Scientific Report

about

Short Visit Grant

within the

ORGANISOLAR-Program

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"Plasmonic organic solar cells"

Final Report

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Host: Assistant Professor Emmanuel Kymakis from Technological Educational Institute (T.E.I) of Crete, Greece

1. Introduction

The continuously new achievements in organic solar cells 8.3% (Konarka) proves that organic materials are very good competitors of inorganic materials for solar cells. Their solubility allows low cost deposition methods such as spin coating and roll to roll process[1] for mass industrial production. Most of the efficiencies improvements till now are related with the chemical structure of the blended materials electron donor and acceptor. However an important parameter which it can further enhances the performance is the efficient management and coupling of light [2, 3] into the active layer. Such smart light coupling of light can be archived incorporating plasmonic structures[4, 5] either in the front, back contacts or inside the active material[6].

2. Purpose of the visit

The purpose of that short visit was to discuss and exchange knowledge between experts in the field of plasmonic organic photovoltaic diodes. In addition explore how incorporated Au metal nanoparticles affect the resistivity of the front electrode and their optical properties. Furthermore to examine the suitability of spray pyrolisis as a method for depositing Pedot:Pss with Au particles over large areas for plasmonic solar cells, and examine fabrication of P3HT: PCBM solar cells in atmospheric air conditions. Finally we discussed about possible future collaboration.

3. Electrical characterization with Hall Effect

40nm Pedot:Pss spin coated on top of 150nm ITO, after drying the films a number of various Au thickness thin films deposited (Figure 1) and annealed to create metal nanoparticles. The fabrication made in Advanced Technology Institute (ATI) at University of Surrey. The resistivity of the films measured at the Technological Educational Institute (T.E.I) of Crete with a Hall Effect probe PCB SPCB-01 from ECOPIA (Table 1).

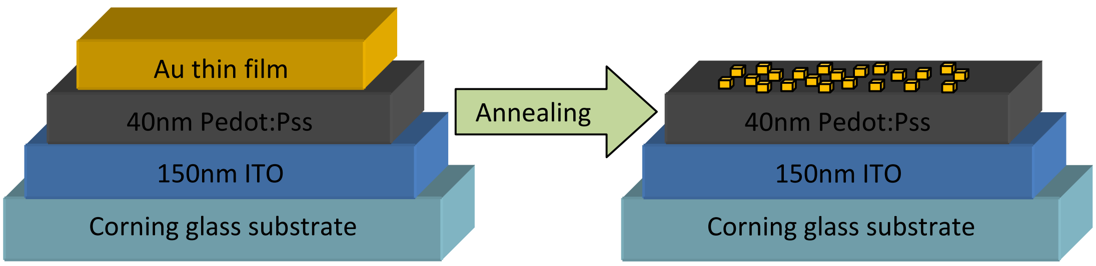


Figure 1 Films structure which used for the resistivity measurements

Deposition Method of nanoparticles	Initial Metal Film Thickness	Film Resistivity (Ω cm)	Film Magneto-Resistance (Ω)
Plain ITO	0nm(ref)	1.566E-04	1.183E-02
Plain ITO & Pedot:Pss Laser	0nm(ref)	1.634E-04	1.528E-02

annealing			
Laser annealing	0.6nm	1.561E-04	1.526E-02
Laser annealing	1nm	1.615E-04	2.166E-02
Laser annealing	2nm	1.485E-04	1.532E-02
Laser annealing	3nm	1.554E-04	1.725E-02
Laser annealing	4nm	1.577E-04	1.289E-02

Table 1 Resistivity of ITO/Pedot:Pss/Metal nanoparticles films for different thickness of the initial Au film.

4. Optical Characterization

The reflectivity for those samples where measured (Figure 2) to determine how the plasmonic resonance of Au metal nanoparticles affects the incoming light.

