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Synthesis, Characteristics and Study the Photoluminscience of the CdS_xSe_{1-x} Nanocrystaline Thin Film

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Abstract:

The present work focuses on the changing of the structural characteristics of the grown materials through different material characterization methods. Semiconductor CdS_xSe_{1-x} nano crystallines have been synthesized by chemical vapor depostion. (X- ray Diffraction; XRD), (Field Emission Scanning Electron Microscopy; FESEM), measured the characterization of Semiconductor CdS_xSe_{1-x} nano crystallines. The optical properties of semiconductor CdS_xSe_{1-x} nanocrystallines have been studied by the photoluminescence (PL) (He-Cd pulsed ultraviolet laser at 325nm excitation wavelength) at room temperature. The results showed the change rule of photoluminsence peak at different S/Se ratios according to the photoluminsence spectral analysis technology. The photuminscence peak can be continuously modulated between (500- 650) nm, so the tunable emission of the materials in the present work have novle applications in the area of bioscience and spectroscopy, etc.

Key words: CdS_xSe_{1-x}, CVD, PL, Semiconductor nanocrystallines.

Introduction:

Semiconductor nanocrystallines have attracted great attention of the scientific researchers. Because of the novle optical and electrical properties (1), II-VI semiconductor materials, such as Cadmium Sulfide (CdS) and Cadmium Selenium(CdSe) which have good area in the optical detectors. The properties of the semiconductor CdS_xSe_{1-x} nanocrystalline has same properties of original material CdS and CdSe (2, 3). Cadmium sulphide is a group II-VI with practical applications at room temperature, and it has bandwidth of 2.42eV (4, 5), is used as a solar cell material and it has a high infrared transmittance, because of its excellent optical properties, photoluminescence, non-linear optics, and laser applications, (6). As another kind of important direct band gap semiconductor compound in Group II-VI, CdSe is extremely sensitive to visible light, there will be lots of extremely similar properties between the solid solutions and original binary compounds of both compounds. Semiconductor nano-structure CdS_xSe_{1-x} is integrated with the excellent optical properties of both materials (7).

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Therefore, source material proportion can be changed to adjust the material components and the basic properties of the material. For example, the bandgap, band structure and lattice constant, etc. are free to deploy, which provides a very high degree of autonomy and selectivity for the selection of device materials. (8, 9,10,11,12). In 2006 Qian and et.al (13) were studied nonlinear optical properties of ZnO nanostructures, they showed. The emission properties were attributed to the band-edge emission of the recombination of carriers excited by single- photon absorption processes in the wide-bandgap semiconductor. In the present work, Semiconductor CdS_xSe_{1-x} nanoscrystallines have been synthesized via Chemical Vapor Deposition (CVD) method, at different concentrations values (x), in order to adjust the band gap of materials, and the relationship with lattice constant.

Materials and Methods:

Semiconductor CdS_xSe_{1-x} thin film nanocrystalline have been synthesized by (chemical vapor deposition CVD) method. a suitable quantity of CdS and CdSe nano powder (according to a certain mixing ratio) was put in the quartz boat, which is placed in the center of the tube furance. Silcon substrates was put in the downstream of the airflow carrier gas. The furance tube of the synthesis system was flashed with argon gas for one hour. The heating system mainly consisted of the tube furnace as shown in Fig1. The temperature controller is used to set the heating rate and the heating temperature, which must be kept for a period of time. After that, the thermostat was turned off and quartz tube was cooled down to the natural ambient temperature.

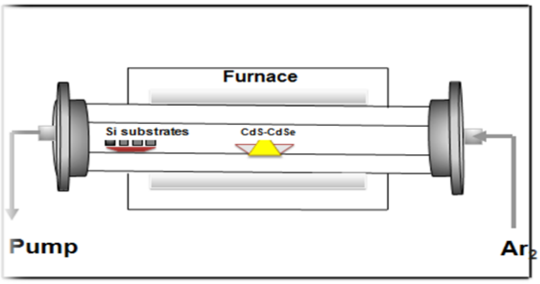

Figure 1. Tube Furnace of Chemical Vapor Deposition system(12).

Results and Discussions:

X-ray diffraction (XRD):

The purity and crystallinty of semiconductor CdS_xSe_{1-x} nanocrystallines were characterized by (XRD) with different Sulfide/Selenide ratios grown in the present work.

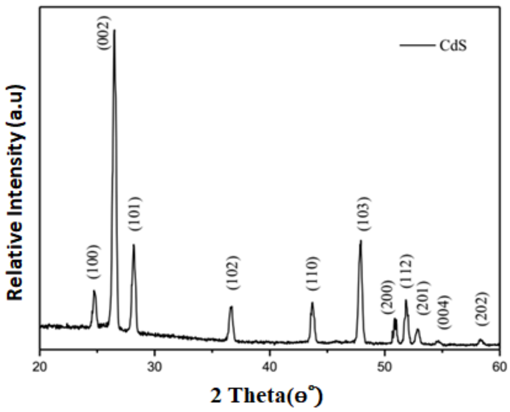

Figure 2. X-ray diffraction pattern of CdS nanocrystallines.

