ITO-free Organic Solar Cells on Flexible Plastic Substrates

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Organic solar cells (OSCs) offer a promising alternative to inorganic solar cells due to its low cost, easy fabrication and compatibility with flexible substrate over large area. However, Indium Tin Oxide (ITO), the most popular material for transparent and conductive electrode widely used in most of the organic solar cell devices fabricated today, is not optimal for low cost and flexible application. It is known that ITO is getting more expensive because of limited supply of indium element, and its poor mechanical property and conductance on flexible substrate limit the device performance, and the durability in bent condition.[1,2] To get around these problems, we present organic solar cells made with nanopatterned metal-based transparent electrode on flexible substrate and evaluate its performance as compared with the devices made with conventional ITO electrode.

Transparent metal electrodes are fabricated by metal transfer printing using flexible PDMS stamps.[3] In this process, thin metal such as Au is transferred from PDMS onto polymer coated flexible substrate and used as etch mask during oxygen RIE etching of the exposed polymer layer. A lift-off process after additional metal deposition then completes the fabrication of transparent metal electrode. Alternatively, nano-patterned metal electrode can also be fabricated directly onto flexible substrate by transferring metal onto conductive PEDOT coated flexible substrate. Fig. 1 shows the fabricated metal electrodes in both cases. The optical transmittance in the visible band was measured and shown in Fig. 2, along with that of the conventional ITO electrode. Preliminary organic solar cells having the layered structure of transparent Ag electrode (or ITO) on glass, PEDOT:PSS, P3HT:PCBM (1:1), LiF, and Al from bottom to top were fabricated. As shown in Fig. 3, devices with Ag grating worked similarly to ITO devices with slightly lower photocurrent, which is mainly caused by the lower transmittance of the Ag wire arrays than that of the ITO electrode. The works on using different metals and periods of grating for higher transmittance and OSC efficiency are currently underway. Organic solar cells with optimized structure of metal electrode on flexible substrate will also be presented at the conference together with the assessment of electrical property under bent condition (e.g. the maximum radius of curvature of transparent metal electrode on flexible substrate).

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1 Z. Chen, B. Cotterell, W. Wang, E. Guenther, and S.-J. Chua, Thin Solid Films **394,** 201 (2001).

2 B. Maennig, J. Drechsel, D. Gebeyehu, P. Simon, F. Kozlowski, A. Werner, F. Li, S. Grundmann, S. Sonntag, M. Koch, K. Leo, M. Pfeiffer, H. Hoppe, D. Meissner, N. S. Sariciftci, I. Riedel, V. Dyakonov, and J. Parisi, Appl. Phys. A **79,** 1 (2004).

3 M.-G. Kang and L. J. Guo, J. Vac. Sci. Technol. B **26,** 2421 (2008).

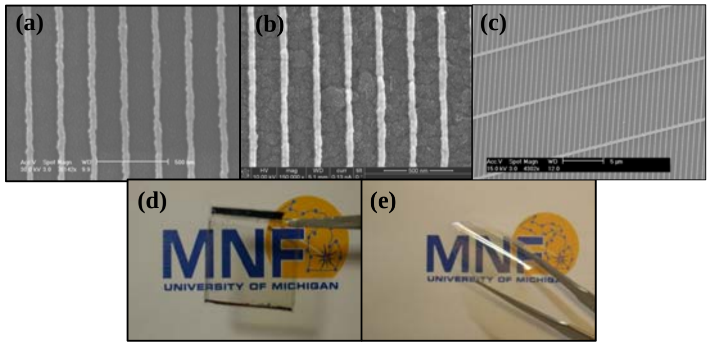

Figure 1. The SEM images of the Ag nanowires with a line width of 50 nm and a period of 220 nm fabricated by metal transfer assisted nanolithography on (a) glass and (b) PET substrates, respectively. (c) A SEM image of 700 nm period Cu nanowire electrode on PEDOT coated PET. (d), (e) are the corresponding photographs of (a) and (b) structures.

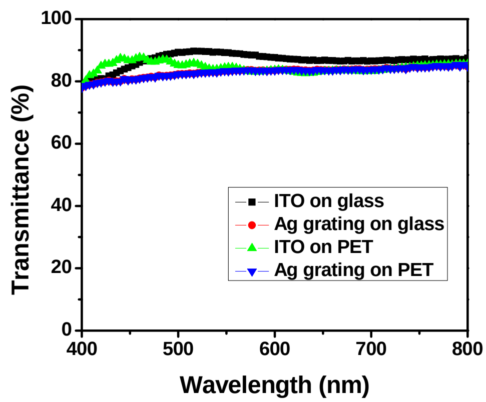

Figure 2. The optical transmittance spectra of Ag nanowire array and ITO electrode.

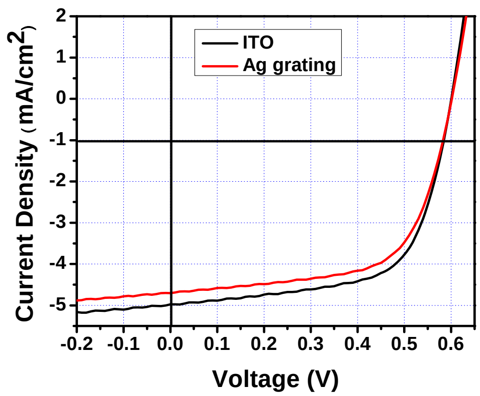

Figure 3. The current density vs. voltage characteristics of the organic solar cells with Ag wire array and ITO as cathodes fabricated on glass substrate.