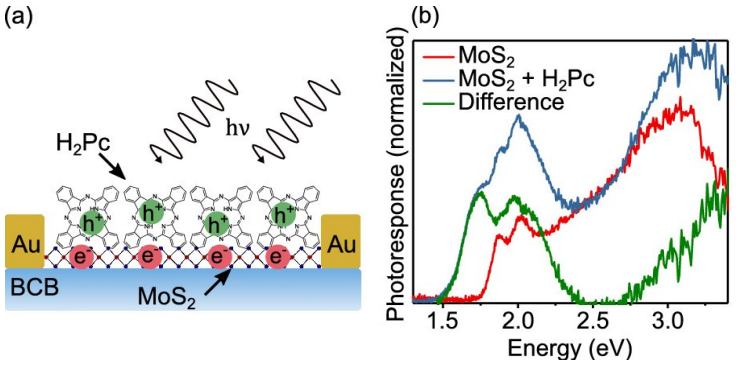
Excited-state charge transfer enabling MoS2/Phthalocyanine photodetectors with extended spectral sensitivity

The combination of inorganic monolayer (ML) transition-metal dichalcogenides (TMDCs) with organic semiconductors holds the promise to further improve opto-electronic device properties with added functionality. The authors of this research highlight investigate a hybrid inorganic/organic system (HIOS) consisting of metal-free phthalocyanine (H2Pc) as thin organic absorber layer and ML MoS2 as TMDC. Via a combination of photoemission (PES), photoluminescence (PL), and photocurrent action spectroscopy they demonstrate, that excited-state charge transfer from the H2Pc layer enhances the photo response of ML MoS2 without loss in sensitivity extended to spectral regions where the TMDC is transparent. This observation is explained by the staggered type II energy-level alignment at the hybrid interface facilitating efficient exciton dissociation and excited-state charge transfer with the holes residing in the H2Pc HOMO and the electrons in the MoS2 conduction band. In hybrid photodetectors, these transferred charges increase the concentration of carriers in MoS2 and with that its photoconductivity. The present demonstration of a highly efficient carrier generation in TMDC/organic hybrid structures paves the way for future nanoscale photodetectors with very wide spectral sensitivity.



(a) Schematic design of the hybrid H2Pc/ MoS2 photodetecting device. The H2Pc layer thickness is dH2Pc = 3.0 nm b Photoresponse of the hybrid (blue) and the reference MoS2-only (red) device. The spectra were normalized at the spectral position where H2Pc does not absorb, i.e., between 2.5 and 2.55 eV. The difference between the spectra of the hybrid (Rhyb) and reference (Rref) devices ΔR = Rhyb – Rref (green).

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