Nanoimprinted Semi-Transparent Metal Electrode and its Application in Organic Solar Cells

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In organic photovoltaics (OPVs), indium tin oxide (ITO) is the predominant choice as a transparent electrode because it offers good transmittance as well as low electrical resistivity. However, it is still chemically problematic,[1] and getting more expensive because of indium element. Furthermore, the conductivity of the ITO is not sufficiently high, which limits the fill-factor of OPVs. Therefore, it is questionable whether ITO is the optimum choice as transparent electrode of OPVs. In this work, we present a scheme to fabricate semi-transparent metal electrode in the form of periodically perforated metal films in the nanoscale by nanoimprint lithography (NIL) and evaluate its potential as a transparent electrode for OPVs.

A grating mold with a narrow line-width was first fabricated using the grating mold with 50% duty cycle by a simple technique based on NIL and shadow evaporation. The rectangular shape pattern for NIL was then created by sequential NIL using two grating molds with different periodicity. The perforated metal electrodes on glass were subsequently fabricated by NIL using such molds, metal deposition, followed by a lift-off process. Figure 1 shows the SEM images of the fabricated mold and the metal electrode on glass. Average transmittance of 74% and sheet resistance of 4.79Ω/□ for 40nm thick Au electrode have been achieved by changing the metal line-width and thickness, respectively. Figure 2 shows the measured transmission spectra of a 40nm thick semi-transparent Au electrode. We demonstrate that the transmittance and the sheet resistance can be tuned separately by changing the aperture ratio and the metal thickness

OPVs having the layered structure of semi-transparent metal electrode on glass, PEDOT:PSS, P3HT:PCBM 1:1, and Al from bottom to top were then fabricated. Electrical characterization of the OPVs constituted of nanostructured Au film as transparent electrode has shown improved performance in terms of short circuit current and power conversion efficiency as compared with those having conventional ITO electrodes. Optimization of the ratio and the thickness of the conjugated polymer layer and the sheet resistance and the transmittance of the semi-transparent metal electrode for higher performance is currently underway.

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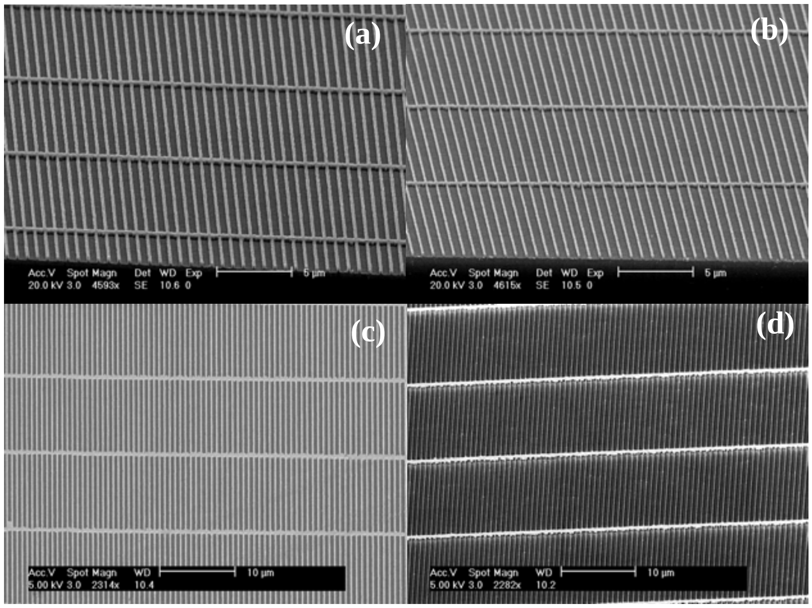

Figure 1. SEM images of the rectangular shape mold with line-width of (a) 200nm and (b) 120nm and semi-transparent metal electrode on glass with line-width of (c) 200nm and (d) 120nm.

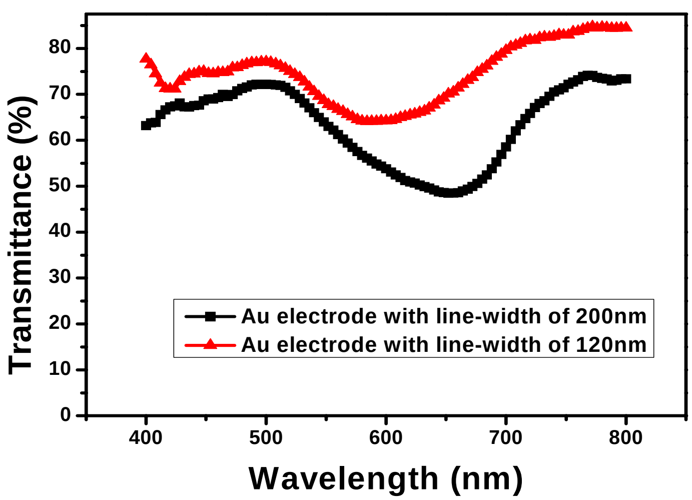

Figure 2. Transmittance of metal (Au) electrode with line-width of 200nm and 120nm.