Highlights

Activity E - Advanced materials and techniques for organic electronics, biomedical and sensing applications - 2021

Space-charge accumulation and band bending at conductive P3HT/PDIF-CN_2 interfaces investigated by Scanning-Kelvin Probe Microcopy

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The possibility to achieve localized regions with enhanced charge density is a powerful strategy to strongly improve the performances of a large number of organic electronic devices such as light emitting diodes, photodetectors and field-effect transistors. Because of the complex structures of many organic compounds and the diversity of electronic interactions ruled by specific morphological features, however, the interfacial energy landscape of any combination of materials needs to be carefully investigated. In this work, the surface potential landscape of poly(3-hexylthiophene) (P3HT)/PDIF-CN_2 donor/acceptor organic heterointerfaces was analyzed. The electrical characterization, relying on the field-effect transistor configuration, outlined that the presence of a PDIF-CN_2 overlayer induces a semiconductor-to-conductor transition in spin-coated P3HT polymer films (Fig.1a). The mutual doping effect was investigated by Scanning Kelvin Probe Force Microscopy (SKPFM) as a function of the PDIF-CN_2 coverage and nominal thickness (Fig.1b,c), with the results clearly pointing at the occurrence of charge transfer phenomena between the two materials. The related band bending (Fig.1d) at the interface leads to the formation of a hole rich area within the P3HT layer and an electron rich area within the PDIF-CN_2 layer. The related thickness and charge density have been estimated as 15 nm and E~10^{18} cm^{-3}, respectively. Significantly, by tuning the PDIF-CN_2 overlayer coverage, the P3HT work function can be tuned within 1 eV, opening an interesting perspective for the achievement of organic optoelectronic devices with improved functionalities.

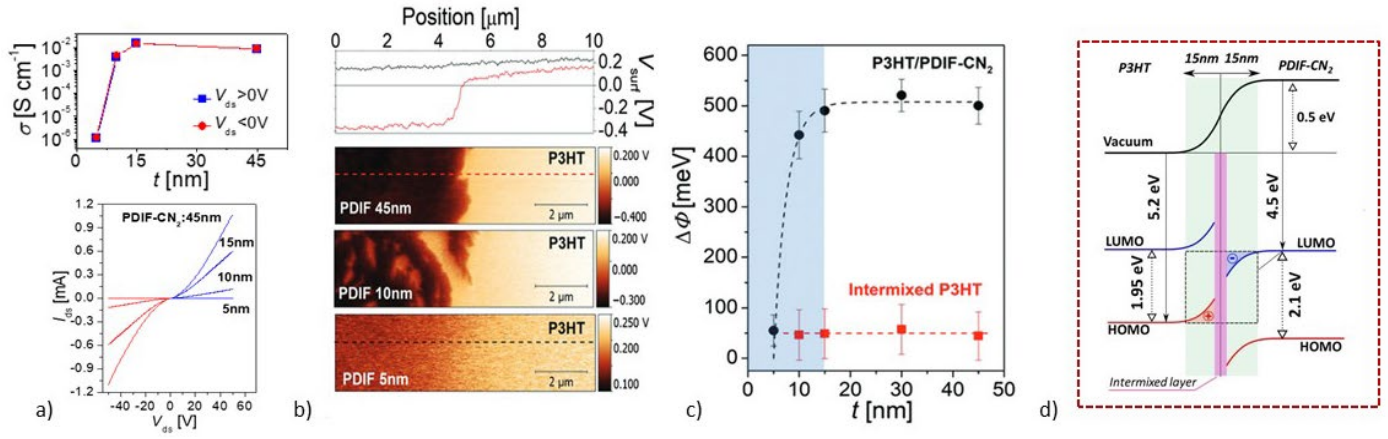

Fig.1: (a) Output (IV) curves measured in vacuum (at V_{GS}=0V) for the P3HT/PDIF-CN_2 heterostructures as a function of the PDIF-CN_2 overlayer thickness (t). The upper panel reports the corresponding estimated conductivity values. (b) Surface potential maps acquired in the boundary region between P3HT and shadow-masked PDIF-CN_2 for t = 5, 10 and 45 nm. The upper panel shows the corresponding surface potential profile for t = 5 nm and 45 nm (black and red lines, respectively) (c) Summary of the work function differences of panel (b) expressed as function of t. (d) Band diagram of the P3HT/PDIF-CN_2 heterointerface highlighting the band bending phenomenon along the organic boundary.