Highlights

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

Balanced ambipolar charge transport in phenacene/perylene heterojunction-based organic field-effect transistors

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Electronic devices relying on the combination of different conjugated organic materials are considerably appealing for their potential use in many applications such as photovoltaics, light emission and digital/analog circuitry. In this study, the electrical response of field-effect transistors achieved through the evaporation of picene and PDIF-CN_2 molecules, two well-known organic semiconductors with remarkable charge transport properties, was investigated (Fig.1). With the main goal to get a balanced ambipolar response, various device configurations bearing double layer, triple-layer, and co-deposited active channels were analyzed. The most suitable choices for the layer deposition processes, the related characteristic parameters, and the electrode position were identified to this purpose. In this way, ambipolar organic field-effect transistors exhibiting balanced mobility values exceeding 0.1 $cm^2\ V^{-1}\ s^{-1}$ for both electrons and holes were obtained (Fig.2). These experimental results highlight also how the combination between picene and PDIF-CN_2 layers allows tuning the threshold voltages of the p-type response. Scanning Kelvin probe microscopy (SKPM) images acquired on picene/PDIF-CN_2 heterojunctions suggest the presence of an interface dipole between the two organic layers. This feature is related to the partial accumulation of space charge at the interface being enhanced when the electrons are depleted in the underlayer.

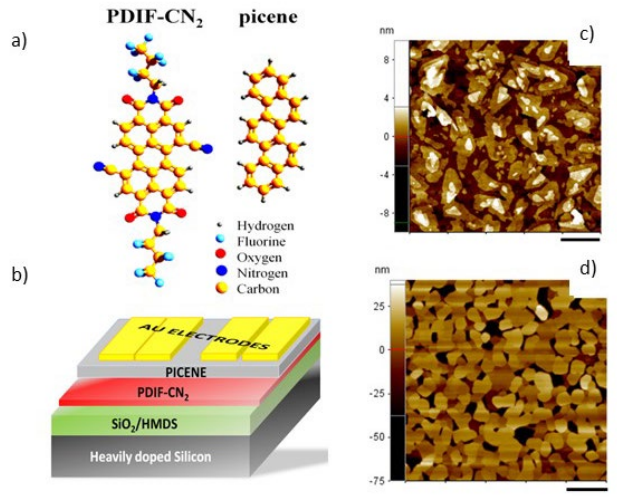

Fig.1:(a) PDIF-CN_2 and picene molecular structures. (b) The bottom-gate top-contact device configuration mainly analyzed in this work. 5x5 μm^2 AFM images of (c) a 30 nm thick PDIF-CN_2 single layer and (d) of a PDIF-CN_2(15 nm)/picene (60 nm) bilayer. The black sign is a reference of 1 μm.

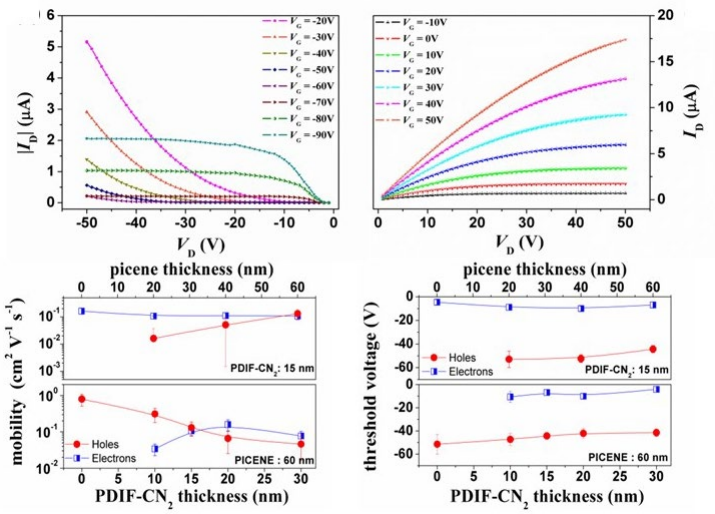

Fig.2: (top) A typical ambipolar response of a PDIF-CN_2/picene bilayer field-effect transistor. (bottom) Hole and electron (right) mobility and (left) threshold voltages values achieved with PDIF-CN_2/picene bilayer devices as a function of the thickness of the two organic layers.