Electronic Supplementary Information for

In-situ Investigation of Energy Transfer in Hybrid Organic/Colloidal Quantum Dot Light-Emitting Diodes by Magneto-Electroluminescence

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Experimental Section

A. Materials.

The CdSe-ZnS Core-Shell QDs with a thick ZnS shell in toluene (10 mg mL^{-1}) were provided by Najing Tech Inc. The HTL of poly (N,N'-bis(4-butylphenyl)-N,N'-bis(phenyl)benzidine) (poly-TPD) were obtained from Xi'an p-OLED Corp. The ETL of 1,3,5-tris(N-phenylbenzimiazole-2-yl) benzene (TPBi) and poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT: PSS) were purchased from Sigma Aldrich. All these materials were used as received. The ZnO nanoparticles were synthetized following the procedure reported in the literatures. [9,24]

B. QD-LEDs fabrication and characterization.

The QD-LEDs with active area of 2×2 mm^2 were fabricated based on the device structure of ITO/PEDOT: PSS/poly-TPD/CdSe-ZnS QDs/TPBi/LiF/Al as shown in Figure 1a. Before the device fabrication, patterned ITO substrates were ultrasonically cleaned in acetone, ethanol, and deionized water in succession, and dried in a hot oven. The PEDOT: PSS was deposited on ITO substrate by spin coating at 3000 rpm followed by thermal annealing at 120 ºC for 10 minutes. Then, the poly-TPD was spin-coated on the top of PEDOT: PSS from its chlorobenzene solution (8 mg mL^{-1}). The resulted poly-TPD films were annealed at 110 ºC for 20 minutes in a glovebox to remove the residual solvent. After the films cooling down to room temperature, CdSe-ZnS QDs were deposited on poly-TPD by spin coating at 2000 rpm and then annealed at 80 ºC for 30 minutes. Then, all the prepared samples were quickly transfered into the high vacuum chamber (~10^{-5} Pa) for deposition of ETL, LiF and Al cathode by thermal evaporation. The thickness of TPBi layer is varied from 0 to 80 nm for different devices. The deposition processes of LiF (1 nm) and Al (120 nm) were in accordance with the previsously reported procedure. [S1] The bilayer device based on QDs/TPBi and QDs/ZnO are fabricated following the same conditions except for the ZnO nanoparticle layer. The ZnO nanoparticle layer was spin-coated on QDs at 2000 rpm from its butanol solution (25 mg mL^{-1}). After the preparation of samples, the current-voltage-luminescence characteristics were measured by a Keithley 2400 SourceMeter and a silicon photodetector coupled with a Keithley 2000 apparatus. The EL and PL spectra measurement were carried out with a SpectraPro-2300i spectroscopy. A He-Gd gas laser (325 nm) as the excitation source for the PL measurements.

C. MFE measurements.

These MFE measurements were performed in a close-cycle cryostat (Janis CCS-350s) as described elsewhere. [S2] The magnetic field with a maximum strength of 500 mT was applied parallel to the device surface during MEL measurement. In order to exclude the influence of current changes cuased by the applied magnetic field (MC) on the EL intensity, the MEL values were calibrated by subtracting the corresponding MC values, which reflects the MFEs on the internal quantum efficiency. [S3]

Supported Figures

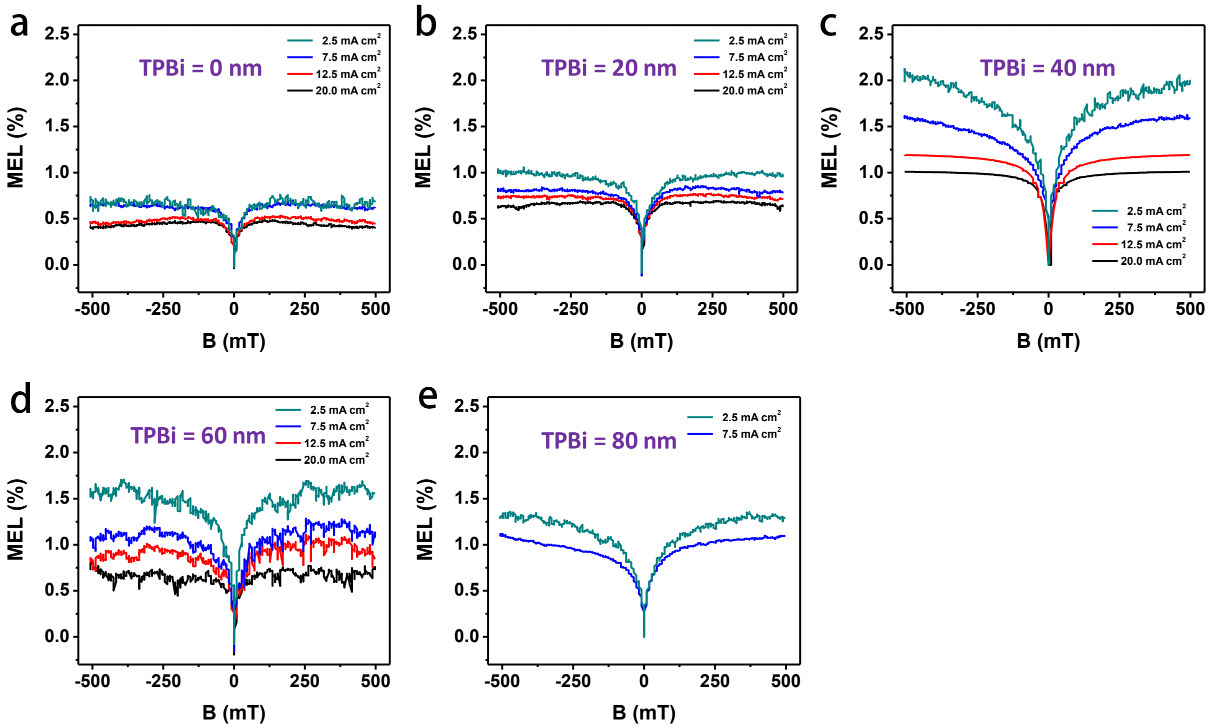

Figure S1. MEL(*B*) responses at different current density for all these devices with various TPBi thickness: (a) 0 nm; (b) 20 nm; (c) 40 nm; (d) 60 nm; and (e) 80 nm.

References:

S1. Y. Lei, Q. Zhang, L. Chen, Y. Ling, P. Chen, Q. Song, Z. Xiong, *Adv. Opt. Mater.* **2016**, 4, 694.

S2. Y. L. Lei, Y. Zhang, R. Liu, P. Chen, Q. L. Song, Z. H. Xiong, *Org. Electron.* **2009**, *10*, 889.

S3. Y. Zhang, R. Liu, Y. L. Lei, Z. H. Xiong, *App. Phys. Lett.* **2009**, *94*, 083307.