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REGULAR ARTICLE

Study of Electrical Conductivity and Raman Spectra of CdSe Nanoparticles Irradiated by CO_2 Laser

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The effect of different times (0, 60, 90, 120 and 180 sec.) CO_2 laser irradiation of wavelength (10.6 μm) on the electrical resistivity, conductivity, Hall mobility, the electron carrier concentration and Hall coefficient have been investigated on the CdSe nanoparticles. The resistivity has been observed in order of 104 Ω·cm which it was increased as increasing radiation laser, on the opposite, the conductivity for an irradiated CdSe was decreased. The values of electrons carriers' concentration and the charge mobility have been decreased by increasing radiation laser until 180 sec. Hall coefficient of CdSe samples exhibit *n*-type conductivity. From Raman spectra measurements were found that the bands have been become sharper with an asymmetry around 209 and 410 cm^{-1} for CdSe irradiated nanoparticles. High intensity at different radiation times around the frequency 209 cm^{-1} and the appearance another band around 255 cm^{-1} in case of CdSe irradiation at 180 sec.

Keywords: Electrical conductivity, Raman spectra, CdSe Nanoparticles, Laser, Hall effect.

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1. INTRODUCTION

CdSe nanoparticles and nanostructures as a very substantial II-VI compound semiconductors to improve of different modern technologies including optical waveguides and switches [1-4], photoconductors, windows for IR laser, nuclear radiation detector, infrared detector [5] and solar cells [6-11]. They have been fabricated by variety methods such as sol-gel [12], chemical bath deposition [13-15], RF magnetron sputtering method [16], molecular beam epitaxy and electrochemical deposition [17-18]. The effect of strong laser radiation occurs in semiconductor processes, mostly improving quality of electronic devices [19], changing their properties [20], an increasing the rate of chemical reactions on the semiconductor surface [21] and diffusion of impurity atoms along the surface [22-23]. Continuous low energy radiation reflection of CO_2 laser by powerful pulses from the surface on the II-VI nanoparticles' compounds such as CdS, ZnSe, CdSe and ZnS were investigated. The low power carbon dioxide laser in CdS semiconductor is reflected by spatial periodicity of the collapse in the structured crystal, but in CdSe is occurs due to the crystalline lattice oscillations, moreover the rise has been observed at reflection from nonirradiated surface of the monocrystalline [24]. In this work the influence of CO_2 laser irradiation on the conductivity and Hall parameters of CdSe nanoparticles at varies radiation laser times were investigated and study of Raman spectra for CdSe samples without radiation and irradiated by CO_2 Laser.

2. EXPERIMENTAL DETAILS

CdSe nanoparticles have been deposited on quality glass slides by CBD technique. These slides were cleaned in chromic acid, distilled water and they were placed in acetone and dried. Selenium powder was added to an aqueous solution of sodium sulphite with 10 ml distilled water in reflex system and heated until all the selenium was dissolved and filtered to get Na_2SeSO_3. Solutions of $CdCl_2$ dissolved in distilled water (10 ml) and 1 ml ammonia and mixed with sodiumselenosulphite. The solution was stirred and glass slides were placed vertically in the walls of the beaker. After deposition, slides were removed and dried. CdSe nanoparticles have been a small thickness between (300 – 800 nm). The samples of CdSe nanoparticles were irradiated to CO_2 laser of power (2 watt) at distance (10 cm) from the source during (60, 90, 120, 180 sec). The electrical resistivity and conductivity were measured by the four-probe electrometer and CdSe nanoparticles was analyzed by using Hall measurements at room temperature. The Raman spectra were obtained with a Raman spectrometer using 542 nm.