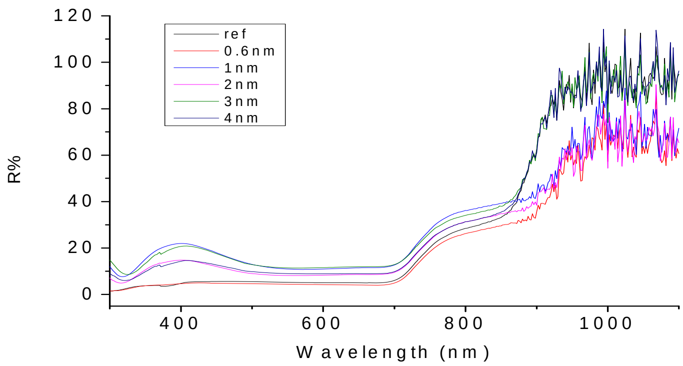
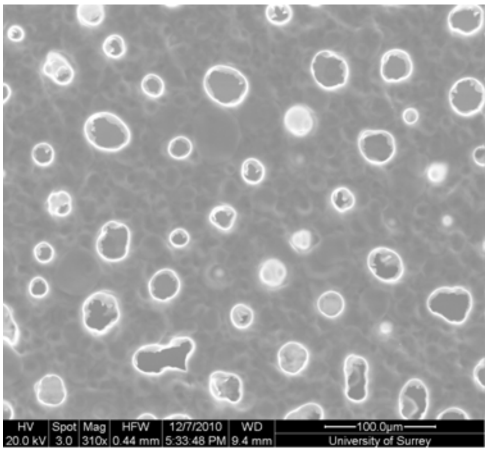


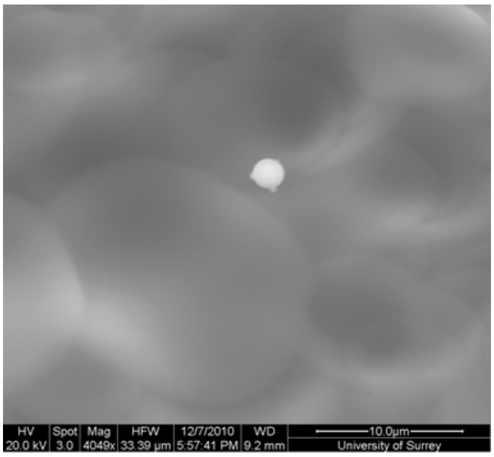
Figure 2 Reflectivity of the substrates with Au metal nanopartilces.

5. Spray pyrolysis

Spray pyrolysis where used to deposit Pedot:Pss mixed with nanoparticles on top of ITO as a new method to deposit thin films favorable for industrial production of large area plasmonic photovoltaic's.

Solutions with 4%, 8% and 10% concentration of Au nanoparticles into Pedot:Pss were used to fabricate films at the Technological Educational Institute (T.E.I) of Crete with spray pyrolysis. The characterization of the films with SEM performed at University of Surrey and revealed that Au nanoparticles were successfully deposited.





Concentration 10%, spray time 60min, annealing temperature 60°C

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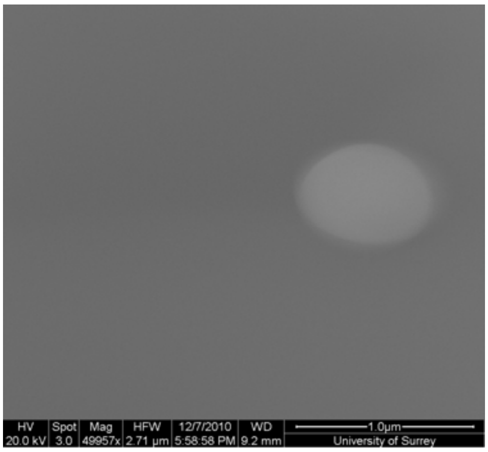

