RESEARCH PAPER

Study of the Optical and Structural Properties of ZnTe/Para nitro Aniline Polymer Micro/nano Composite and Calculation of the Solar Cell Efficiency

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ABSTRACT

The work presents a study of plasma parameters by producing a nanocomposite of semiconductor ZnTe and Nano conductive polymer Para nitro aniline by using Nd-YAG laser ablation with wavelengths of 1064 nm and 532 nm and pulse numbers of 620, 320, 4Hz frequency in distilled water. The structural and optical properties of the prepared nanocomposite were analyzed using XRD, Fe-SEM, LIBS and UV-Vis spectroscopy tools. Where pulsed laser ablation in liquids was used experimentally to create ZnTe nanoparticles after compressing them into a disc shape by a heat pres. The emission spectra of the nanoparticles were examined using laser-induced breakdown spectroscopy (LIBS) methodology. Calculations were made for plasma properties such as electrontemperature, plasma density and frequency. In addition, UV-Vis, XRD, FE-SEM and UV-Visible properties are used to measure the optical properties. XRD analysis indicated the presence of several peaks belonging to ZnTe nanoparticles. XRD analysis also showed a relationship between the intensity of these peaks and the number of laser pulses. While FE-SEM results revealed spherical shapes with medium sizes. The nanocomposite was used in solar cell application and the results showed that it enhanced the performance of the solar cell and increased its absorption, which led to an increase in its efficiency. Therefore, we conclude that the nanocomposite can be used to increase the efficiency of solar cells.

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INTRODUCTION

Nanoscience and nanotechnology have advanced significantly, enabling precise control of materials at the atomic and molecular scales [1]. Semiconductor and polymer nanoparticles exhibit unique optical properties due to quantum size effects and high surface area [2]. Among these properties, photoluminescence (PL) emission plays a key role in understanding their electronic structure [3]. The emitted light depends on factors such as size, shape, and composition, as demonstrated in quantum dots with tunable colors [4]. Combining polymers with semiconductor nanoparticles enhances stability and functionality, making them promising for applications such as solar energy and optoelectronic devices [5].

ZnTe is another semiconductor material that is used in many applications with a 2.26 ev energy

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gap [6]. There are many techniques have been used to prepare nanostructured thin films including physical and chemical methods these methods are molecular beam epitaxy [7,8], chemical vapor deposition [9,10], magnetron sputtering [11,12], and pulsed laser deposition technique is the most promising method to produce high quality thin films [13].

In this paper, the effect of preparation parameters on the composition, surface morphology, size and optical and structural properties of ZnTe/ Polymer produced by laser ablation were studied.

MATERIALS AND METHODS

In the experimental part, two types of ZnTe-based nanocomposites were prepared. The first consisted of pure ZnTe nanoparticles, while the second involved ZnTe combined with a polymer matrix. Both samples were synthesized using the pulsed laser ablation (PLA) technique. A Nd:YAG pulsed laser with a wavelength of 1064 nm was initially applied to both samples, followed by the use of its second harmonic at 532 nm under similar conditions. The outcomes observed for both systems were recorded and analyzed. Consequently, four distinct samples were obtained, and a series of optical, structural, and spectroscopic characterizations were performed to evaluate their properties.

RESULTS AND DISCUSSIONS

Structural analysis and surface morphological

Calculating the electron temperature, plasma frequency, electron density and particle number

To estimate the performance of the plasma, accurate knowledge of the electron temperature and electron density is important. The process

