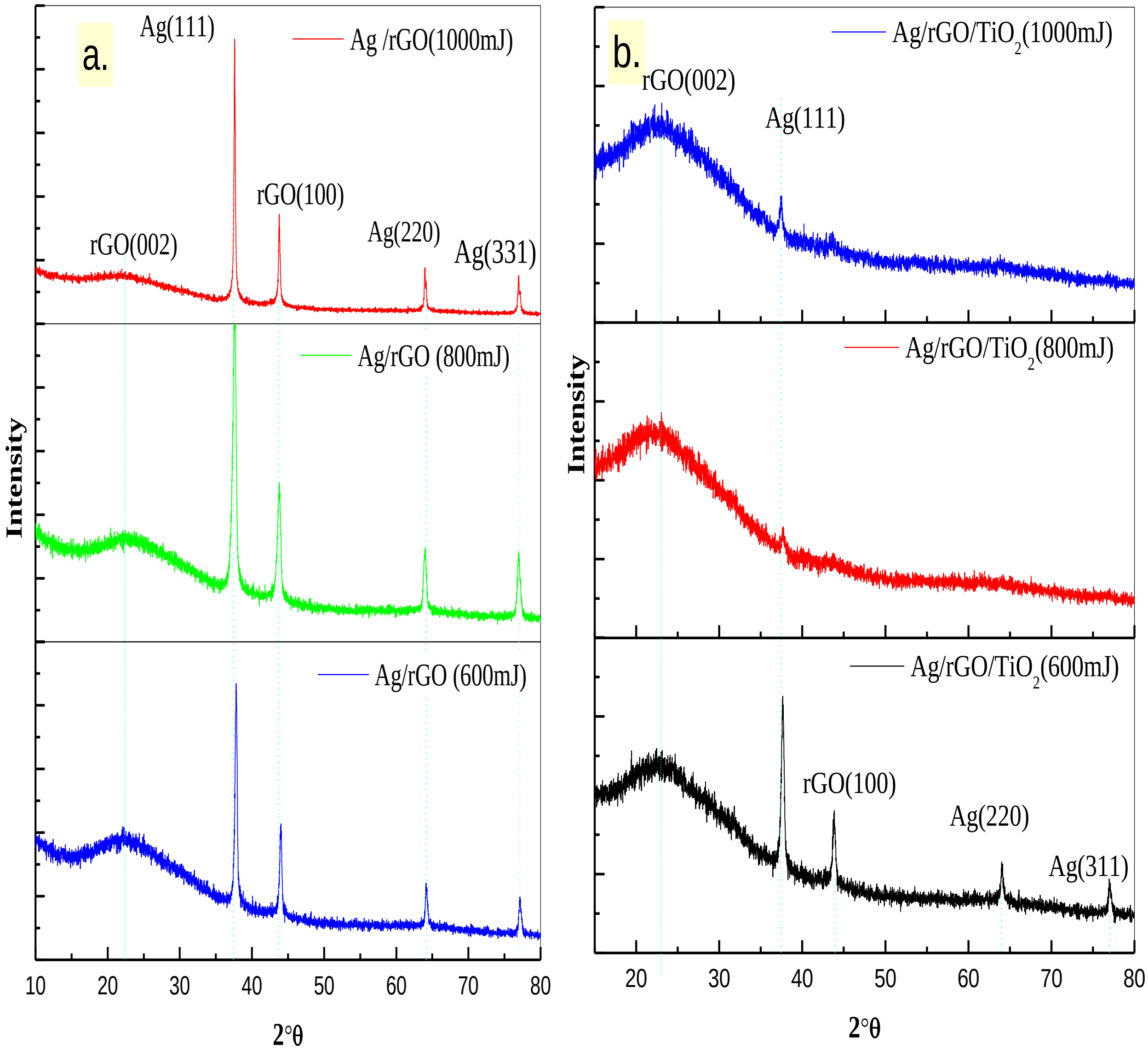


Figure1: a) XRD of Ag/rGO film with varied pulsed energy, b) XRD of Ag/rGO/TiO_2 film with varies pulsed energy.

Table 1: The **hkl** planes and peak position **2Θ°** at various pulse energy.

