PUSH-COATING: EXTREMELY LOW-COST AND ECO-FRIENDLY PROCESS FOR POLYMER SOLAR CELL FABRICATION

Shusei Inaba, Varun Vohra

University of Electro-Communications, Japan

Polymer solar cells (PSCs) are often presented as a low-cost alternative to state-of-the-art photovoltaic technologies. In fact, thin active layers are usually deposited by solution process from chlorinated solvents using spin-coating. However, spin-coating not only generates a large amount of material waste but also the process itself does not allow for easy recycling of chlorinated solvents. These solvents are harmful for both the environment and human health and consequently, developing an active layer deposition process that considerably reduces wastes while giving the possibility for solvent recycling is of major importance in the field of PSCs and more generally, for solution processed organic electronics.

Push-coating is a simple process in which a poly(dimethylsiloxane) (PDMS) stamp is deposited on top of an extremely small amount of active material solution (~5µl).[1] The solvent then diffuses from the solution into the PDMS film to generate homogeneous active layers with controllable thicknesses. We developed this deposition process and verified whether it could be applied to PSC fabrication with device performances similar to spin-coated ones (Figure 1a).[2] Compared to spin-coating, formation of PSC active layers using push-coating results in reducing the amounts of used active materials and chlorinated solvents by factors of 50 and 20, respectively. Push-coating generates no active material waste and, as the chlorinated solvents are temporarily trapped within PDMS, they can easily be recovered and recycled. Solvent retention inside PDMS also allows for easy removal of the stamp without damaging the active layer surface. Furthermore, as push-coating is a relatively slow drying process compared to other conventional deposition techniques, it generates higher degrees of crystallinity in the polymer thin films, which can be beneficial for PSCs as higher charge mobilities can be expected.

Figure 1: (a) schematic comparison between the push-coating and spin-coating process along with (b) J-V curves of PSCs prepared using the two methods.

For instance, as-prepared push-coated films (50°C for 5 min applied during the process) of the state-of-the-art donor:acceptor materials for PSC (P3HT:PCBM) exhibit higher degrees of crystallinity than spin-coated films which are post-annealed at 140°C for 10 min. Using push-coated active layers, we were able to fabricate devices with similar or slightly higher performances compared to spin-coated ones without any post-deposition annealing (Figure 1b). The spin-coated and push-coated devices prepared using dichlorobenzene have power conversion efficiencies of 3.30 and 3.34 %, respectively.

Furthermore, the process is virtually applicable to any chlorinated solvent polymer solution and consequently, is not limited to PSC fabrication. Our study also emphasizes the PDMS reusability and scaling-up factors of push-coating which clearly indicates that this process is roll-to-roll compatible. While most research on PSC focuses on improving the device performances, we demonstrate that the development of new eco-friendly processes which considerably reduce the use of chlorinated solvents is compatible with maintaining device performances.