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In situ impedance spectroscopy study of Zn(OEP)/C_{60} heterojunction solar cells under photo-irradiation: carrier mobility and built-in potentials

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Abstract:

Organic photovoltaic (OPV) cells consisting of organic donor (D) and acceptor (A) materials have attracted much attention worldwide in the past decade, because they have many fascinating advantages such as low-cost fabrication, resource-free carbon materials, a lightweight, and flexibility, etc. However, the power conversion efficiency (η) of OPV cells has been still low at most 7% [1], though many attempts to improve it have been made so far [2]. To improve the η, it is important to understand what kinds of factors are related to the short-circuit current-density (J_{SC}) and open-circuit voltage (V_{OC}) of OPV cells for their practical use.

Impedance spectroscopy is a powerful tool to investigate a system including hetero-interfaces non-destructively and has been applied to several kinds of systems (solid state devices, corrosion of materials, and electrochemical power sources) [3]. In the present study, we applied it to measure *in situ* the physical properties of Zinc-octaethylporphyrin [Zn(OEP)]/C_{60} heterojuncton OPV cells (Fig. 1) under photo-irradiation and examined their built-in potentials (related to V_{OC}) and carrier mobility (related to J_{SC}). Here, Zn(OEP) and C_{60} were respectively used as a donor and an acceptor.

V_{OC} was found to exhibit a dependence on the wavelength of monochromic irradiation light. This can be explained in terms of both the sum of built-in potentials (ΣV_{bi}) and the fill factor (*FF*) that are related to the accumulation and mobility of photo-generated carriers near the D/A interfaces, respectively. It is interest to note that V_{OC} was in a good agreement with ΣV_{bi} [4]. This suggests that the charge redistribution of photo-generated carriers in the vicinity of the D/A interface plays a dominant role of determining V_{OC}.

In addition, we succeeded in estimating the mobility of both electrons in the C_{60} film and holes in the Zn(OEP) film for the OPV cells under photo-irradiation [5]. Details of these findings will be presented in our talk.

Fig. 1. Schematic representation of Zn(OEP)/C_{60} heterojunction solar cells.

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