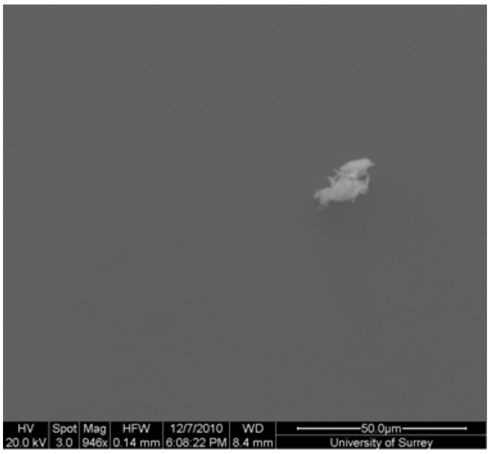

Concentration 10%, spray time 10min, annealing temperature 30°C

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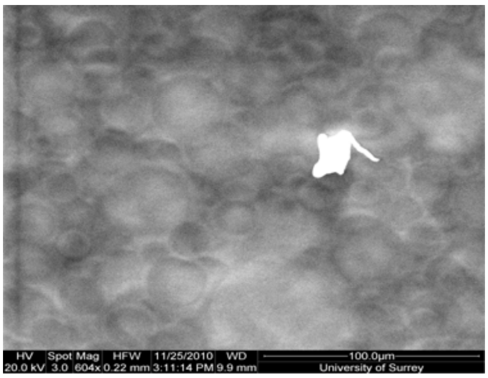
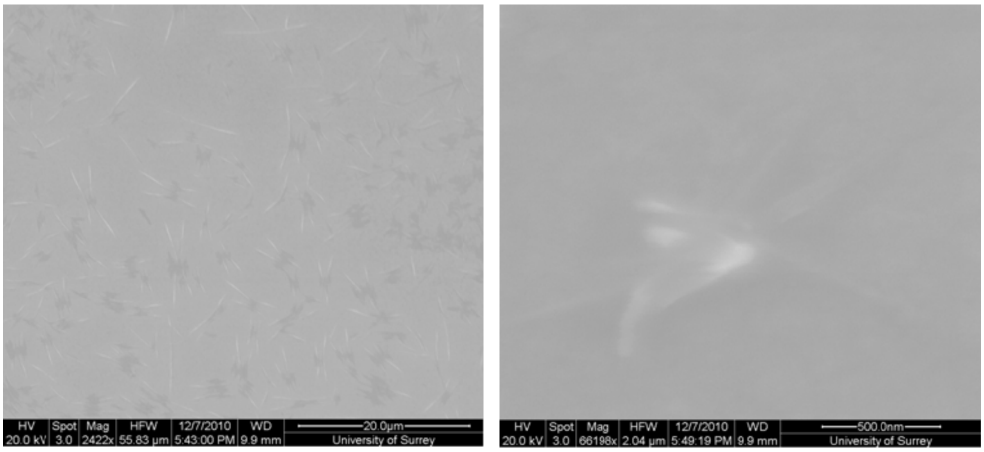


Concentration 8%, spray time 10min, annealing temperature 30°C



Concentration 4%, spray time 10min, annealing temperature 30°C	Concentration 4%, spray time 10min, annealing temperature 30°C

Figure 3 SEM images of different films of Pedot:Pss with Au deposited with spray pyrolysis.

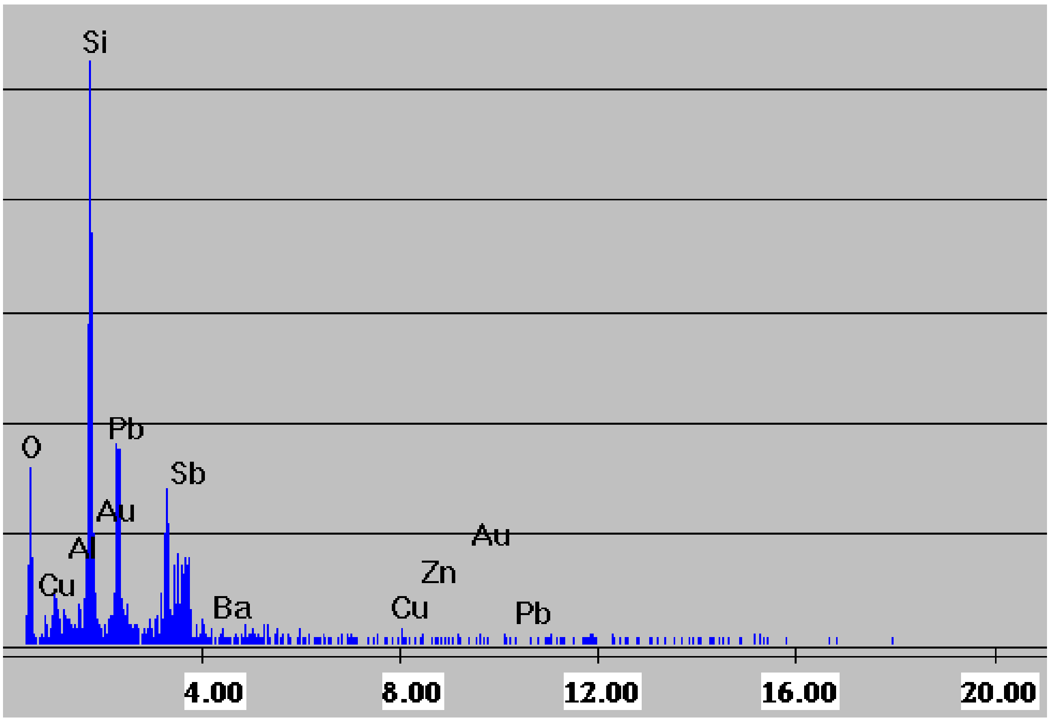
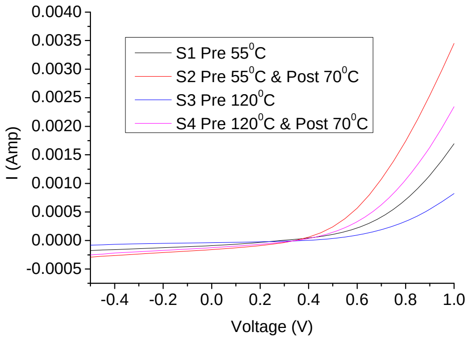