Sample	hkl	2Θ°	Pulse Energy(mJ)
	rGO-(002)	22.06	
Ag/rGO	Ag-(111)	37.66	**1000**
	rGO-(100)	43.69	
	Ag-(220)	64.01	
	Ag-(331)	77.01	
	rGO-(002)	22.06	
Ag/rGO	Ag-(111)	37.46	**800**
	rGO-(100)	43.69	
	Ag-(220)	64.01	
	Ag-(331)	77.01	
	rGO-(002)	22.06	
Ag/rGO	Ag-(111)	37.83	**600**
	rGO-(100)	44.06	
	Ag-(220)	64.19	
	Ag-(331)	77.19	
	rGO-(002)	22.63	
$Ag/rGO/TiO_2$	Ag-(111)	37.46	**1000**
	rGO-(002)	22.63	
$Ag/rGO/TiO_2$	Ag-(111)	37.66	**800**
	rGO-(002)	22.63	
$Ag/rGO/TiO_2$	Ag-(111)	37.66	**600**
	rGO-(100)	43.88	
	Ag-(220)	64.01	
	Ag-(311)	77.01	

Uv-vis Absorption Spectroscopy

The optical characterization of the films presented by UV-vis absorption spectra for Ag/rGO and $Ag/rGO/TiO_2$ thin films have been deposited upon silicon substrate over varied pulse energy 600-1000mJ.

In **Fig.2-a),** the sharper peak of Ag/rGO appears at 417nm, according to optical absorption of both Ag and rGO which leading to a red shift as energy pulse increased from 600 to 1000mJ appears at 461nm, which confirmed Ag/rGO formation, this result agree with [15]. In **Fig.2-b),** however, all the peaks of absorption for ($Ag/rGO/TiO_2$) are broader, the more intense peak observed at 400nm with pulse energy 1000mJ, the blue shift at 348nm confirms formation of the $Ag/rGO/TiO_2$ thin film as result of TiO_2 NPs deposits which are UV absorber, this result agree with [16].

