Strategies to Control Crystal Growth for Application in Highly Ordered Rubrene:C60 Heterojunctions for Organic Photodetectors

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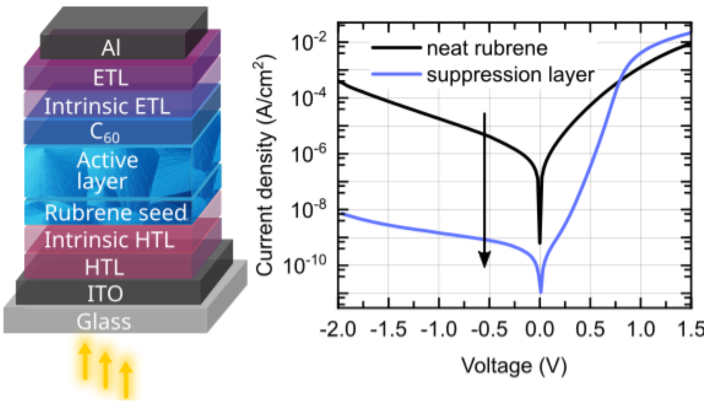

Organic semiconductors have raised much attention due to their many attractive properties, like low-cost, light weight, mechanical flexibility, and abundant availability. Despite that, they still lack high mobility compared to their inorganic counterparts as a consequence of their often amorphous nature.
An exception to this is rubrene, which can form highly ordered phases, demonstrating an extraordinarily high charge carrier mobility for holes (>10 $cm^2/(Vs)^{-1}$) even in thin films. Depending on the post-treatment of our vacuum-deposited films, we can control different crystalline phases, like the orthorhombic and triclinic ones.
For fast-response OPDs, the triclinic phase is a promising candidate since it exhibits high hole mobility in the vertical direction. However, the high surface roughness is a crucial reason why these devices fall short in specific detectivity up to now. In this work, we employ different strategies to reduce the impact of Ohmic shunts within the device to minimize the noise current of our devices. Optimizing the concentration of rubrene and C_{60} in the active layer and adjusting the electron transport material and its thickness are essential building blocks for achieving low noise currents. However, the most promising approach has been to establish a suppressing layer for the post-treatment of the film. This suppressing layer allows to reduce the dark current by four orders of magnitude. We characterize the morphology of our films with atomic force microscopy and grazing-incidence wide-angle X-ray scattering and investigate the performance parameters of fully working devices. In addition to a low noise current, a high external quantum efficiency is crucial for achieving high specific detectivity values. We can accomplish a competitive specific detectivity of 10^{13} with the employed strategies based on thermal noise domination at 0 V. Speed, noise, and linear dynamic range are investigated to complement the study.

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