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Short Communication

Enhanced optical absorption in organic solar cells using metal nano particles

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ABSTRACT

In this study, for increasing absorption of the active layer in bulk hetero junction (BHJ) organic solar cells (OSCs) we used surface Plasmon effects of metal nano particles (MNPs). We embedded the MNPs inside the active layer and studied the device structure. For shown the results we investigated the model of our structure with Finite Difference Time Domain (FDTD) numerical method and achieved electromagnetic field characters. From the result of this model, drown absorption curve that obviously shown enhancement in light absorption and thus the improving in power convertion efficiency **(**PCE).

Keywords: *Light absorption; Organic solar cells; Metal nano particle; Surface plasmon; Power Convertion Efficiency (PCE).*

INTRODUCTION

Renewable energy resources are adequate to meet all potential energy needs. In order to develop in expensive renewable energy source the organic solar cells (OSC) based on conjugated polymer: fullerene blend at tract a significant attention, Because of the low cost fabrication, light weight, mechanical flexibility and easy processing [1]. However, OSCs low power conversion efficiency limit their feasibility for commercial use. Also the performance of OSCs have been improved by introduction of bulk hetero junction (BHJ) concept for an active layer, and it is reported that the efficiency increases up to ~6% for a single layer cell, but despite recent improvement the efficiencies of OSC are not yet high enough to be commercially viable [2, 3]. Recently, much effort has been devoted to improve the performance of OSCs with enhancing light absorption or controlling the domain size, in order to increasing the absorption curve in long wave length range and improving the charge carrier path in traveling to the electrode.

In this study to investigate the high performance OSC, we consider two dimensional (2D) models for the internal structure of our cell and embedded metal nano particles (MNPs) in the active layer of OCS for enhancement in the absorption spectrum. Then discuss how different kind of NPs with different thickness of active layer and different distribution of NP influence the performance of our structure. The light absorption curve of this structure, computed with solving the Maxwell's equation versus time by using of the finite difference time domain (FDTD) numerical method.

EXPERIMENTAL

In the optical model the structure such as shown in Figure 1 are used: indium tin oxide (ITO)/ poly (3,4_Ethylenedioxythiophene): polystyrene Sulonate (PEDOT: PSS)/ poly (2_methoxy_5_(2'_ethylhexoxy)_1,4_phenylene vinylene) (MEH_PPV)/ lithium florid (LiF)/ aluminum (Al).

Optical constants (n, k) of each layer in the device taken from different literature, have been determined by ellipsometric measurements [4], [5], and use as input parameters in our optical model. In this 2D model in order to computation, using the R Soft Photonics CAD Layout software package and light consider as normal incident electric field that intern from the air in to the layers of the solar cell.

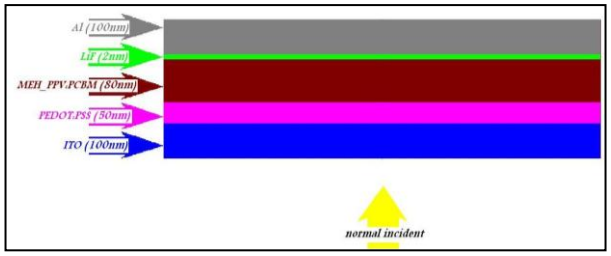

Fig. 1. The device structure of bulk hetero junction organic solar cell.

RESULTS AND DISCUSSION

In our first structure we consider active layer without NPs and calculate the absorption of active layer with different thickness (Figure 2), for the other layer we chose best thickness to have best buffering effect in order to confine light at the active layer (Figure 1).

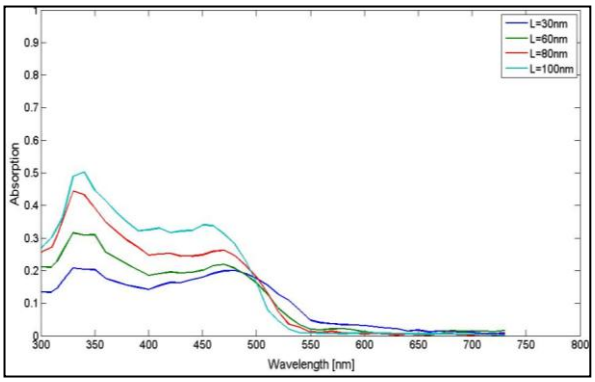

Fig. 2. The absorption curve for active layer with different thickness.

It is obviously that the thicker active layers have better absorption, however according to the short life time and short traveling lengths of the free charge carrier we prefer improve the absorption of thinner active layer.

In this step we show the effect of the MNPs on the absorption curve of the active layer. At optical frequencies the metal's free electron gas can sustain surface and volume charge density oscillations that called Plasmon, Plasmon are useful to enhance the absorption of light and generation of exciton and thus efficiency enhancements in solar cells [6]. Surface Plasmon frequency mainly depend the density of free electrons in the particle, thus different kind of metals have different Plasmon resonance and thus different absorption curve. For show this phenomena and its effect we first consider just have silver or gold NPs in free space and achieve their absorption spectrum at the wave length range between 300_800nm, in this simulation NPs diameter is equal to 35nm and their space from neighboring particle is 30nm (Figure 3). Then we replace each kind of MNPs at the mid of the active layer and calculate the absorption of this layer and compare the results in Figure 4.