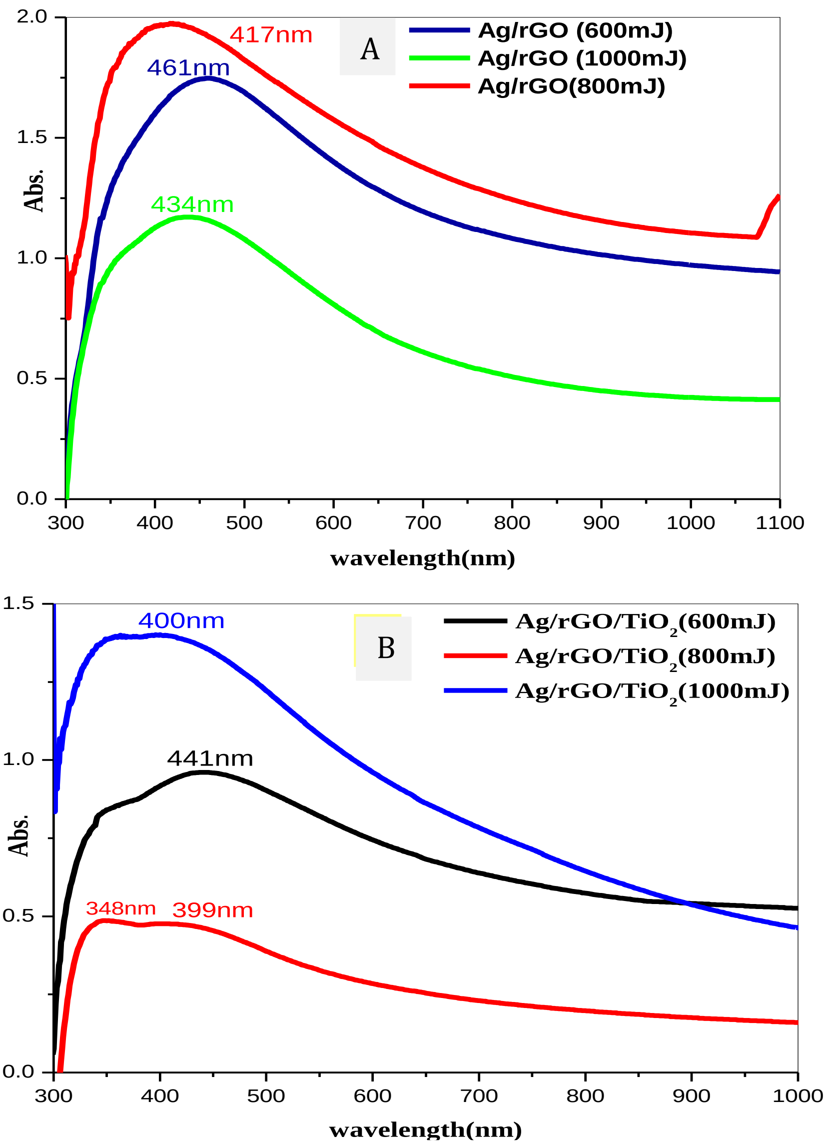


Figure 2: a) UV absorption of Ag/rGO film with varied pulsed energy, b) shows UV absorption of Ag/rGO/TiO_2 film with varies pulsed energy.

Field Emission Scanning Electron Microscopy (FE-SEM) and Scanning Electron Microscopy (SEM)

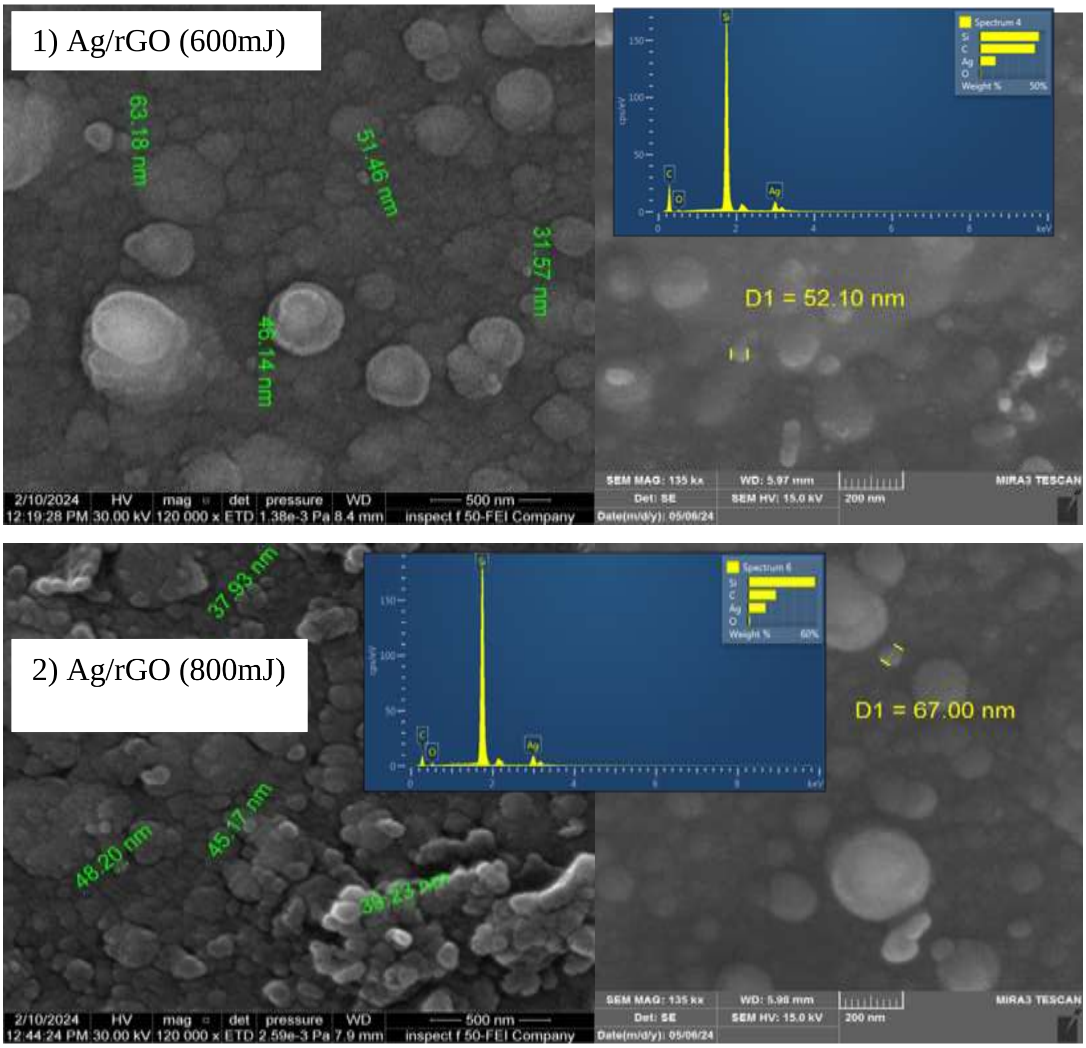
Field Emission Scanning Electron Microscopy FESEM has a higher resolution of the morphological surface for thin films than Scanning Electron Microscopy SEM. **Fig.3(1-3)** depicts rGO deposited on Ag forming two layers of (Ag/rGO) using pulse energy ranging from

