Construction and Evaluation of Organic Solar Cells Using a Spray-Coating Method

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1. Introduction
Organic solar cells using organic compounds have been investigated to reduce global warming and the depletion of fossil fuels. It is easier to fabricate organic solar cells than inorganic solar cells because a wetting method can be applied to organic solar cells. Moreover, organic compounds are low cost and flexible. However, organic solar cells have low conversion efficiency and short lifetime compared with inorganic solar cells. These problems must be solved in order to realize low cost, effective organic solar cells.

Poly(2,3-dihydrothieno-1,4-dioxin)poly(styrenesulfonate)[PEDOT/PSS] is the buffer layer of the hole carrier. First, the surfaces of thin films are observed by atomic force-microscopy (AFM) image of the thin films fabricated by spray coating, and spin-coating methods. The morphology of the thin films prepared by spin-coating and spray-coating methods was evaluated by X-ray diffraction (XRD).

2. Experimental details
The surface of the organic solar cell substrate includes indium thin oxide (ITO). With a buffer layer, Poly(3,4-ethylenedioxythiophene)/poly(styrene sulfonate)[PEDOT:PSS] was coated using the spin-coating method on ITO. Subsequently, the PEDOT:PSS thin film was dried and heated with an ambient temperature of 130 degrees centigrade. In the next step, 1wt%P3HT-0.8wt%PCBM was dissolved by chloroform fluid, whereupon the active layer of P3HT-PCBM was fabricated on the PEDOT-PSS by spin-coating. Figure 1 shows a cross-section of the organic solar cell structure. The V-J characteristic of the organic solar cell fabricated with the above-mentioned procedure was measured by an AM 1.5 solar simulator.

Figure 3 shows a schematic cross section of the spray method. In the latter, the buffer layer of the PEDOT-PSS was coated on a indium thin oxide (ITO) of the substrate. Subsequently, 1wt%P3HT was dissolved with chloroform, whereupon the P3HT layer was fabricated by the spin-coating method on PEDOT-PSS thin film. Figure 2 shows a schematic diagram of the spin-coating method. Afterwards, the fog fabricated by the 0.8wt%PCBM dissolved by chloroform was sprayed onto the P3HT-thin film. After drying, an aluminum electrode was evaporated using a vacuum evaporation method to the active layer.

3. Results and discussion
Figure 4 shows an AFM image of the surface of the active layer fabricated by the spin-coating method.

![Fig. 1 The cross-sectional structures of the organic thin film solar cell.](image)

![Fig. 2 Schematic diagram of the spin-coating method.](image)

![Fig. 3 Schematic cross section of the spray method](image)

Figure 5 shows an AFM image of the surface of the active layer fabricated by a spray method. Figures 4 and 5 show that the root mean square surface (RMS) roughness of the thin film fabricated by the spray method is smoother compared with that prepared by the spin-coating method.
This means that organic solar cells with active layers fabricated by the spray method are expected to have better performance compared with those with an active layer prepared by the spin-coating method.

Fig. 4 AFM image of the surface of the active layer fabricated by a spin-coating method (RMS roughness 1.11).

Fig. 5 AFM image of the surface of the active layer fabricated by a spray method (RMS roughness 0.288).

Fig. 6 shows the XRD profiles of the active layers fabricated by spray and spin-coating methods. The active layer fabricated by the spray method from Fig. 5 is understood to be high crystallinity, which also suggests that the organic solar cell fabricated by the active layer is high performance. Figure 7 shows the J-V characteristic of the organic solar cell fabricated by a spray method. Based on Fig. 7, the short circuit current (Isc) is 2.5 mA/cm², the open circuit voltage (Voc) 0.45 V, the fill factor (FF) is 0.28, and the power conversion factor (PCE) is 0.35%. The PCE is low compared with the reported value of about 6% in recent years, which means that the low performance of P3HT/PCBM-organic solar cells of the cross penetration type is subject to the damage inflicted by the organic solvent, which occurs when making the PCBM layer after the P3HT layer of the lower layer is formed by the spray method. Moreover, because the active layer was fabricated under atmosphere, there is the potential for oxidation degradation and no heat-treatment was performed at the present stage. These are closely related to the low performance of organic solar cells fabricated by the spray method. However, the spray-coating method is easy compared with the spin-coating method. Moreover, when the printing method technique is used, it is possible to make a large area organic solar cell.

4. Conclusion
The adopted solution method of this study indicates that organic thin-film solar cells can be easily fabricated with a large area. However, the power conversion efficiency of organic thin-film solar cells is low.