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MORPHOLOGICAL STUDY OF CDSE QUANTUM DOTS IN POLY (3-HEXYLTHIOPHENE)(P3HT) PREPARED BY ANGLE LIFTING DEPOSITION METHOD

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Abstract: Hybrid organic-inorganic nanocomposite thin films have attracted researchers due to their unique combined benefits. In this study, thin film of (poly (3-hexylthiophene) (P3HT)) doped CdSe quantum dots were deposited on silicon substrate by using a novel home-design Angle Lifting Deposition (ALD) thin film deposition technique. The films were investigated to observe their morphology effects due to different dopant weight percentage (wt%) I,e 25% and 50%. The morphology of P3HT:CdSe quantum dots thin films were characterized using Ultra High Resolution Field Emission Scanning Electron Microscopy (UHR-FESEM) and their elements were analyzed using Energy-dispersive X-ray emission (EDX) spectroscopy. The findings revealed that high weight composition of CdSe quantum dots has changed the morphology of P3HT thin films.
Keywords: P3HT, CdSe quantum dots, FESEM-EDX, Morphology.

1. Introduction

Organic semiconductor materials have shown promising alternatives to their inorganic counterparts in optoelectronic applications such as solar photovoltaic. It can be processed from a solution at room temperature, low cost, lightweight and flexible [1,2]. Unfortunately, organic semiconductor devices alone cannot produce excellent photovoltaic efficiency. Nowadays, hybrid thin films of organic semiconductor and inorganic nanocomposite have found their role in solar cells applications owing to their unique properties emerging from the combination of organic and inorganic hybrid materials. Contribution of inorganic material enhances the carrier mobility [3] in organic semiconductor solar cells. Semiconductor polymer materials are generally characterized by a carbon-rich backbone, which offers mechanical flexibility, and by a π-conjugated electronic system which enable them to access full range of electrical properties [1]. This type of polymer has high charge carrier mobility and it is also a good light absorber [4]. In this study, hybrid organic-inorganic thin films of Poly(3-hexylthiophene) (P3HT) doped with CdSe nanoparticles were prepared. Two samples were fabricated at different weight percentages of CdSe in P3HT i.e. 25% and 50%. The

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samples morphology was characterized using Ultra High Resolution Field Emission Scanning Electron Microscopy (UHR-FESEM) and Energy-dispersive x-ray emission spectroscopy (EDX).

2. Methodology

2.1. Substrate cleaning

Silicon substrates were cleaned by immersing and ultrasonicating them in solvents (acetone and ethanol) solution for 5 minutes. Consecutively, they were rinsed by ultrapure de-ionized (DI) water and dry by the flow of nitrogen gas.

2.2. Sample Preparation

P3HT solution was prepared by dissolving P3HT powder into its solvent, chloroform ($CHCl_3$) and then blended with cleaned CdSe quantum dots at different weight percentage of CdSe, 25% and 50%. The CdSe quantum dots were cleaned by mixing them with hexanoic acid and chloroform. Finally the solution were centrifudged at 3000rpm for 10 minutes. Blended solution of P3HT:CdSe quantum dots was spreaded on a subphase of a Langmuir-Blodgett (LB) trough. The subphase is ultrapure DI water with resistivity better than 18.2 MΩ-cm. The solution was left for 15 minutes to let the solvent vapours evaporate. Next, the trough barrier was closed to apply pressure to the surface of the solution molecules. The real time phase changes of the molecules from the gas phase to liquid phase and subsequently solid phase were observed by a PC which controlled the LB. Finally thin film of P3HT:CdSe quantum dots were transfered from the LB trough onto a silicon substrate using a novel home-design stamping technique known as Angle Lifting Deposition (ALD) as shown in Figure 1.

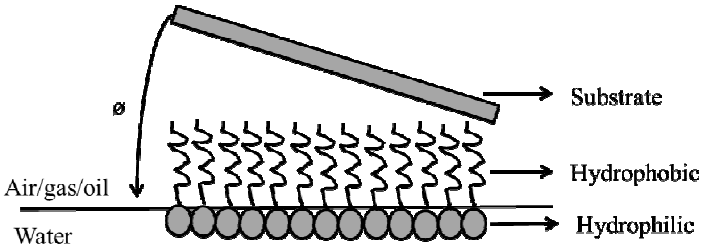


Fig. 1. Angle Lifting Deposition (ALD) technique

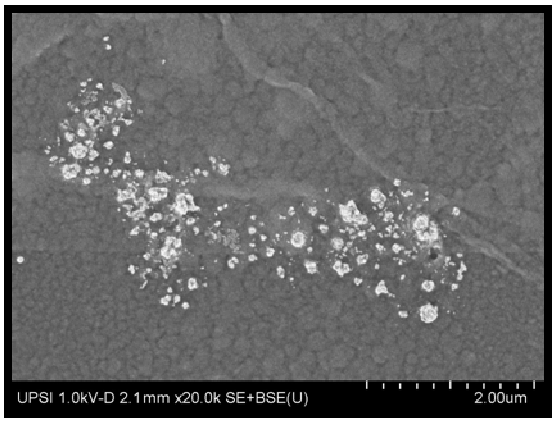
2.3 Characterization

The hybrid P3HT:CdSe quantum dots films morphology and elements analysis (at different wt%) were characterized using Ultra High Resolution Field Emission Scanning Electron

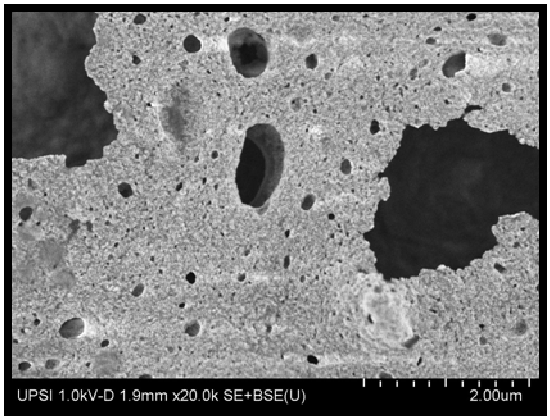
Microscope (UHR-FESEM) model Hitachi SU8020 equipped with EDX. UHR-FESEM is a powerful tool for the imaging and characterization of nano-materials.

