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PAPER

Enhancement of electrical and photo-electrical properties of P3HT:$CrCl_2$ thin films for photo sensing applications

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Abstract

In this work, doped and undoped P3HT thin films are prepared and deposited onto ITO interdigitated electrodes. To improve the optical and the electrical properties of the pure P3HT thin film, chromium (II) chloride was used as dopant material with three different weight percentage, 2.5%, 5%, 10%. Room-temperature current–voltage (I-V) characteristics of the samples were measured, showing an increase in the electrical current with increasing the dopant concentration. Under dark condition, the conductivity and resistivity of the pure P3HT thin films were enhanced by a factor of 5× as a result of doping the P3HT by 10 wt% of $CrCl_2$. Under light intensity (50 mW cm^{-2}) and at 10 V bias, the conductivity and resistivity obtained from P3HT:$CrCl_2$ (10 wt%) thin films are 4.75×10^{-4} S cm^{-1} and ~2 kΩ, respectively. These results exhibit an enhancement by a factor of ~12× compared to those obtained from pure P3HT thin film. The current of the photo-sensors based on doped/undoped P3HT thin films are measured as a function of time under light intensity ranging from 0 to 50 mW cm^{-2} at 1 V bias, exhibiting high photo-response and good reproducibility. Three different wavelengths, white, green, and red were used as light sources to expose the photo-sensors. Under white light, photo-sensor based on P3HT:$CrCl_2$(10 wt%) exhibit the highest values of the photo-responsivity and quantum efficiency, ~23.3 mA W^{-1} and 5.8%, respectively, showing an enhancement by a factor of ~ 11.5× compared to those obtained from the photo-sensor based on pure P3HT.

1. Introduction

Organic semiconductors have attracted the scientific community and the manufacturers due to their properties such as, ease of fabrication, mechanical flexibility, processability, low manufacturing cost, small size, simple manufacturing techniques and the possibility of developing components over large areas by roll-on-roll or inkjet printing, as well as electronic and optical properties [1–5].

Small molecules and conjugated organic polymers have the potential to achieve large surface area and flexible optoelectronic devices [6–9], and their optoelectronic properties can be easily controlled by controlling their molecular structure to optimize radiative recombination, charge transfer, or photogeneration depending on the application required. P3HT polymer is currently one of the most widely used conjugated polymers in photovoltaic devices, thanks to its amazing properties and processability. It is currently used in photovoltaic applications by forming it into well-ordered thin films. This material gives a high rate of hole movement [10]. It can also be used as a solution as it is mixed with other materials such as soluble graphene, which has a thickness of one atom and a two-dimensional structure, and is used as the active layer in heterogeneous polymer photovoltaic cells (BHJ) [11].

This polymer is used in many applications such as photodiodes, self-powered photodetectors based on organic and inorganic linkers that are suitable for optical imaging, and a self-powered UV [12] and in field effect transistors as a sensor for ammonia gas [13]. With the increasing global demand for renewable energy sources, the role of P3HT as an active layer in solar cell applications has emerged [14] because it is a p-type