Conductivity enhancement of PEDOT:PSS thin film for ITO-free hybrid c-Si solar cell

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Abstract

The conductivity enhancement of poly(3,4-ethylenedioxythiophene): poly(styrenesulfonate) (PEDOT:PSS) thin film till 1044 S·cm^{-1} and its transparency in the visible spectrum more than 80 % are reported. The PEDOT:PSS thin film is promising material for fabrication of opto-electronic devices thanks to high mechanical flexibility, excellent thermal stability, low-cost potential and simple fabrication processing [1]. Particularly, it serves as hole extraction material of hybrid c-Si solar cell since it possesses high transparency, wide band gap, and relatively high work function, ϕ_m = 5.0 eV [2]. However, pristine PEDOT:PSS thin film suffers from a drawback of low conductivity of less than 1 S·cm^{-1}. The insulator PSS naturally acts as shell to surround the charging PEDOT, which forms an energy barrier for the charge transport across the PEDOT chains. One solution to increase its conductivity is to weaken the interaction between PEDOT and PSS by dropping the polar solvent as methanol under annealing temperature. The hydrophilic –OH groups of methanol dissolve and remove the insulator PSS from core-shell structure of PEDOT:PSS. The pristine PEDOT:PSS thin film was formed by spinning coating onto glass and then, annealing at 120 ^{o}C for 20 min. This film was treated by dropping with 100 µl methanol in interval of 5 min at 170 ^{o}C. Finally it was dried at the same temperature for 20 min. The conductivity is remarkably enhanced from 0.2 to 736 S·cm^{-1} after first drop of methanol [Fig. 1a]. It yields the conductivity of 1044 S·cm^{-1} after 4th drop of methanol. Furthermore, the transmittance of treated PEDOT:PSS is higher than pristine one since the thickness of PEDOT:PSS is reduced after treatment with methanol [Fig. 1b]. These results demonstrate that treated PEDOT:PSS is replaceable of ITO for fabrication of c-Si based solar cell.

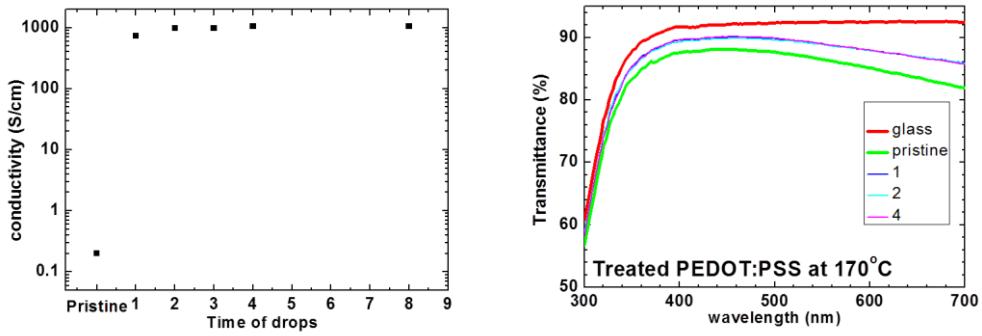

Figure 1: *a) The conductivity of PEDOT:PSS thin film after treating with several times of drop with methanol*; *b) The transmittance of PEDOT:PSS in visible range of spectrum.*

[1] *"Significant Conductivity Enhancement of Conductive Poly(3,4-ethylenedioxythiophene): Poly(styrenesulfonate) Films through a Treatment with Organic Carboxylic Acids and Inorganic Acids"*, Yijie Xia and Jianyong Ouyang, **ACS Appl. Mater. Interfaces**, 2, 474-483, 2010.

[2] "*The Origin of the High Conductivity of poly(3,4-ethylenedioxythiophene)−Poly(styrenesulfonate) (PEDOT−PSS) Plastic Electrodes"*, X. Crispin, F. L. E. Jakobsson, A. Crispin, P. C. M. Grim, P. Andersson, A. Volodin, C. van Haesendonck, M. Van der Auweraer, W. R. Salaneck, and M. Berggren, **Chem. Mater.**, 18, 18, 2006.