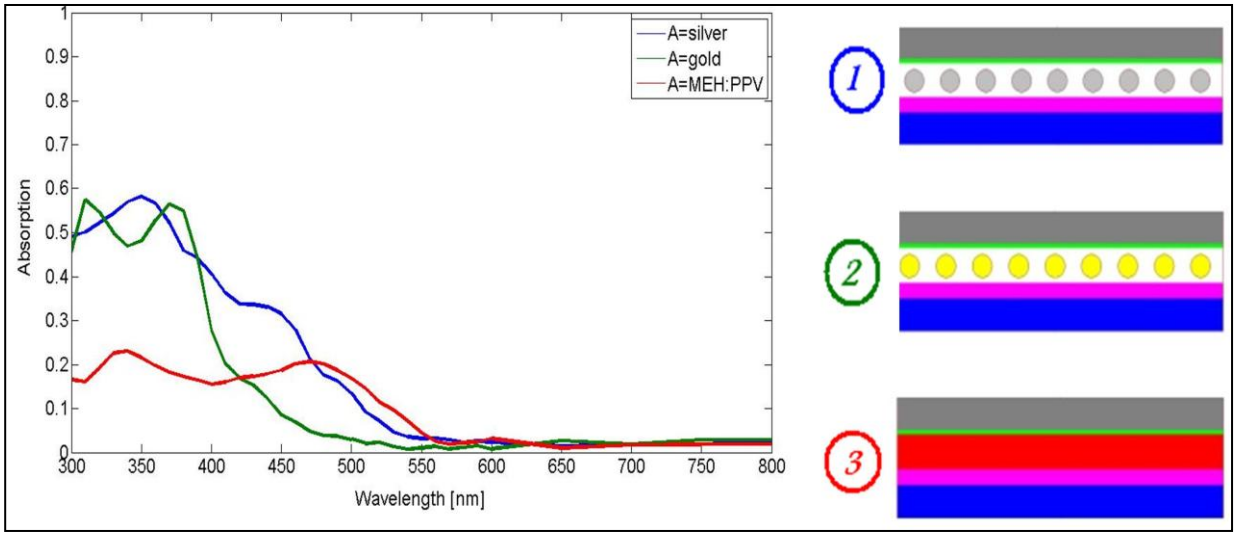

Fig. 3. Calculated values of absorption curve versus wave length for silver and gold NPs.

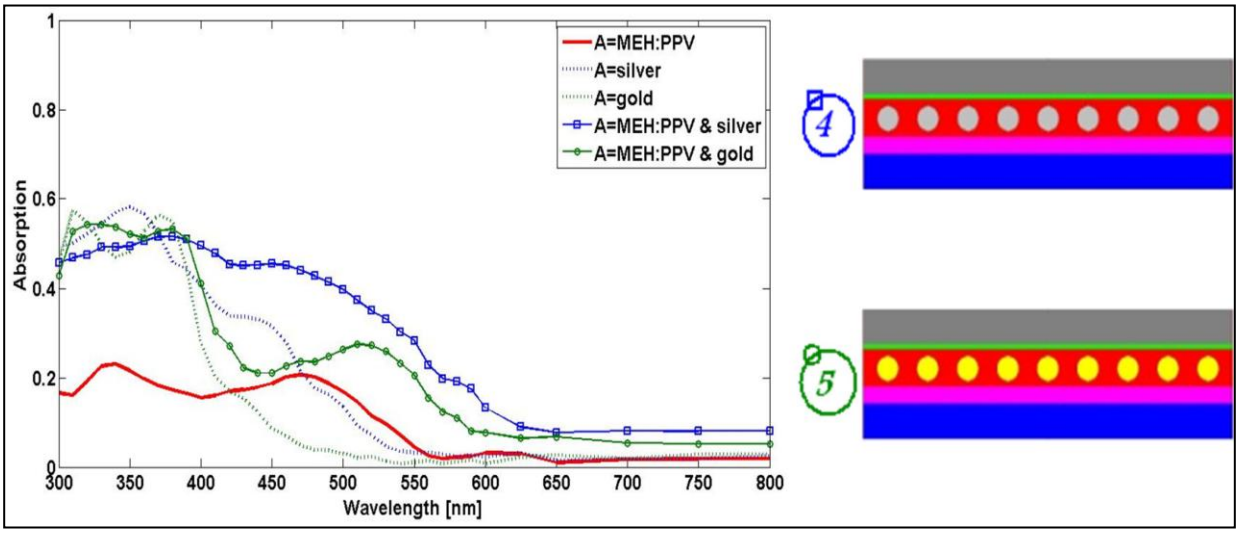

Fig. 4. Calculated results of absorption curve versus wave length for active layer with different kind of NPs and compare between the improving absorption with each kind.

