Interface Engineering of Inverted Organic Solar Cells using V-Shaped Polyaromatic Amphiphile as Fullerene-catching Surface Modifier

The Univ. of Tokyo[1], Uni. of Banja Luka[2], Tokyo Inst. of Tech.[3] °Il Jeon[1], Sasa Zeljkovic[2], Kei Kondo[3], Michito Yoshizawa[3], Munetaka Akita[3], Yutaka Matsuo[1]

E-mail: il.jeon@chem.s.u-tokyo.ac.jp

Extensive efforts have been put into developing OSCs for their low-cost, light-weight, and potential flexibility. Effort to avoid the low-work-function metals have created inverted architecture of the device where oxide ETL such as ZnO have been used on ITO electrode to invert the polarity of the bulk heterojunction devices. Among different types of ZnO, sol-gel-prepared colloidal nanoparticles, discovered by A. Heegar and his colleagues, have most widely been used. However, the major challenges in using the ZnO nanoparticle films are the inevitable near-surface defects, and poor spatial distribution of the nanoparticles over a large area. These are originated from oxygen vacancies (V(O)s) and zinc interstitials (Zn(i)) which change the degree of doping and in turn result in a change of the Fermi level position. Furthermore these affect carrier density, chemical potential and the chemistry with the adjacent organic layers. Hence, to realize highly efficient inverted OSCs, it is imperative that we develop low-defect and uniform ZnO films, because a significant hurdle is the extraction of charge carriers at the contact.

Here we present the anthracene-based amphiphile as a surface modifier that has positively charged trimethylammonium group (-$N^{+}(CH_3)_3$) on one end and two bent polyaromatic groups on the other end. When they overcoated ZnO, the charged ends reacted with the defect sites to alleviate the poor contact between ZnO and the active layer interface as proven by recovery of V_{OC} loss. As organic compounds, they possessed HOMO and LUMO levels that corresponded to ETL; When they were deposited on ITO, they offered ohmic contact for collection and allowed optimum photogenerated charge-carrier harvest replacing ZnO. One distinguishing quality these anthracene derivatives possessed was that they had polyaromatic surfaces of the V-shaped amphiphiles which could effectively catch fullerenes through multiple aromatic-aromatic interactions. This induced a thin PCBM layer as a barrier for hole carrier injection as substantiated by elevations of J_{SC} and FF.

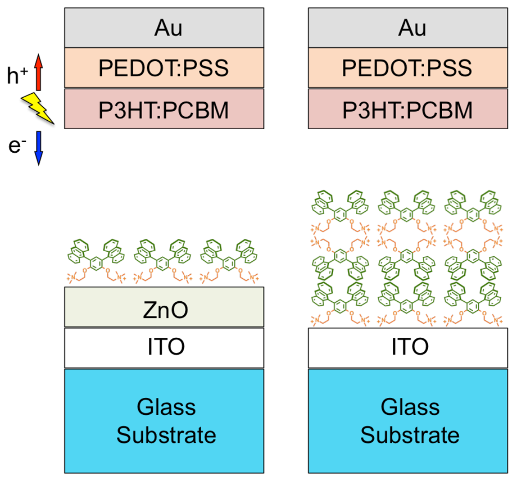

Figure 1. Illustrations of Anthracene treatments in inverted solar cells.