3. RESULTS AND DISCUSSIONS

The electrical parameters such as the resistivity of thin

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materials are the important factor to calculate the electrical characteristics of any material [25-26]. One of the most ways of measuring, was a four-probe method [27-28]. The DC resistivity (ρ) of CdSe nanoparticles were determined by four probe and the space between probes (2 mm) which it is measured by Eq. 1 [29].

$$\rho_m = 2\pi s \frac{V}{I} \qquad (1)$$

We observed the resistivity for an irradiated and nonirradiated CdSe nanoparticles by CO_2 laser (10^4 ohm.cm) and increased from 0.1 to 5 ohm.cm with increasing radiation laser time from 0 to 180 sec respectively as shown in Fig. 1 and the values was tabled in Table 1. On the contrary, the electrical conductivity is decreased as increased radiation time at 180 sec, so it is expected that the reason for this is due to the increase of defects like interstitial and vacancies, a decrease in the grain boundary, it is also believed that the formation of CdSe is another factor in the decrease in conductivity [30]. The variation is depicted as in Fig. 2 and in Table 1.

According to Eq. (1) the conductivity (σ) was determined from Eq. (2) [31] which is affected by transferring of excited free carriers to local states at the band edge [32].

$$\sigma = \frac{1}{\rho} \qquad (2)$$

Table 1 – The Resistivity and Conductivity of CdSe at different radiation laser time

Radiation laser time / sec	Resistivity $\rho \times 10^4 (\Omega \cdot cm)$	Conductivity $\sigma \times 10^{-4} (\Omega \cdot cm)^{-1}$
0	0.1	10
60	0.2	5
90	0.6	1.6
120	2.5	0.4
180	5	0.2

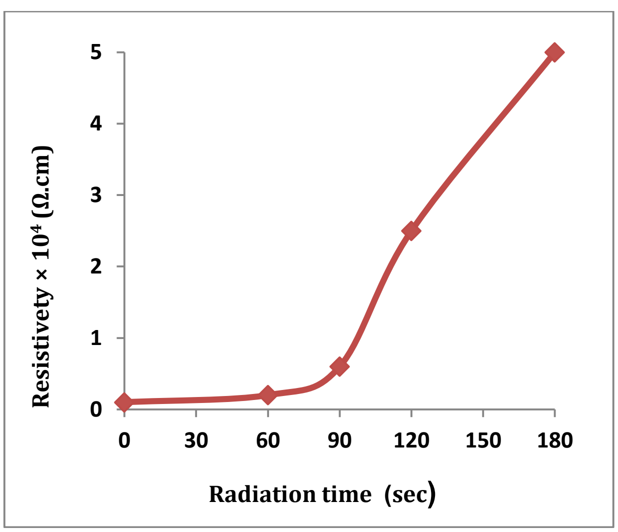

Fig. 1 – Variation resistivity vs. radiation laser time

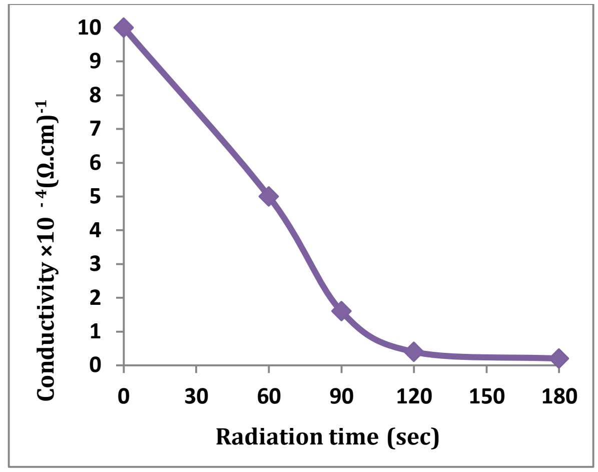

Fig. 2 – Conductivity as a function of radiation laser time

Hall coefficient (R_H) and carrier concentrations (n) for CdSe films at different radiation times were calculated from the relation [33]

$$R_H = \frac{dV_H}{IB} = -\frac{1}{ne} \qquad (3)$$

Where d – thickness of CdSe between (300 – 800 nm), V_H – Hall voltage, I – the current, B – magnetic field (600 G), e – electron charge equal 1.6×10^{-19} Coulomb.

