Saving the planet with flexible electronics

June 27 2017

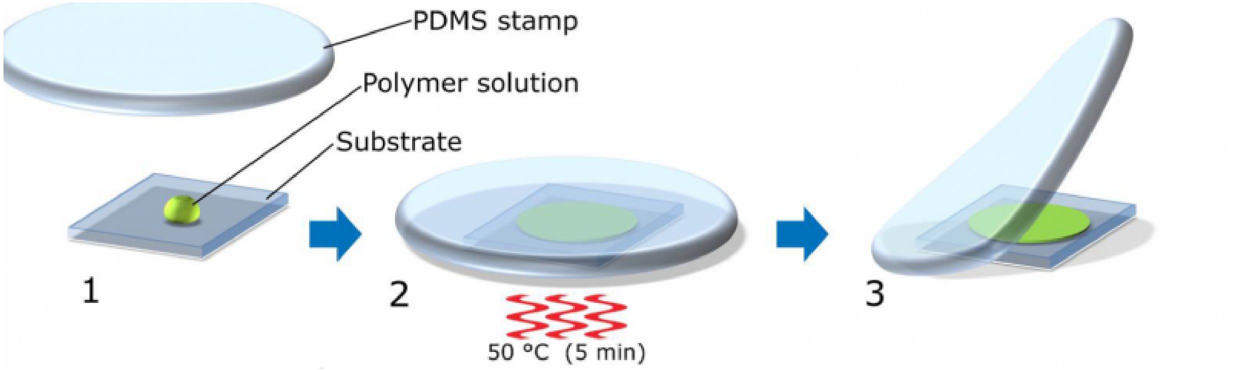

Fig. 1 Push coating devices onto substrates with polydimethylsiloxane (PDMS) films. 1. Deposit approximately 5 microliters of solution on a substrate; 2. Press the PDMS stamp against it. 3. Wait for the solvent to diffuse inside PDMS and remove PDMS. Credit: University of Electro Communications

"My research on organic photovoltaic (OPVs) devices reflects my fascination with electronic gadgets and concerns about the environment," says Varun Vohra, tenure-track assistant professor at the Department of Engineering Science, UEC, Tokyo. "So I want to save the planet with flexible electronics."

In a nutshell, Vohra and his group aim to produce low cost, eco-friendly, and highly efficient solar cells using organic materials.

"Eco-friendly organic photovoltaics necessities reducing the quantity of chlorinated solvents used in their fabrication process," says Vohra. "This is slightly counterintuitive to the perception held by non-scientists, where 'organic' is often envisaged as being good for nature."

So how do you reduce chlorinated solvents during the manufacture of OPVs? Vohra and his colleagues are working on two promising approaches. The first is so-called 'push-coating' where polydimethylsiloxane (PDMS) films are used to capture the solvent from a small amount of polymer solution to fabricate homogeneous thin active layer for polymer devices formed on a transparent electrode substrate without generating any active material waste (Fig.1). This process necessitates robust 2 to 4 mm thick PDMS films that are easy to handle and have favorable solvent retention properties. The UEC group has fabricated organic photovoltaic and light emitting diodes using PDMS where the device layer thicknesses were optimized by varying the solution concentration and thickness of PDMS. Importantly, the push-coating process requires only 5 microliters of polymer solution compared with 100 microliters for spin coating methods. However, the UEC researchers emphasize that the push-coating approach is limited to solvents that diffuse inside PDMS layers.

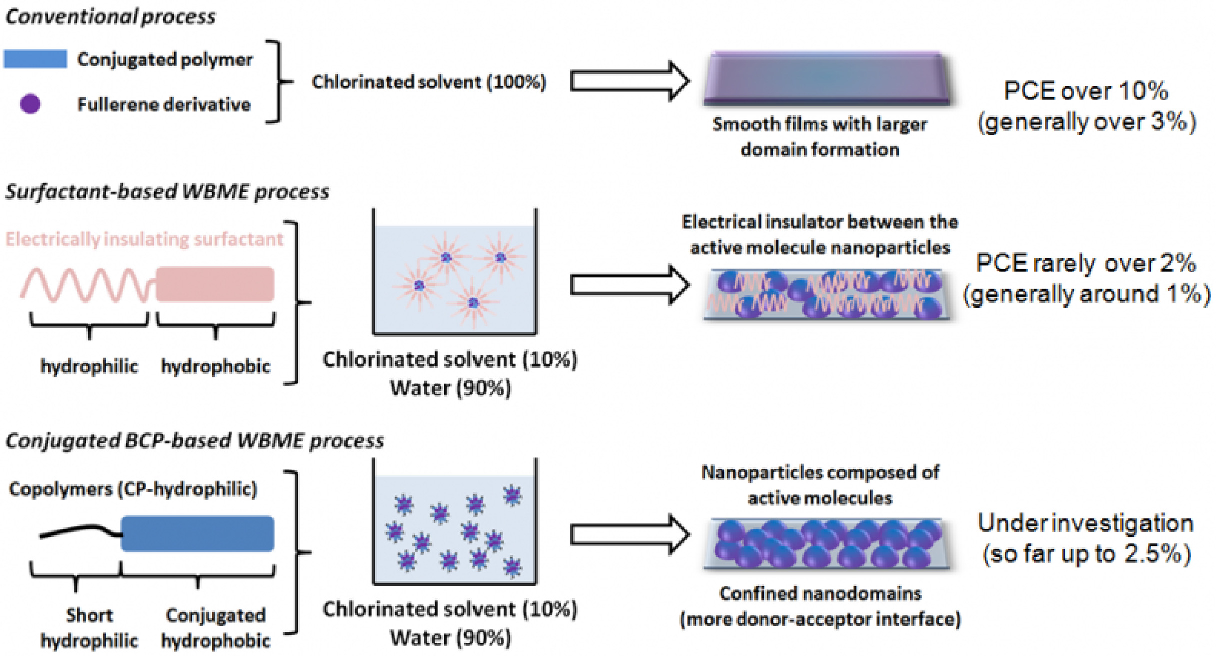

Fig. 2: Schematic comparison of thin film morphology and device performances of active layers prepared using conventional spin-coating from chlorinated solvents, recently introduced water-based micro-emulsion processes and water-based micro-emulsion process developed at UEC. Credit: University of Electro Communications

"We have fabricated densely packed crystallites at low temperature by push-coating," says Vohra. "The typical power conversion efficiency (PCE) of devices was around 3.1% with a fill factor of 64%. These results are promising for low cost, high volume manufacture of devices by roll-to-roll production."

The other approach being pursued is the synthesis of 'donor-acceptor' nanoparticles from water based micro emulsions in which the active material (donor) also acts as the emulsifying agent (Fig.2). "To-date the main problem with similar procedures has been that the surfactant (insulator) is not entirely removed after the synthesis and finds its way into the active layers," explains Vohra. "However, the block-copolymer we have designed is an electrically active surfactant and we have obtained PCEs of 2.5% with this method. So it has real potential."

Plans for research on water based emulsions include the fabrication of inverted architecture OPV devices and other devices including organic LEDs and field-effect transistors.

Other projects at the Vohra lab include self-assembled nanoporous films for PDMS-based hybrid nanostructured electrodes for light-emitting pressure sensor fabrication; biomimetic ordered polymer assemblies for PDMS based deformation and solvent vapor sensors, where the color of the films changes when it is deformed or senses solvents.

More information: Varun Vohra et al. Efficient inverted polymer solar cells employing favourable molecular orientation, *Nature Photonics* (2015). DOI: 10.1038/nphoton.2015.84

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Provided by University of Electro Communications

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