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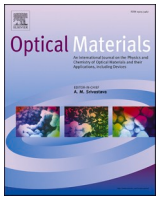

Research Article

Investigation of structural, optical, and electrical properties of $CoCl_2$-doped P3HT for organic devices applications

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ABSTRACT

In this study, thin films of poly(3-hexylthiophene) (P3HT) doped with cobalt chloride ($CoCl_2$) at varying weight ratios (2.5 wt%, 5 wt%, and 10 wt%) were prepared, and their structural, optical, and electrical properties were investigated. Atomic force microscopy (AFM) and X-ray diffraction (XRD) analyses as well as reflectance revealed dopant increase laminal layers of aggregated P3HT, which improve film crystallinity and conductivity. The absorbance spectra showed an increase in peak intensity with higher $CoCl_2$ concentrations. The influence of light intensity on photo-electrical parameters was also examined, demonstrating enhanced photocurrent with higher $CoCl_2$ ratios. Notably, the photo-sensitivity ($(I_{photo}/I_{dark})\%$) reached approximately 115% at 10 wt% $CoCl_2$, compared to ~30% for pure P3HT thin films. The current-time characteristics of the P3HT:$CoCl_2$(10 wt%) based photo-sensors show that the photo-responsivity and efficiency are 30.8 mA/W and 7.5%, respectively, exhibiting an enhancement by a factor of ~10%. Furthermore, Schottky diodes based on both doped and undoped P3HT thin films were successfully fabricated, and their current-voltage (I–V) characteristics were analyzed. The results showed that doping with 10 wt% $CoCl_2$ reduced the barrier height and resistance per area of the ITO/P3HT:$CoCl_2$(x%)/Al diode from 0.85 eV to 1.76 kΩ/cm^2 to 0.759 eV and 0.165 kΩ/cm^2, respectively. These findings highlight the potential of $CoCl_2$-doped P3HT thin films in optimizing the performance of photo-sensing devices and Schottky diodes.

1. Introduction

Although poly(3-hexylthiophene) P3HT studied under sub pico-second interferometry back in 1992 [1], it received endless by many researchers around the globe since it was synthesized first by Lohwasser et al., [2]. The pure P3HT and composed with various materials were widely investigated and characterized by the research groups. In the first way it have processed at low temperature solid state [3], it have been characterized by quantitative end-group functionalization [4], ultrafast relaxation of its emission spectrum [5], calculation of its charge transport [6,7], H-aggregate analysis of its thin films [8], enhance the thermo-electric performance of its films via organic small molecule epitaxy [9], understanding of its intrinsic carrier transport [10], study electrical and optical properties stability as thin films [11], photo-luminescence properties [12], vibrational and optical properties [13] and crystal structure thin film [14].

In the second way P3HT has been composed with many materials for various purposes, such as, P3HT: PCBM blends for organic solar cells and photovoltaic applications [15–18], organic photo-sensor based on P3HT:PCBM:Schiffbase thin films [19], P3HT-PCBM nanoparticles doped by Cobalt NPs for organic photovoltaic applications [20], P3HT doped by Ag_2S nanoparticles to improve the photophysical and electrical properties [21], P3HT/PbI_2 hybrid thin films to enhance the optical and electrical properties [22], P3H:ICBA doped by $CoCl_2$ and $CrCl_2$ for optoelectronics applications [23], P3HT:$CrCl_2$ thin films for photo-sensing applications [24], P3HT doped by $AuCl_3$ (NPs) for photo-sensing applications [25], thin film transistors based on P3HT doped by WO_3 [26], P3HT:MoS_2 thin film based organic field effect transistors and thin film transistors based on P3HT:OH-MWCNTs for gas sensing applications [27,28], P3HT-rGO composites for photo-detecting

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