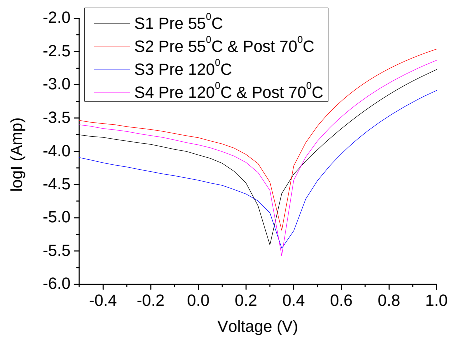
Figure 4 EDX signatures of the deposited films for verifying Au existence.

EDX characterization of the spay pyrolysis samples confirmed the existence of Au particles as well. Therefore this method it can be successfully used for preparing large area plasmonic substrates.

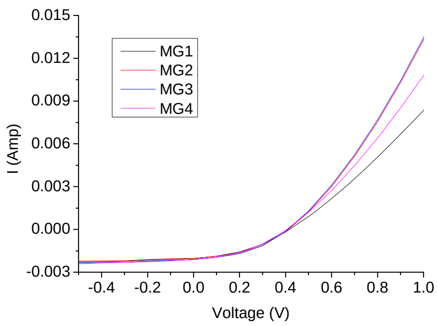
6. Solar cells characterization

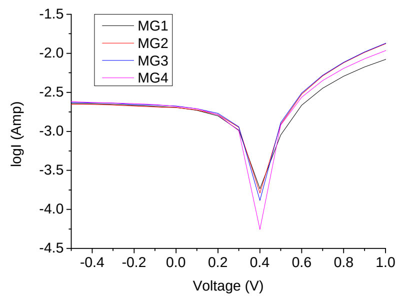
Solution of 10mg P3HT and 10mg PCBM dissolved into 1ml DCB and mounded in a magnetic stirrer for 24h at 70°C. ITO coated glass substrates cleaned using ultrasonication bath for 10min in soapy water, acetone and blow dried with nitrogen. Plain Pedot:Pss spin coated on substrates at 1000rpm for 60sec and annealed in oven at 120°C for 15min. The substrates cooled down in air and then the P3HT:PCBM blend solution spin coated at 800rpm for 60 sec in atmospheric conditions. The samples dried for 1h in nitrogen filled glove-box and then annealed at different temperatures within oven for 10min. A shadow mask used to create Al patterns for back contacts. Each sample exposed to 1 sun at 1.5AM.G and IV curves acquired.





Samples S2 and S4 where post annealed at 70°C for 5min in addition to pre annealing. These preliminary recoded efficiencies were very low in the range of 0.02 to 0.05%. These low efficiencies are due to degradation of P3HT from atmospheric oxygen.





On the second batch of solar cells much higher efficiencies in the order of 10 where achieved. The measured efficiencies for the second batch where in the range of 0.7 to 0.85%. Further optimization of the process is undergoing and we are expecting to achieve better efficiencies.

7. Future collaboration with host institute

On the basis of the acquired result, further collaboration with the host institute will continue.

References

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