Here we consider have two layers of NPs in active layer of our solar cell. At the first layer we embed gold NPs and at the other layer of active layer replace silver NPs. In this simulation structure we suppose active layer thickness equal to 40nm and NPs diameter 20nm that place at the space 20nm from each other. From the result of absorption spectrum we show that absorption of active layer have bester improving in this structure, in front of others (Figure 5).

In this part we consider that our silver NPs in simulation structure have coated of dielectric such as silica. We know that this coat could have helpful effect on carrier transport. But if the dielectric became thicker than one range can have bad influence on absorption thus we attempt to find best coat size for NPs, as a result consider silica with different thickness around the silver NP and calculate the absorption curve as shown in Figure 6. From the calculation results we found that for our NP with diameter=35nm and space=30nm, silica coating should be thinner than 5nm.

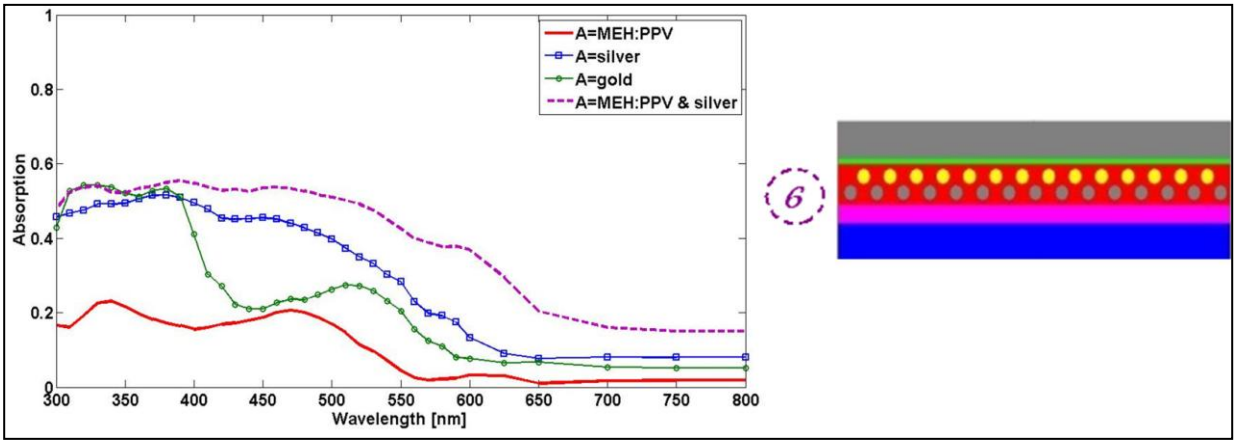

Fig. 5. Absorption curve of active layer with two layers of MNPs.

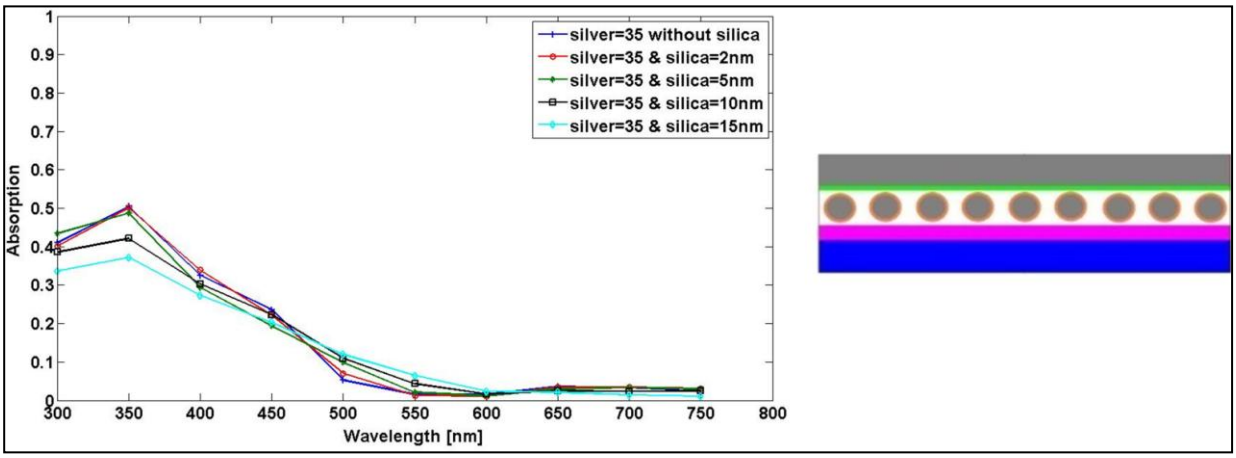

Fig. 6. Calculation values of absorption curve for silver NPs that coating with silica.

CONCLUSIONS

In this paper, we performed FDTD numerical method in order to calculate the light absorption in OSCs. Then shown that our solar cell absorption could be improved with added the MNPs in active layer, and found that this particle kind and distribution could play important role at determined the best result.

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