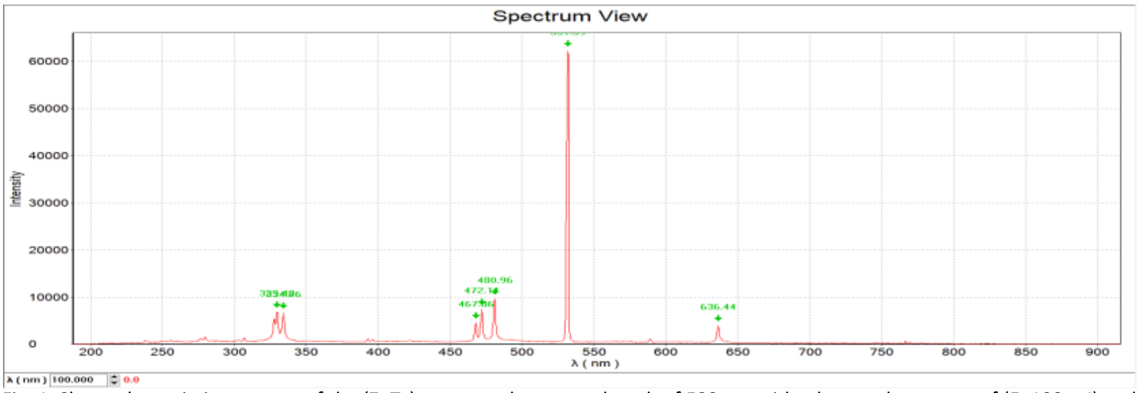


Fig. 1. Shows the emission spectra of the (ZnTe) compound at a wavelength of 532 nm with a laser pulse energy of (E=100 mJ) and a frequency of 4 Hz.

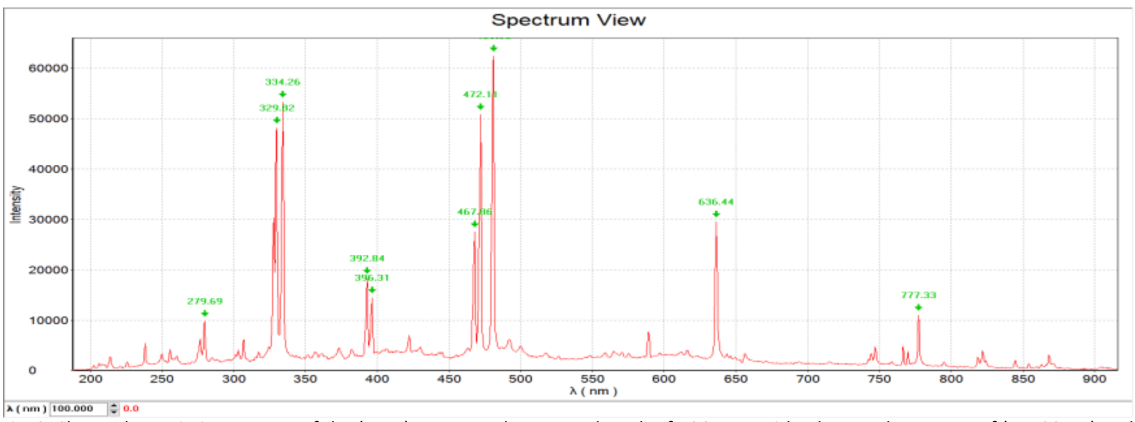


Fig. 2. Shows the emission spectra of the (ZnTe) compound at a wavelength of 1064 nm with a laser pulse energy of (E=100 mJ) and a frequency of 4 Hz.

of decomposition, ionization and excitation in the plasma can be understood through the above parameters. Through the theory of atomic emission spectroscopy, the plasma was generally estimated by the relative emission intensity of the spectral lines, and the intensity of the emitted spectral emission is a measure of the energy level corresponding to a certain type in the plasma. The plasma is limited to (LTE) (and optically thin lines) under the assumptions, all wavelengths indicated by the spectral lines in the spectral region (900-200 nm) are determined to calculate the electron temperature and electron density as shown in Figs. 1-3 and Table 1.

Optical absorption spectrum of mixtures ((Uv-Visible) Spectroscopy

In this work, we focused on two types of mixtures after relying on the results of the plasma emission spectrum and choosing the best energies resulting and measured at different wavelengths 532,1064 nm and preparing the samples and the polymer mixture in the form of discs and performing the fragmentation process with a pulsed laser at a frequency of 4 Hz and a number of 620, 320 pulses at the best chosen energies, which are 100 mJ.

After conducting the examination process using a device to measure the absorbance of the material (Uv-Visible), the results showed that the tangent to the curve is located at wavelengths 325.4, 426.

After identifying the optical absorption spectrum of the ZnTe compound with different measurements, the energy gap was calculated for the best selected measurements, which is at a number of pulses of 620 and at different wavelengths of 1064,532 nm. Noting a difference in the energy gaps in the two cases and their noticeable increase as shown in Fig. 4.