600-1000mJ. The SEM image is not sharp enough to discern the shape of the particles, but the FESEM image appears spherical. However, **Fig.3(4-6)** shows the three layers of (Ag/rGO/TiO_2) multiple layers that vary in pulse energy; for the entire sample, it could be noticed that when the energy of the pulse increases, so does the amount of deposit particles since that pulse energy is one of effects for the amount of deposits particles at the surface of substrate so the higher energy transfer from laser pulse to the particles at targets surface the more particles deposits on substrate surface; there is a little accumulation which may be observed during pulse energy 800mJ, presenting TiO_2 deposits on Ag/rGO[17,18]. The information on the applied voltage, magnification, and image size has been embedded in the photographs individually.

Energy Dispersion X-ray (EDX)

Chemical composition has been determined on thin film samples using energy dispersion X-ray (EDX) analysis. **Figure.3** percent's the contact (EDX) pattern for Ag/rGO, which demonstrates the production of a thin film with presence peaks attributable to carbon, silver, and oxygen, in addition to the silicon peak of the substrate **Fig.3(1-3)**.

A significant peak for silver was discovered in the spectrum displayed in **Fig.3(3)** due to high pulse energy, which causes more particles to deposit, as corroborated by FESEM and SEM pictures. The EDX tests show the production of Ag/rGO/TiO_2 thin films over the surfaces of SiO_2 substrate **(Fig.3(3-6)**. Indeed, the Ti peak, which appears alongside the peaks for carbon, silver, and oxygen, contributes to the development of multilayer Ag/rGO/TiO_2.