X-ray diffraction XRD pattern of CdS nanocrystallines was shown in Fig. 2. All diffraction peaks can be indexed as hexagonal wurtzite structured CdS with lattice constant of a=0.4141 nm and c= 0.6720 nm be JCPDS. card:41-1049.

Fig. 3 represents the x-ray diffraction(XRD) patterns of pure CdSe nanocrystallines, it indictates a hexagonal wurtzite structure and the purity of CdSe (cadmium selenide) nanocrystallines in a good agreement to standard card number (ICDD):77-0046; a=0.4299nm;c=0.7010nm).

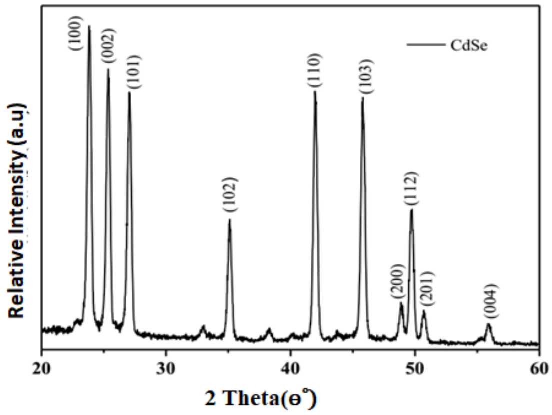

Figure 3. x-ray diffraction XRD patterns of CdSe nanocrystallines.

Figure 4 represents the x-ray diffraction(XRD) patterns of CdS_xSe_{1-x} (selenium cadmium sulfide) nanocrystallines with different values of x, where line (a) is the X-ray diffraction (XRD) of CdS grown (e) line for the growth of CdSe X-ray diffraction (XRD) patterns, show from this figure, (x) changes from 0 to 1, which can be seen from the XRD pattern. (14, 15).

(b - d) are X-ray diffraction (XRD) patterns of selenium-cadmium nanocrystallines, and (a,e) comparison found that the X-ray diffraction (XRD) patterns of the selenium cadmium sulfide nanocrystallines. The shape of each diffraction spectrum of $CdSxSe_{1-x}$(x= 0 ~ 1) is similar, which shows that the two kinds of the structures of CdS and CdSe form a solid solution semiconductor CdS_xSe_{1-x}, the crystal structure, dimensions , surface and energy band structure of semiconductor nanomaterials determine its excellent properties, in which the crystal structure of the semiconductor material itself is similar to the band structure. Solid solution semiconductor is a very important class of semiconducting materials that cannot be obtained by artificially synthesizing materials as needed of the band structure or other properties(16).

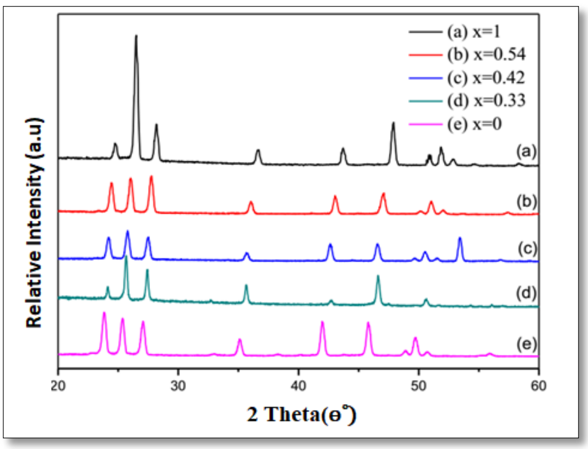

Figure 4. X-ray diffraction pattern of CdS_xSe_{1-x}

SEM and EDX Characterization of semiconductor CdS_xSe_{1-x} Nanocrystallines

The low and high resolution SEM images of CdS_xSe_{1-x} nanocrystallines and EDX spectrum have been showed in Fig. 5(a,b). The SEM images display the lots of long nanobelts and nanowires with a diameter up to hundreds of nanometers distributed uniformly on the silicon wafer, and the selected area electron diffraction (SAED) was shown in Fig. 5(c), The ESD shown in Fig. 5(d) proves that the nanobelts and nano wires that have been got in the present work are composed of CdS_xSe_{1-x}.

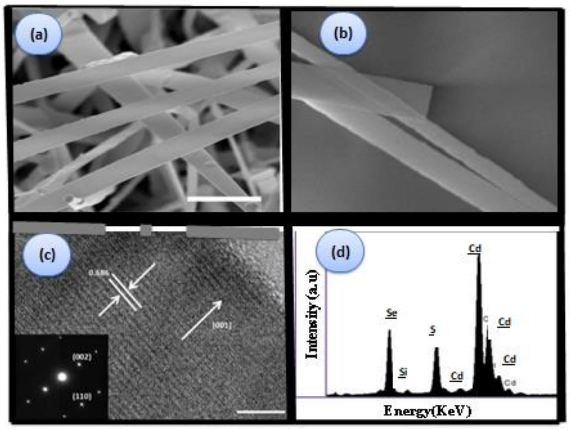

Figure 5. (a) and (b) show different resolution SEM images of CdSSe nanocrystallines, (c) The HRTEM image of selenium-sulfur selenide nanobelts, the illustration is selected area electron diffraction (SAED), (d) EDS spectra of selenium and cadmium.