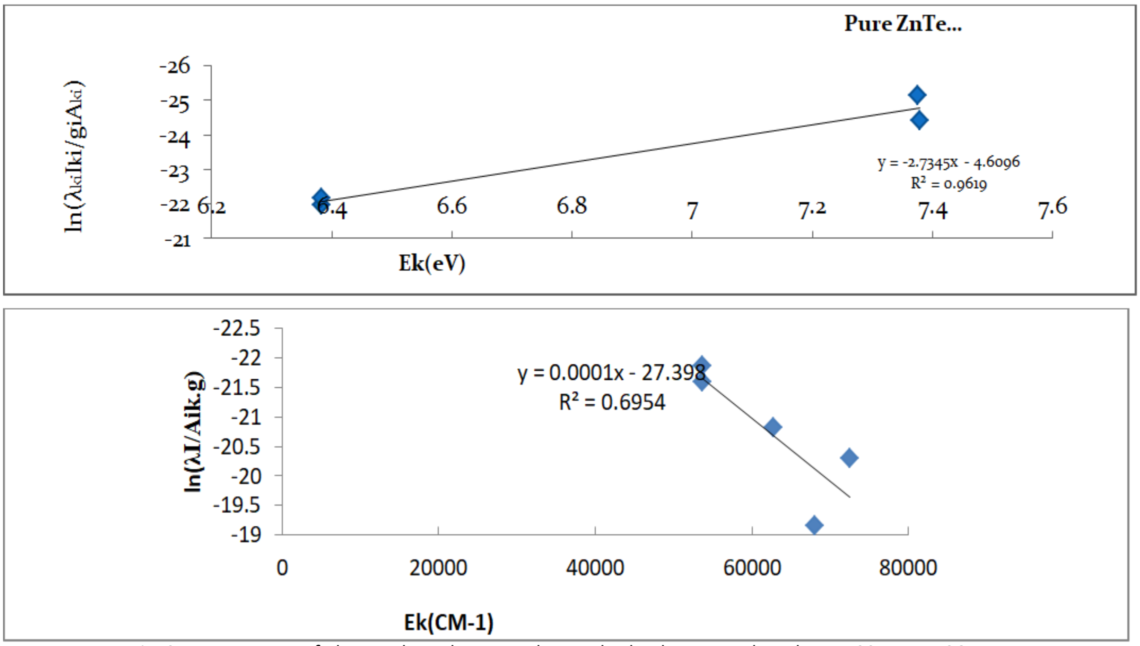


Fig. 3. Temperature of electron by Boltzmann Plot Method at laser wavelengths: A-532nm, B-1064nm.

Table 1. The table represents the calculation of plasma parameters for the ZnTe/polymer complex such as temperature Te, electron density Ne, Debye length Dλ, plasma frequency.

	λ nm	Element	T (eV)	ne (cm^{-3})	λ_D(cm)	ω_p(Hz)	N_D
ZnTe	1064	ZnI	1.449896	7.00E+16	3.39E-05	1.61E+09	1.13E+04
ZnTe	532	ZnI	0.143098207	9.93E+14	8.93E-05	1.78E+09	2.96E+03

The relationship between absorbance and wavelength is shown in Fig. 5 with the observation of a spectral shift towards blue shift, as most previous studies indicated the calculation of the energy gap of the compound. The results showed the appearance of an energy gap of 3.27, 4.5 eV and the formation of accumulated and clustered spherical groups at the absorbance shown in the figure after conducting examinations of the thin films prepared by the FE-SEM scale for the mixtures.

