Crossover between Energy and Charge-transfer in 2D PTCDA/WS_2 Heterocrystals

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Abstract

Two-dimensional (2D) semiconductors are known as suitable testbeds for studying properties such as surface reactions, charge transfer, and material transport between the external environment and interfaces. Heterocrystal comprising highly crystalline 2D organic PTCDA (Perylene-3,4,9,10-tetracarboxylic dianhydride) molecular crystals [1] offer a broader range of possibilities compared to inorganic crystals, which have low absorbance and low tunability. In this work, we report on interlayer excitonic behavior in heterocrystals using a transient absorption and steady-state/time-resolved PL and reflectance spectroscopies. Additionally, we validated the TA signal of monolayer WS_2 as a reference. [2] Based on steady-state reflectance and photoluminescence of 1 to 5L PTCDA on 1L WS_2 samples, we identified the occurrence of inverted photoluminescence intensity trend above 4L PTCDA. This phenomenon could be emerged from the competition between distance-dependent charge and energy transfer processes. Time-resolved experiments and rate equation-based results will be discussed in poster session.

References

[1] D. Kim et al., Nat. Commun., 14 (2023) 2736
[2] Y. Li et al., Appl. Phys. Lett., 119 (2021) 051106

Figures

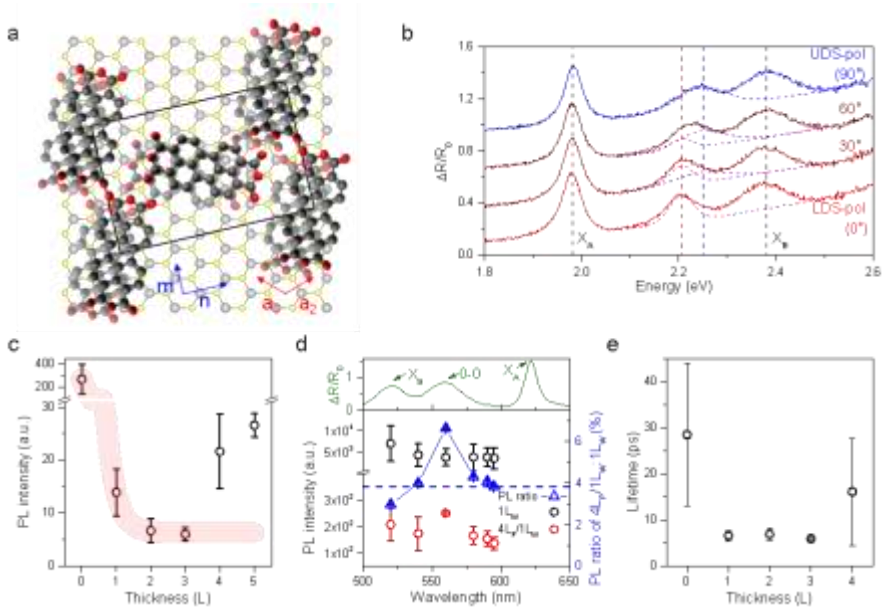

Figure 1: (a) Schematic structures of the 2L PTCDA on 1L WS_2 heterocrystals. (b) Polarization-dependent reflectance spectra of 1L PTCDA on 1L WS_2 show changes in the 0-0 peak (2.1~2.3 eV) of PTCDA along white-light polarization. (c) The intensity areas of the A exciton peak for nL PTCDA on 1L WS_2. (d) Excitation wavelength-dependent PL ratio of 4L PTCDA on 1L WS_2 over 1L WS_2 (blue triangle). (e) TRPL data of t1 in nLP/1LW/quartz under 520 nm excitation wavelength with 0.2 μW power.