Photoluminscienseof the CdS_xSe_{1-x} nanocrystalline at different values of x

Photoluminescence experiment results were measured using an excitation wavelength of the pulsed ultraviolet He-Cd laser 325 nm at room temperature. The photoluminescence emission of the CdS_xSe_{1-x} nanocrystalline indicates emission lines in the visible region with a comparatively simple energy level structure(17). Figure 6 shows the normalized PL measurement spectra of the CdS_xSe_{1-x} nanocrystalline with an excitation wavelength of the pulsed ultraviolet He-Cd laser 325 nm at room temperature. an emission at 527 nm, which is due to the band edge transition. The emission at 572, 610 and 655nm can be attributed to the surface defects/ trap state present due to the S/Cd vacancy or Cd interstitial.

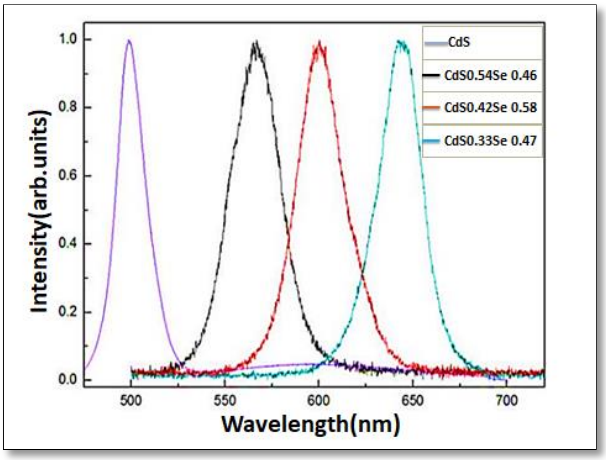

Figure 6. Photoluminescence spectra of CdS_xSe_{1-x} nanocrystallines with different values x.

The change rule of photoluminsence peak at different S/Se ratios according to the photoluminsence spectral analysis technology was shown in Fig. 6. The photuminscence peak can be continuously modulated from 500nm to 650nm. Table 1 shows the results of the Photoluminescence spectra of CdS_xSe_{1-x} nanocrystallines.

Table 1. The Photoluminescence spectra of CdS_xSe_{1-x} nanocrystallines results at different values of x.

S/Se ratios	Photoluminsence spectral peak(nm)
CdS(PURE)	527
$CdS_{0.54}Se_{0.46}$	572
$CdS_{0.42}Se_{0.58}$	610
$CdS_{0.33}Se_{0.67}$	655

Conclusion:

Chemical vipor deposition method was used to synthesis Semiconductor CdS_xSe_{1-x} nano crystallines. The characterization of Semiconductor CdS_xSe_{1-x} nano crystallines was used (X- ray Diffraction; XRD), (Field Emission Scanning Electron Microscopy; FESEM), Semiconductor CdS_xSe_{1-x} nano crystallines results showed the change rule of photoluminsence peak with different S/Se ratios according to the photoluminsence spectral analysis technology. The photuminscence peak can be continuously modulated between (500-650) nm, so the tunable emission of the materials in the present work have novle applications in the area of bioscience and spectroscopy.

Conflicts of Interest: None.

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تحضير ودراسة الخصائص الضوئية لاشباه الموصلات النانوية للمركب CdS_xSe_{1-x}

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الخلاصة:

ركز العمل الحالي على تغير الخصائص التركيبية لتحضير مواد من خلال طرق شبه الموصل النانوي بطريقة الترسيب البخار CdSxSe1-x توصيف المواد. تم تحضير مادة الكيميائي ودراسة خصائصها بواسطة حيود الاشعة السينية والمجهر الالكتروني الماسح والنافذ. وتم دراسة الضيائية البصرية للمواد الانانوية باستخدام ليزر الهليوم- كادميوم النبضي عند درجة حرارة الغرفة وبطول موجي 325 نانومتر حيث اظهرت النتائج ان تغير قمم الضيائية بتغير نسبة الكبريت/ السلينيوم يمكن ان نحصل على الضيائية وبشكل مستمر بين 500-650 نانومتر وبالتالي فان مناغمة الانبعاث لمثل هذه المواد له تطبيقات حديثة في مجال العلوم البايلوجية والطيفية.

الكلمات المفتاحية: كبريتيد الكادميوم وسلينيوم الكادميوم، ترسيب البخار الكيميائي: الضيائية، بلورات شبه الموصل النانوية.