The mobility can be measured according to the relation [34]

$$\mu = \frac{\sigma}{ne} = \sigma \cdot |R_H| \qquad (4)$$

The value of Hall coefficient for CdSe radiation and no radiation are negative, which means that exhibit n-type conductivity and the electrons are majority charge carriers in conduction and they were in the order of 10^{18} cm^{-3} which is in good agreement with [14, 15]. The values of carrier mobility's which are found that decrease with the increase of time radiation laser from 0 to 180 sec. We believed that may be due to the decrease of trapping centers of electron carriers and reduce scattering of grain boundaries which determines electron mobility in thin films [35]. These parameters are illustrative in Table 2 and in the Figs. 3 and 4.

Table 2 – Hall measurements results for CdSe without radiation and radiation by CO_2 laser at various time

Radiation laser time/ sec	Carrier concentration $n \times 10^{18}$ / cm^{-3}	Hall coefficient R_H cm^3 / C	Hall mobility $\mu \times 10^{-4}$ (cm^2/V_s)
0	5.40	1.15	11.50
60	4.30	1.45	7.25
90	2.14	2.92	4.67
120	0.57	10.96	4.38
180	0.31	20.1	4.02

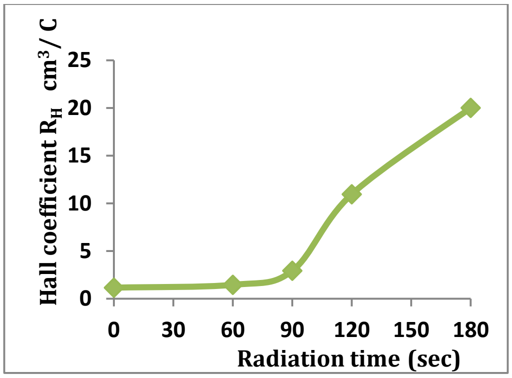

Fig. 3 – Variation RH with radiation time

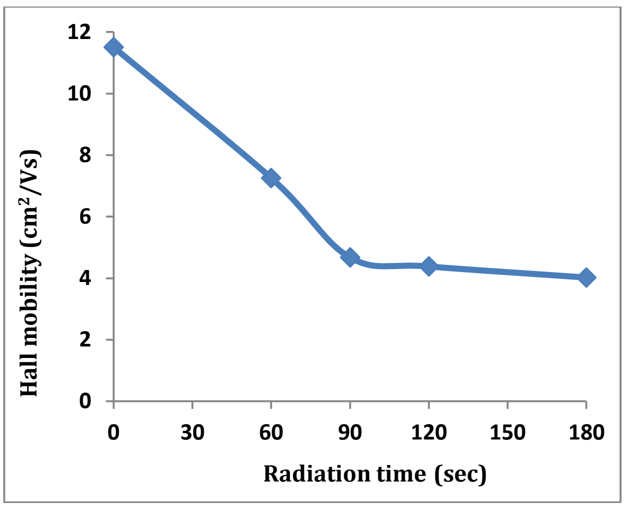

Fig. 4 – The mobility vs. radiation time

Raman spectra of the radiation CdSe nanoparticles at (60, 90, 120, 180 sec) and without radiation were attend the Raman shift of two longitudinal optical modes (209 and 410 cm^{-1}) respectively at room temperature as shown in the Figs. 5 and 6. The blue shift of 410 cm^{-1} can be compared to the phonon frequency 418 cm^{-1} for bulk CdSe [36], this means that the difference in blue shift of order 8 cm-1 in this case which may be due to the lattice contraction through growth and this constriction was mostly happened on the surface [37]. Quantum confinement of the phonon in CdSe nanoparticles due to the influence of size was insignificant, therefore it wasn't contributed in this spectra shift [38]. We observed that the Raman intensity was increased for irradiated CdSe at various times and the peaks become sharper compared with nonirradiated nanoparticles. It is also noted that there is another peak at frequency 255 cm^{-1} in addition to the previous two peaks in the CdSe radiation at 180 sec., this indicated that it may be for an improvement in the CdSe to occur when the time of irradiation CO_2 laser is increased.