1) Ag/rGO (600mJ)
63.18 nm
51.46 nm
31.57 nm
46.14 nm
D1 = 52.10 nm
2) Ag/rGO (800mJ)
37.93 nm
48.20 nm
45.17 nm
D1 = 67.00 nm
500 nm
200 nm
inspect f 50-FEI Company
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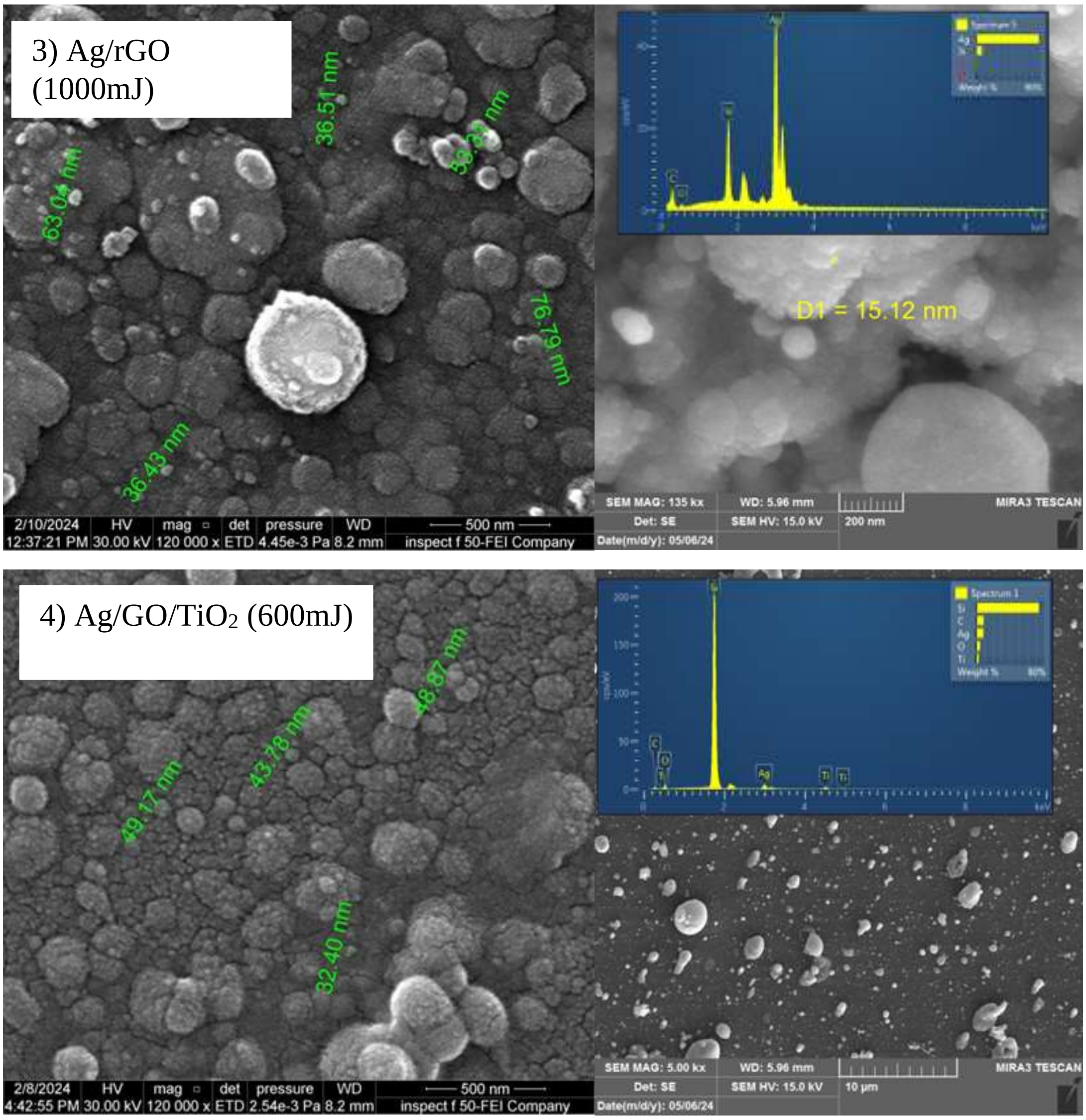
3) Ag/rGO (1000mJ)
36.51 nm
63.04 nm
76.79 nm
36.43 nm
D1 = 15.12 nm
2/10/2024 12:37:21 PM HV 30.00 kV mag 120 000 x det ETD pressure 4.45e-3 Pa WD 8.2 mm 500 nm inspect f 50-FEI Company
SEM MAG: 135 kx WD: 5.96 mm
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Date(m/d/y): 05/06/24
MIRA3 TESCAN
4) Ag/GO/TiO2 (600mJ)
48.87 nm
43.78 nm
49.17 nm
32.40 nm
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SEM MAG: 5.00 kx WD: 5.96 mm
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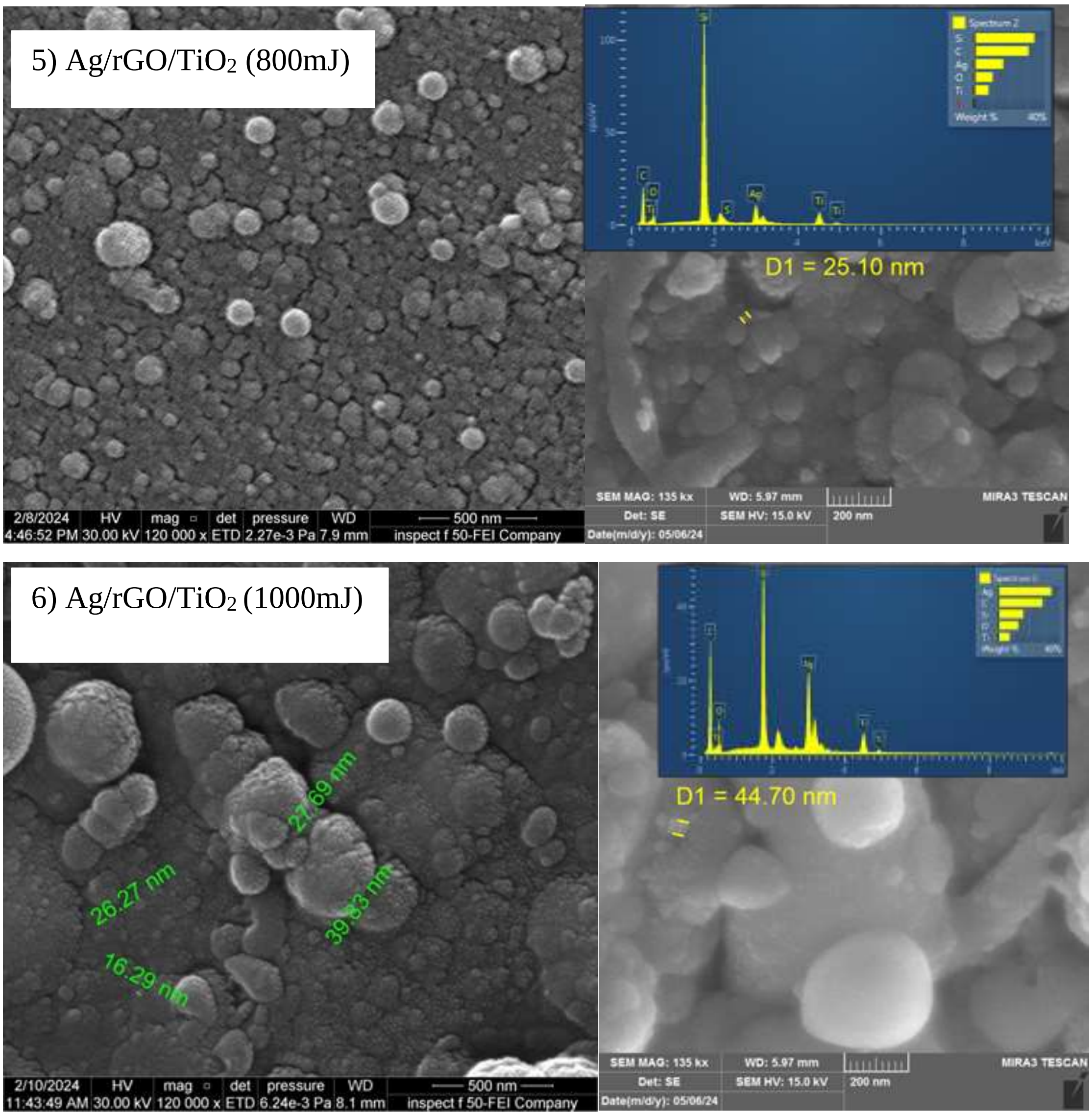

Figure 3: (1-3) FESEM of Ag/rGO film with varied pulsed energy, (3-6) shows FESEM of $Ag/rGO/TiO_2$ film with varies pulsed energy.

Conclusion

In this research, thin film as well as multilayer thin films have been felicitously synthesized using straightforward techniques like pulsed laser deposition methods, and as can be seen from XRD, FESEM, and UV absorption data, the samples have amazing morphological, structural, and optical characterization. Additionally, it shows how the energy pulse used in the laser deposition method affects the properties of the thin films, with a consistent change in sample spectra as energy increases from 600 to 1000 mJ. Pulsed laser deposition has enormous potential for a variety of commercial applications, including coated conductors, solar cells, sensors, and laser resonance improvement.

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Conflict of interest: The authors declare that there is no conflict of interest.

Ethical clearance: Ethical approval was not required for this research.

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