Study of Anti-Cancer Properties of Thin Layers of Cadmium Oxide (CdO) Nanostructure

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Abstract

Thin layers of Cadmium Oxide (CdO) with various volumes of Cadmium acetate solution (60, 80 and 90 ml) were deposited using spray pyrolysis technique over a glassy substrate. Samples were investigated using FESEM images, XRD and UV-V is spectra as well as I-V characteristic. It was found that all samples were grown up with polycrystalline nanostructures along the preferred direction of (002). In addition, it was found that grew up samples in the volume of 80 (ml) are of optimum anti-cancer properties condition in visible range regarding optimum structural (largest crystallite size and lowest crystallite defect density) and optical (smallest band gap and highest light absorption) conditions.

Keywords

Cadmium Oxide (CdO), Spray pyrolysis technique, Anti-cancer properties, Nanostructure, Visible light, Thin layers

Introduction

Cadmium Oxide (CdO) is one of the rare inherent semi-conductors of type P with a narrow band gap of about 1.5-2.5 (eV) which has a monoclinic structure with limited transparency in the region of visible light [1-23]. Thin layers of this material are frequently dark brown to black. This darkness is due to narrow band gap and direct transitions between bands [24-84]. This fact leads to high absorption of visible light and can be used in optical pieces such as solar cells. In addition, this material is considered due to abundance of raw material, non-toxicity, easy production and ability to change and optimizing its physical properties using various

physical and chemical methods such as chemical vapor deposition [85-127], spray pyrolysis [128-153] and so on. This material is one of the important mineral oxides for applying in pieces such as solar cells, electrochromic pieces and gaseous sensors due to its availability, high absorption rate and low cost [154-183].

A good question is, "Why don't our bodies recognize and remove cancer cells as they would, say a bacteria or virus?" The answer is that most cancer cells are indeed detected and removed by our immune systems. Cells in our immune cells called natural killer cells have the job of finding cells that have become abnormal so that they

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can be removed by other cells in our immune system. Cancer cells remain alive either by evading detection or by inactivating the immune cells that come to the scene [146,184-195].

The ability of the immune system to recognize and eliminate cancer cells is thought to be responsible for the uncommon but well-documented phenomena of some cancers going away without treatment of (the spontaneous remission of cancer). This process also lies at the crux of the new field of cancer treatment known as immunotherapy [196-200].

Precancerous cells may look abnormal and similar to cancer cells but are distinguished from cancer cells by their behavior. Unlike cancer cells, precancerous cells do not have the ability to spread (metastasize) to other regions of the body [191,197,201-208].

An often confusing condition is that of carcinoma-*in-situ* (CIS). Carcinoma *in situ* consists of cells with the abnormal changes found in cancer cells, but since they have not spread beyond their original location (or technically, have not gone beyond something called the basement membrane), they are not technically cancer. Since CIS can turn into cancer, it is usually treated as early cancer [209-222].

In the current research, cost effective spray pyrolysis technique was used to investigate anti-cancer properties of Cadmium Oxide (CdO) thin layers with various volumes of spray solution.

Samples Preparation

To prepare thin layers of Cadmium Oxide (CdO), Cadmium acetate powder was solved in deionized water and 0.35 (M) Cadmium acetate solutions was prepared. Then, this solution was sprayed over glassy substrate in various volumes (60, 80, 90 ml) - corresponding to samples of S1, S2, S3 - to prepare the considered layers. It is expected that in pyrolysis process, the following chemical reaction mechanism happens [5]:

During each step, cleaned substrates were heated up to 570 (°C) in spray device and then, solution was sprayed under air pressure (2.6 bar). In this process, distance of sprays from substrates was 55 (cm).

Structural analysis of samples was performed by X-Ray Diffraction (XRD) device (XRD; Brucker AXS) with CuK α spectral line emission (1.5405 Å) and the surface morphology of samples were investigated by Scanning Electron Microscopy (FESEM Hitachi S.4160). Optical characteristics of layers were measured using passed and absorbed spectra by optical spectroscopy (Shimadzu UV-Vis 1800) in the range of 200-1200 (nm).

Surface Morphology

Figure 1 shows SEM images of samples in

Figure 1: SEM images of thin layers of Cadmium Oxide (CdO) for samples prepared in various volumes.

Figure 2: XRD spectra of Cadmium Oxide (CdO) layers with various volumes of solution.

Table 1: Calculated structural and physical properties for the preferred peak (002).

Sample	D (nm)	$\delta (\times 10^{-2} \text{ nm}^{-2})$	$\epsilon (\times 10^{-3})$
S1	23.77	0.456	2.60
S2	39.63	0.237	2.79
S3	19.81	0.514	3.60

the scales of 1 micron and 1000 (nm). Although the images for S1 and S3 samples show uniform surface along with some grains with 1 and 500 (nm), respectively, S2 sample is of porous surface along with woven fibers and mud-like particles that differentiate it from two other samples.

Structural and Physical Properties

XRD spectra of samples are shown in Figure 2. Diffraction curves of samples indicate that they are of polycrystalline structure with monoclinic structure and principal planes of (002) and (111) located at angles of 39.23° and 43.84°. The results indicate that S2 sample with solution volume of 80 (ml) is of weaker peaks at directions of (202) and (020) at angles of 58.91° and 63.56°, respectively. The presence of these peaks along with relative intensity of the major peaks indicates that crystalline structure improves compared to other samples.