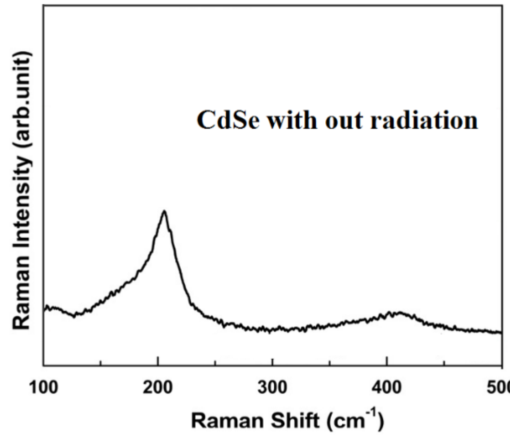

Fig. 5 – Raman spectrum for CdSe without radiation

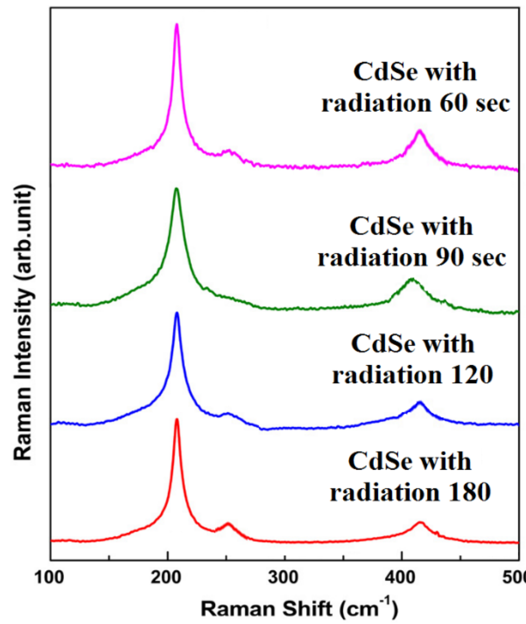

Fig. 6 – Raman spectra of CdSe at different radiation times

4. CONCLUSION

The resistivity of irradiated CdSe nanoparticles by CO_2 laser at different times and nonirradiated were found to be higher of 10^4 Ω.cm and increased at 180 sec, while the conductivity is decreased and the minimum value was reached about 0.2 in order 10^{-4} ohm^{-1}·cm^{-1}. Hall measurements have been done and they were showed that the conductivity is n-type. The electrons carrier's concentration was in the order of 10^{18} cm^{-3} and the mobility are decreased with an increasing of time radiation. Raman spectra of CdSe without radiation and with radiation of 60, 90, 120 and 180 sec have been investigated where the Raman blue shift has two longitudinal peaks around 209 and 410 cm^{-1} at times 0, 60, 90, 120, 180 sec but there was another mode at shift 255 cm^{-1} at 180 sec.

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Дослідження електропровідності та спектрів комбінаційного розсіювання наночастинок CdSe, опромінених CO_2-лазером

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На наночастинках CdSe досліджено вплив різного часу (0, 60, 90, 120 і 180 с) опромінення CO_2-лазером з довжиною хвилі (10,6 мкм) на питомий електроопір, провідність, холлівську рухливість, концентрацію носіїв електронів і коефіцієнт Холла. Питомий опір спостерігався в порядку 10^4 Ом·см, який він збільшувався зі збільшенням випромінювання лазера, навпаки, провідність для опроміненого CdSe була зменшена. Значення концентрації носіїв електронів і рухливості заряду зменшено збільшенням випромінювання лазера до 180 с. Коефіцієнт Холла зразків CdSe має *n*-тип провідності. Вимірювання спектрів комбінаційного розсіювання показало, що смуги стали більш різкими з асиметрією близько 209 і 410 $см^{-1}$ для опромінених наночастинок CdSe. Висока інтенсивність при різному часі випромінювання навколо частоти 209 $см^{-1}$ і поява іншої смуги близько 255 $см^{-1}$ у разі опромінення CdSe при 180 с.

Ключові слова: Електропровідність, Спектри КРС, Наночастинки CdSe, Лазер, Ефект Холла.