Highlights

RESEARCH AREA 2 - Functional and Complex Materials for Innovative Electronics and Sensing - 2024

Interfacial charge doping effect in C8-DNTT/PDIF-CN_2 heterojunction field-effect transistors

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In the last 15 years, DNTT-based compounds have emerged as a new generation of hole-transporting (p-type) organic semiconductors with superior charge transport properties. Still today, indeed, this class of derivatives is under intense scrutiny for the achievement of high-performance organic field-effect transistors to be applied in the development of advanced electronic circuits and sensors. In this work, we analyzed the growth of evaporated C8-DNTT films on HMDS-treated SiO_2 surfaces, highlighting the dependence of the related morphological and electrical properties on the substrate temperature (T_{sub}) held during the film condensation. In this way, we identified a T_{sub} range able to guarantee high mobility values (larger than 2.5 $cm^2/V{\cdot}s$) and morphological features being more compatible for the growth of additional layers on their top surfaces. This finding was the basic point to investigate the deposition of n-type PDIF-CN_2 films on bottom C8-DNTT layers for the fabrication of heterojunction field-effect transistors. The electrical characterization of the related devices demonstrates a weak ambipolar behavior of the C8-DNTT/PDIF-CN_2 system but, at the same time, outlines the achievement of a shift of the threshold voltages and a minor sensitivity to the Bias Stress effect in comparison with the single-layer C8-DNTT counterparts, as a result of the formation of a charge accumulation region at the organic/organic interface. As more general conclusion, we infer that, for molecular systems showing a strong mutual dependence of the corresponding growth modes, as found here for C8-DNTT and PDIF-CN_2, the occurrence of interfacial electronic interactions is favored and this enhances the possibility to observe charge accumulation effects increasing the overall carrier density of the organic system.

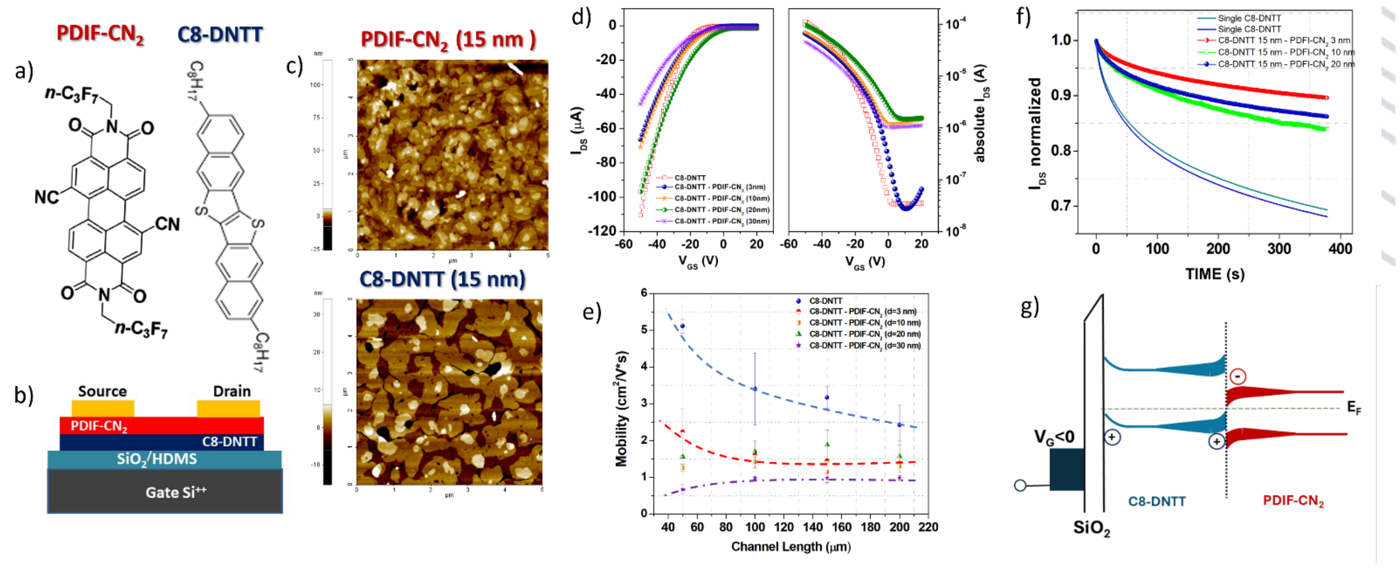

Fig. 1 **a)** Molecular structures of PDIF-CN_2 and C8-DNTT; **b)** Layout of the investigated C8-DNTT/PDIF-CN_2 heterojunction transistors; **c)** AFM images (5 x 5 μm^2) of 15 nm thick PDIF-CN_2 and C8-DNTT films grown on HMDS-SiO_2 substrates; **d)** Transfer-curves measured in the saturation region (V_{DS} =-50 V) for C8-DNTT/PDIF-CN_2 heterojunction transistors (channel length = 200 μm) with different thicknesses of the PDIF-CN_2 top layer; **e)** Hole mobility values estimated for C8-DNTT/PDIF-CN_2 heterojunction transistors with different thicknesses of the PDIF-CN_2 top layer as a function of the channel length; **f)** Normalized I_{DS} current curves acquired during Bias stress experiments performed on C8-DNTT and C8-DNTT/PDIF-CN_2 transistors in the hole accumulation region (V_{DS} =-10 V, V_{GS} = -40 V); **g)** A sketch of the energy level landscape in the investigated C8-DNTT/PDIF-CN_2 heterojunction transistors.

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