X-ray diffraction (XRD) examinations

The films prepared from the ZnTe compound

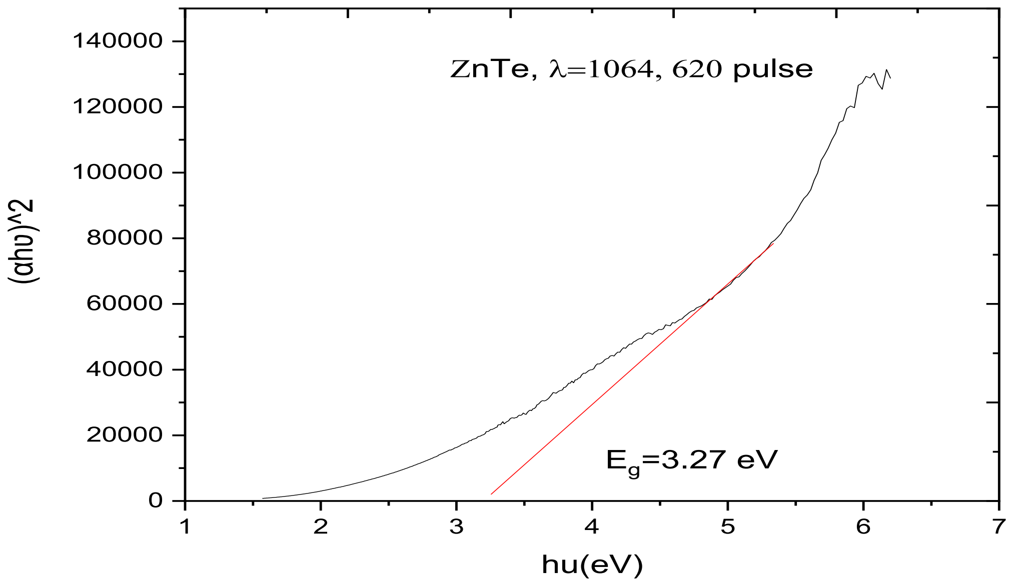


Fig. 4. Energy gap of ZnTe/ polymer nanoparticles.

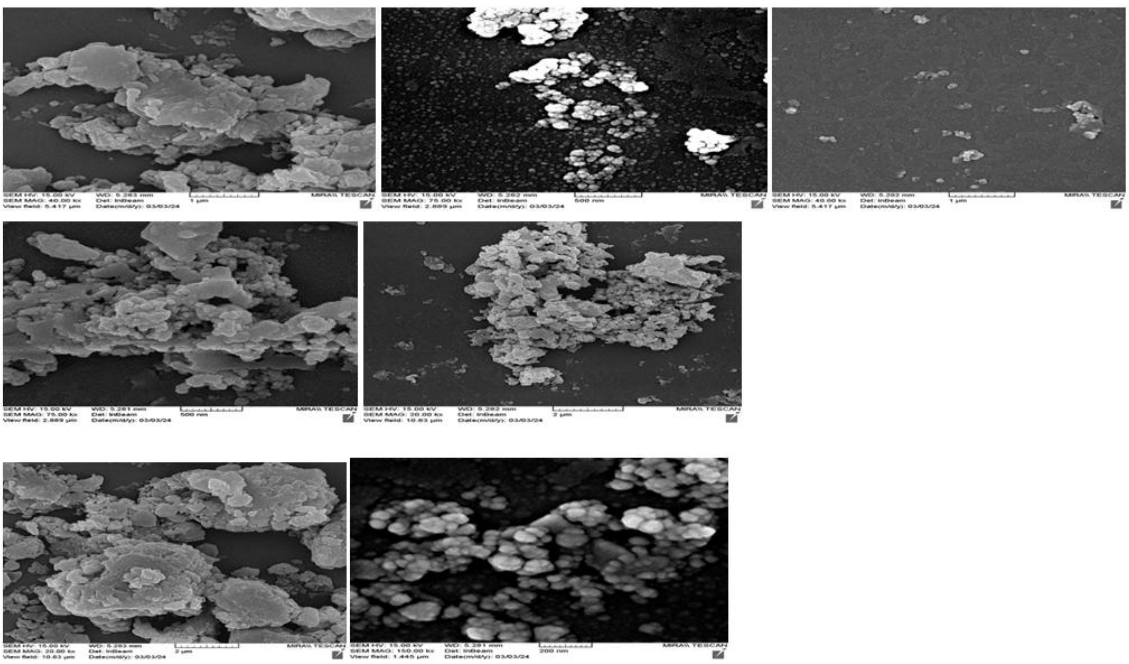


Fig. 5 Images of Nano particles by FE-SEM device.

with the nanopolymer blend were examined using the X-ray system to determine the crystal structure, and the X-ray energy dispersion system was used to determine the molecular weight ratios of the complexes.