For more accurate investigation of structural properties, crystallite size (D), dislocation density (δ) and crystalline strains (ϵ) are calculated [5]:

$$D = 0.9\lambda / \beta \cos \theta \quad (1)$$

$$\delta = 1 / D^2 \quad (2)$$

Figure 3: Passing optical absorption spectra of Cadmium Oxide (CdO) thin layers grown up in various volumes.

$$\epsilon = \lambda / D \sin \theta - \beta / \tan \theta \quad (3)$$

Where, β is half width at full maximum, D is crystallite size, θ is Bragg angle and λ is X-Ray wavelength. Results of these calculations are listed in Table 1.

Optical Properties

Figure 3 shows optical passing spectrum of the under studied layers. It can be seen that in visible region of 200-900 (nm), S2 sample and S3 sample are of the lowest and highest passing, respectively. These variations may be largely due to relative electrical conductivity of layers (Section 4) which is effective is relative amount of metal-like and or insulator-like of layers.

According to the reported results, Cadmium Oxide (CdO) layers are acted as a semiconductor with direct transition between bands so that during these transitions, absorption coefficient is a function

Figure 4: Absorption spectrums of under studied samples in terms of wavelength.

of incident photon energy. **Figure 4** shows the variations of absorption spectra of layers against wavelength.

Since Cadmium Oxide (CdO) is a semiconductor with direct transitions between bands, to determine optical band gap of samples, $(ah\nu)^2$ is drawn against $h\nu$ and data is extrapolated in linear region of high energy with horizontal axis as $a = 0$. **Figure 5** shows this curve in order to determine direct optical band gap and the attached figure shows the results obtained from this analysis related to band gap amounts. The results indicate that the sample with largest crystallite size (S2) has the smallest band gap (2.01 eV) and the sample with smallest crystallite size (S3) has the largest band gap (2.27 eV) which can be a reason for happening a quantum limitation in these samples.

Electrical Properties

Figure 6 shows current - voltage curve of these samples. The results indicate that sample S2 has the highest electrical conductivity (metal-like property) while sample S3 has the lowest one (isolator-like property). This is in good agreement with optical transition behavior of layers.

Anti-Cancer Properties

To investigate anti-cancer properties of samples, the under studied samples were placed under visible light emission (halogen lamp). **Figure 7** shows current - voltage curve of samples under light. As

Figure 5: Analysis of optical spectrums data as a function of photon energy. The attached figure shows band gap of layers.

Figure 6: Current-voltage curve for samples grew up in darkness.

can be observed, all three samples are reacted to the light and after emission, more electrical current passed through samples. This is an expected event due to producing electron - hole pairs in layers as a result of optical photon emission in $h\nu > E_g$. In order to compare optical sensitivity of these samples, the passed electrical current through samples in voltage of 4.5 (V) in darkness and under visible light emission are shown in Figure 8. As can be seen, sample S2 is of highest relative change of electrical current ($I_{\text{Light}}/I_{\text{Dark}} = 15$) and sample S3 is of lowest one ($= 7$). These variations may be due to the effect of various factors such as optical absorption, band gap, crystallite size and crystalline obliquity in the investigated layer.

Results and Discussion

Cancer cells are usually formed after a *series* of mutations cause them to become increasingly abnormal. These mutations are either inherited or more often, caused by carcinogens (cancer-causing substances) in our environment. That cancer is caused by not one but several mutations explain why cancer is more common in older people and why it is often multifactorial (meaning there are several factors that work together to cause cancer). It also helps explain a genetic predisposition to cancer. A genetic predisposition does not mean you will get cancer, but, simplistically, if a few mutations are already in place, it will likely take fewer acquired mutations for a cell to become cancerous.

The process of normal cells becoming cancer often goes through stages in which the cell becomes progressively more abnormal appearing.

Figure 7: Current-voltage curve for samples subjected to visible light.

Figure 8: Passed electrical current through investigated samples.

These stages may include hyperplasia, dysplasia, and finally cancer. You may also hear this described as differentiation. Early on a cell may look much like normal cells of that organ or tissue, but as progression occurs, the cell becomes increasingly undifferentiated. This is, in fact, why sometimes the original source of cancer cannot be determined.

A cancer cell can have thousands of mutations, but only a certain number of these genetic changes in cancer cells cause cancer to divide and grow. Mutations which result in the growth of the cancer cells are referred to as "driver mutations", whereas other mutations are considered "passenger mutations". The term "oncogenes" refers to genes that drive the growth of cancer and give cancer its immortality. Tumor suppressor genes, in contrast, are genes within the cell which tell cells to slow down and stop growing, repair damaged DNA/RNA, or tell cells when to die. Most cancer cells have mutations in both oncogenes and tumor suppressor genes which lead to their behavior.

Conclusion and Summary

The thin layers of Cadmium Oxide (CdO) nanostructures were deposited using spray pyrolysis technique with various volumes of spray solution over a glassy substrate. FESEM images indicate that surface morphology of samples are dependent on the variations of solution volume and XRD spectrum of layers indicate that polycrystalline structures are grew up in preferred direction of (002). Data analysis indicates that at solution volume of 80 (ml), crystallite size and crystallite defect densities are optimum and anti-cancer properties are improved. In visible light region, layers are of low optical transition and of optical

band gap between 2.01-2.27 (eV) so that sample S2 has the lowest band gap among all samples. The obtained results indicate that band gap variations in these samples are controlled by crystallite size and under the effect of happening a quantum limitation. Anti-cancer properties results indicate that sample S2 is of highest optical sensitivity to visible light.

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