3. Results

The morphology investigation on organic-inorganic hybrid thin films with different CdSe wt% in P3HT matrix, shows different images between the two samples. As seen in Figure 2(a), CdSe has formed in between of P3HT film matrix and presented their original shape, i.e. dot shape at various sizes in the range 20 to 100nm. Also, as can be seen from the figure, the P3HT films were smooth and were not perturbed by the inorganic counterpart.



(a)



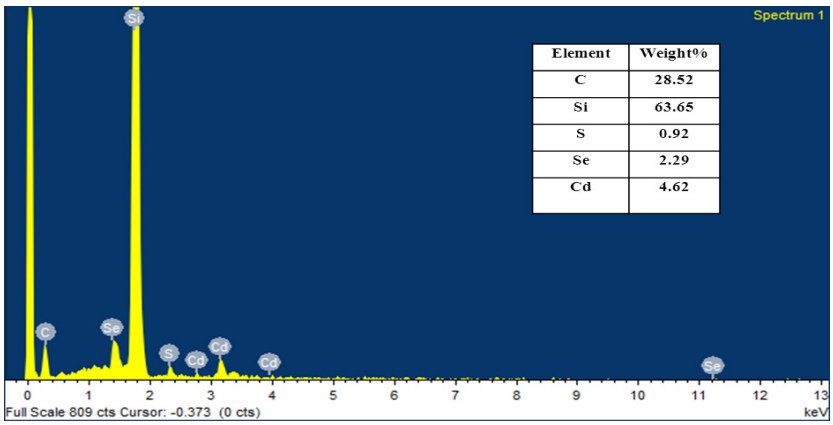
(b)

Fig. 2. FESEM of P3HT:CdSe quantum dots at (a) 25% and (b) 50% of CdSe weight percentage

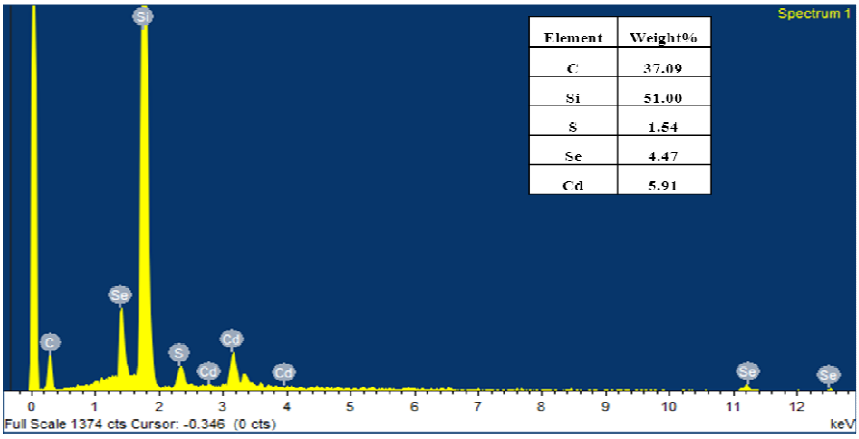
However, at wt50% CdSe quantum dots start to aggregates as shown in Figure 2(b). This could be due to CdSe quantum dots were already saturated and was not well dispersed in P3HT matrix. It is believed that, a large amount of quantum dots will lead to some

aggregation in the sample [5]. Thus, this aggregation will cause the structure of P3HT becomes non-uniform as opposed to wt25%.

Energy Dispersive X-ray (EDX) revealed the existence of Cadmium and Selenide elements and their weight composition in the sample. It can be seen that Cd has peak at 3.1 KeV whilst Se at 1.4 KeV and peak for carbon at 0.26 KeV. These results were similar to [6]. Based on table (inset Figure 3(a) and (b)), the sample with 50% weight percent of CdSe quantum dots had higher Cd and Se elements (5.91% and 4.47%) in the sample as compared to sample with wt25% (4.62% and 2.29%).



(a)



(b)

Fig. 3. EDX result for P3HT: CdSe at (a) 25% and (b) 50% CdSe weight percentage

4. Conclusion

Hybrid organic-inorganic thin films were fabricated by depositing a solution-based conjugate P3HT blended with CdSe quantum dots on silicon substrates using Angle Lifting Deposition (ALD) method. Two samples with different wt% of CdSe dopant (25% and 50%) were used

to study their effects on the hosting material (P3HT) morphology. Ultra high resolution FESEM was used to investigate the film morphology changes due to different in dopant weight percentage. It was observed that CdSe quantum dots wt% had influenced the hosting film morphology. From the EDX results, it has proved that our novel home-design thin film deposition method (ALD) is a promising technique in fabricating large scale hybrid organic-inorganic nanocomposite films.

Acknowledgement

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