The measurements were carried out on

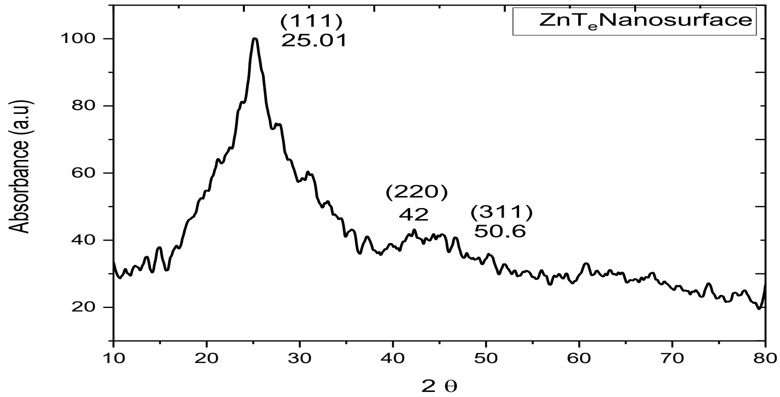


Fig. 6. Miller coefficients using X-ray diffraction.

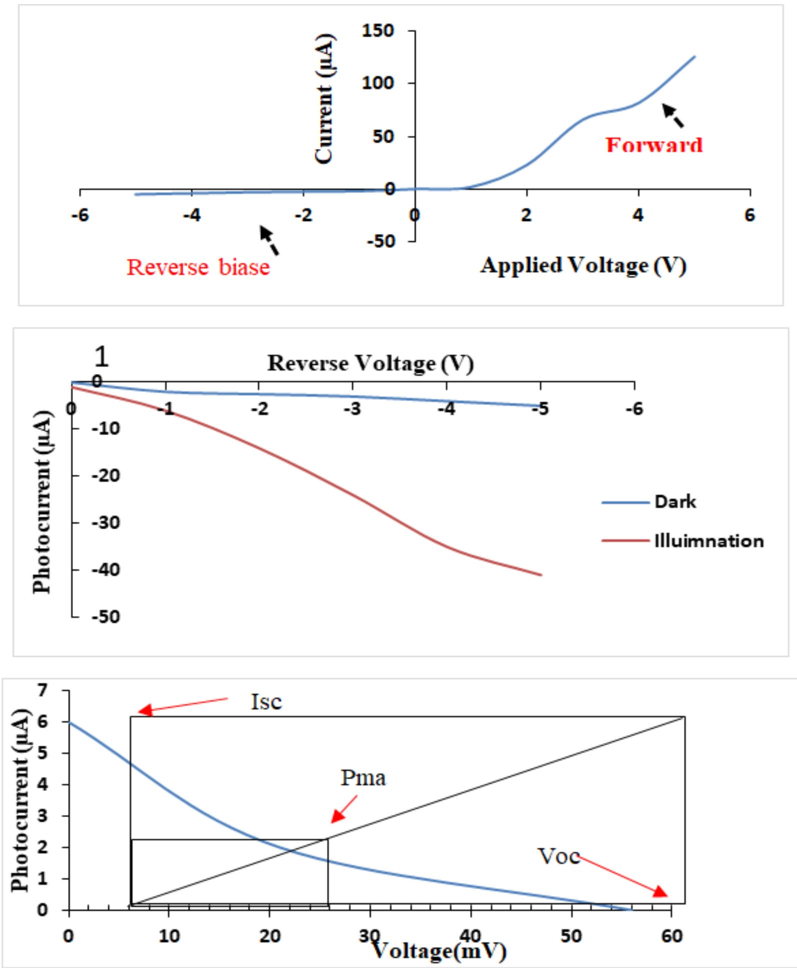


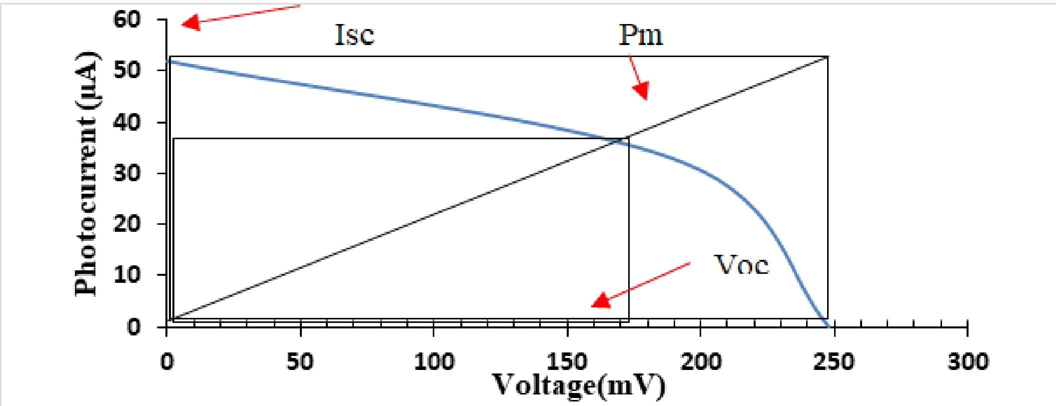
Fig. 7. Shows the behavior of both voltage and current in the case of pure zinc telluride.

the prepared mixture samples after they were fragmented by pulsed laser and using the Scherrer equation and matching them with the results close to it, that the highest peaks were at 25.01, 42, 50.6 = 2θ, and their Miller coefficients were (111), (220), (311). Using and applying the mentioned equation after converting the angle units to the radial units, a crystal size of about 23.63 nm was obtained. It was also noted that some small peaks appeared, indicating the emergence of crystallization with the presence of a covalent bond between the atoms of the compound. The preparation conditions have a great effect on the structural, morphological and optical properties. As for the values of the particle sizes, their values ranged between 23.36-74.26 nm to indicate that nano-solutions can be manufactured by laser scraping with different values depending on the laser energy and the composition elements and determining the crystal sizes from