Comparison of Fast Roll-to-Roll Flexographic, Inkjet, Flatbed, and Rotary Screen Printing of Metal Back Electrodes for Polymer Solar Cells

The majority of polymer solar cells reported today employs processing under high vacuum for one or more of the layers in the solar cell stack. Most notably the highly conducting metal back electrode is almost exclusively applied by evaporation of the pure metal. While it is not impossible to envisage mass production of polymer solar cells using vacuum processing it does present some drawbacks in terms of both processing speed, capital investment in processing equipment technical yield and direct process energy. From this point of view it is clear that vacuum processed electrodes should be avoided and electrodes should be printable using methods that provide a high degree of accuracy and high technical yield. When considering large area polymer solar cells (i.e., not laboratory devices) a few reports have employed printable back electrodes mostly by use of silver formulations[1–4] but also carbon[5] and copper has been discussed whereas copper is unlikely to yield the necessary cost reduction and resistance to oxidation. Most reports have employed flatbed or rotary screen printing whereas other methods are available and described later on. The important question to answer is which technique is most suited for manufacture of polymer solar cell modules in terms of technical yield, materials use and processing speed? Evidently the back electrode has to be of high conductivity, which implies the use of a thick electrode. Therefore thick film printing techniques such as the screen printing techniques have proven excellent while they do present disadvantages in speed due to significant drying requirements but also they do require significant amounts of material.[2,6]

In this paper we employ four different roll-to-roll (R2R) printing methods for printing silver back electrodes for polymer solar cell modules based on the iOne process which is a fully printable, indium-tin-oxide (ITO), and vacuum free technology that provide similar performance to ITO-based polymer solar cell modules when using poly(3-hexylthiophene) (P3HT) and [6,6]-phenyl-C61-butyric acid methyl ester ([60]PCBM) as the active layer. We analyze advantages and disadvantages for each method and also outline boundaries of their use and highlight a few areas where development could lead to disruptive progress for the polymer solar cell as a technology.

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