the process of separating the nanoparticles using the centrifugal system. As for the values of the distance between the crystal planes, they were between 3.53 A°, 2.00 A° for the prepared sample film as shown in Fig. 6.

Applications of ZnTe Nano particles and ZnTe / Polymer nanocompsite:

By applying pure zinc telluride and the mixture with nano polymer on solar cells, it was observed that the current value changes with the voltage in the case of forward bias for the dark and light conditions. The figure shows the change in the current with the voltage and the calculation of the efficiency and quality factor according to the mentioned relationship. Its values were in the case of the pure material Fig. 7 and the mixture Fig. 8.

Because of superior charge transfer, decreased



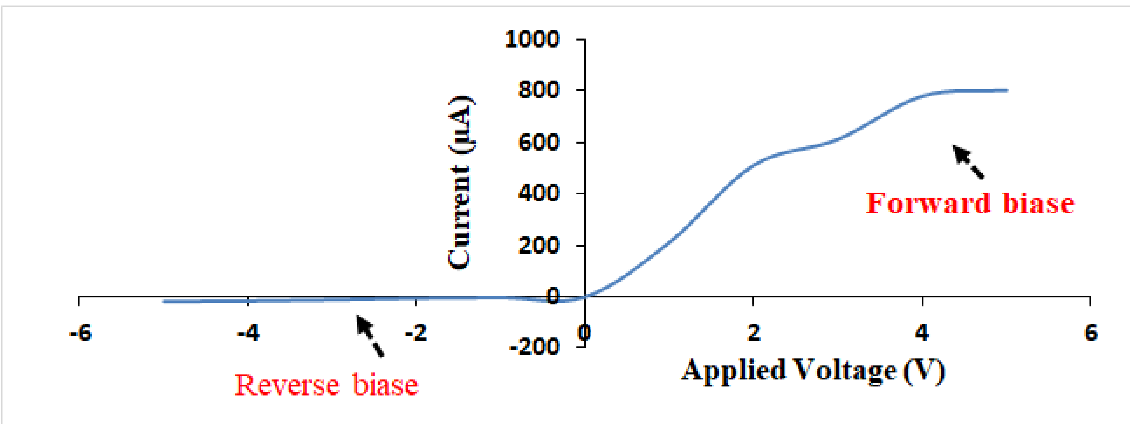


Fig. 8. Shows the behavior of both voltage and current in the case of zinc telluride/polymer.

recombination, higher light absorption, optimal band alignment, and increased overall stability, the ZnTe/ortho-nitroaniline Nano composite is more efficient than pure ZnTe nanoparticles. Together, these elements improve the material's photovoltaic performance and increase its efficiency as a light-to-energy converter in solar.

CONCLUSION

The findings indicate that ZnTe exhibits a stronger response at a wavelength of 1064 nm compared to 532 nm, as demonstrated by the experimental measurements. The results also suggest that a laser pulse energy of 100 mJ is optimal for producing thin films, supported by emission spectrum data along with optical and structural analyses. Moreover, pronounced quantum confinement effects were observed, resulting in the formation of very small nanoparticles with distinct physical characteristics and modified energy band gaps. The morphology at the nanoscale is influenced by the laser energy as well as the characteristics of the generated plasma, which plays a key role in shaping the final structure.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

REFERENCES

1. Yecheskel Y, Dror I, Berkowitz B. Catalytic degradation of brominated flame retardants by copper oxide nanoparticles. Chemosphere. 2013;93(1):172-177.
2. Groeneveld E, de Mello Donegá C. The Challenge of Colloidal Nanoparticle Synthesis. Nanoparticles: Springer Berlin Heidelberg; 2014. p. 145-189. http://dx.doi.org/10.1007/978-3-662-44823-6_6
3. Maoz M, Shah SAB, Lughi V. Photoluminescence Enhancement in CdSe/CdS Quantum Dot Colloidal Films Induced by Gold Nanoparticles (AuNPs). ACS Omega. 2025;10(37):42472-42479.
4. Qu L, Peng X. Control of Photoluminescence Properties of CdSe Nanocrystals in Growth. Journal of the American Chemical Society. 2002;124(9):2049-2055.
5. Răduță A-M, Panaitescu A-M, Manica M, Iftimie S, Antohe V-A, Toma O, et al. Effect of Deposition Working Power on Physical Properties of RF-Sputtered CdTe Thin Films for Photovoltaic Applications. Nanomaterials. 2024;14(6):535.
6. Manica D, Antohe V-A, Moldovan A, Pascu R, Iftimie S, Ion L, et al. Thickness Effect on Some Physical Properties of RF Sputtered ZnTe Thin Films for Potential Photovoltaic Applications. Nanomaterials. 2021;11(9):2286.
7. Franta D, Ohlídal I, Klapetek P, Montaigne-Ramil A, Bonanni A, Stifter D, et al. Optical properties of ZnTe films prepared by molecular beam epitaxy. Thin Solid Films. 2004;468(1-2):193-202.
8. Guo Z, Chen G, Cometto C, Ma B, Zhao H, Groizard T, et al. Selectivity control of CO versus HCOO− production in the visible-light-driven catalytic reduction of CO_2 with two cooperative metal sites. Nature Catalysis. 2019;2(9):801-808.
9. Yu ZQ, Wang CM, Engelhard MH, Nachimuthu P, McCready DE, Lyubinetsky IV, et al. Epitaxial growth and microstructure of Cu_2O nanoparticle/thin films on $SrTiO_3$ (100). Nanotechnology. 2007;18(11):115601.
10. Shan CX, Fan XW, Zhang JY, Zhang ZZ, Lu YM, Liu YC, et al. Spontaneous and stimulated emission in ZnCdTe–ZnTe quantum wells grown by LP-MOCVD. Thin Solid Films. 2001;401(1-2):225-228.
11. Abbas HF, Ahmed IS. The Properties of Types of Real Valued Set Functions Over Algebra. Lecture Notes in Networks and Systems: Springer Nature Switzerland; 2025. p. 160-168. http://dx.doi.org/10.1007/978-3-031-91008-1_15
12. Huang LS, Yang SG, Li T, Gu BX, Du YW, Lu YN, et al. Preparation of large-scale cupric oxide nanowires by thermal evaporation method. J Cryst Growth. 2004;260(1-2):130-135.
13. Kim T, Kim Y, Lee I, Lee D, Sohn H. Ovonic threshold switching in polycrystalline zinc telluride thin films deposited by RF sputtering. Nanotechnology. 2019;30(13):13LT01.