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Enhancement of Luminescence Intensity in TMPY/Perylene Co-Single Crystal

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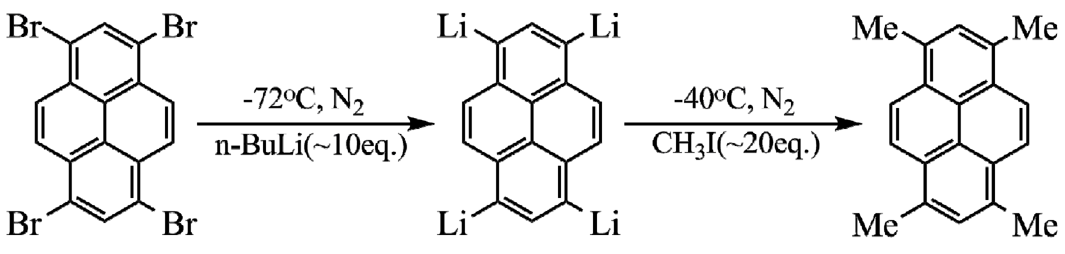
【Introduction】

Recently, organic light-emitting field-effect transistors (o-LEFETs) are of interest both for recombination physics which offers a promising route for understanding the current-driven organic lasers. To make high performance OLEFET, it is essential to coping with two factors: (1) Ambipolar property with high carrier mobility. (2) High luminescence quantum yield. However, it is quite difficult to combine the two factors because the high mobility often needs strong molecular packing, but strong packing structures lead to increasing non-radiative decay paths for excitons, which cause the devices exhibit low quantum yield. One promising way to overcome this contradiction is introducing the host-guest system which wide gaped host and narrow gaped guest play a role of carrier transport and luminescence center, respectively.

In this paper, a new molecule 1, 3, 6, 8-tetramethylpyrene (TMPy), which has the similar shape to the renowned luminescence material perylene, has been successfully synthesized. We use perylene as the narrower HOMO-LUMO gaped guest materials to dope into the wider gaped host TMPY single crystals. luminescence properties of doped single crystals with different percentages had been characterized. From the luminescence spectra, we can find the luminescence performance is significant enhanced, and amplified spontaneous emission(ASE) has been observed from the side edge of the doped crystal.

【Experiment】

Synthesis scheme of TMPY:



The mixed co-crystals were made by physical vapor transportation in sealed pyrex tube. We successfully get the crystal structure of pure TMPY and co-crystal (Perylene 12.8%).

For investigating the luminescence performance, we measure the absorption spectra and emission spectra of pure TMPY and co-single crystals with different percentage. The ASE experiments had been measured with 5% doped co-single crystal, which has the highest quantum yield. The FET performance of pure TMPY had also been checked.

【Results and Discussion】

Both TMPY and Co-single crystal have the typical herringbone structure, and the cell parameters are not dramatically changed between pure TMPY and co-crystal. Since TMPY has the similar shape as the perylene, this reduces the mismatch in the crystal lattice. The absorption spectra showed that the energy is mainly absorbed by TMPY molecules in co-crystal.

We measured the emission spectra of doped co-crystal with different perylene ratios. There is no emission from the TMPY molecules but only emission from the perylene molecules. This result convinces that there is an effective energy transfer from the TMPY to perylene. From the photoluminescence (PL) quantum yields of different ratios co-crystal, we can find the luminescence efficiency is significantly enhanced (~ 80 %) compared with pure TMPY (~ 5 %) as shown in Figure 1. By analyzing the full width at half maximum(FWHM) of pumped doped cystal, we find the amplified spontaneous emission has happened(Figure 2). To get the transport properties of TMPY, we fabricated the FET devises of the TMPY single crystal. During the operation, we only observed p-typed characteristics. The mobility is as good as 0.26 $cm^2 V^{-1} s^{-1}$.

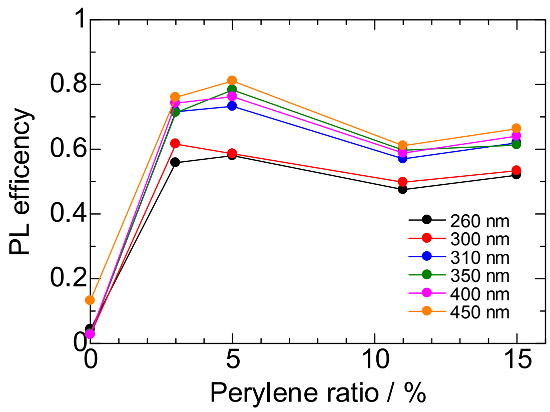


Figure 1 PL quantum efficiency of TMPY/perylene co-single crystals.

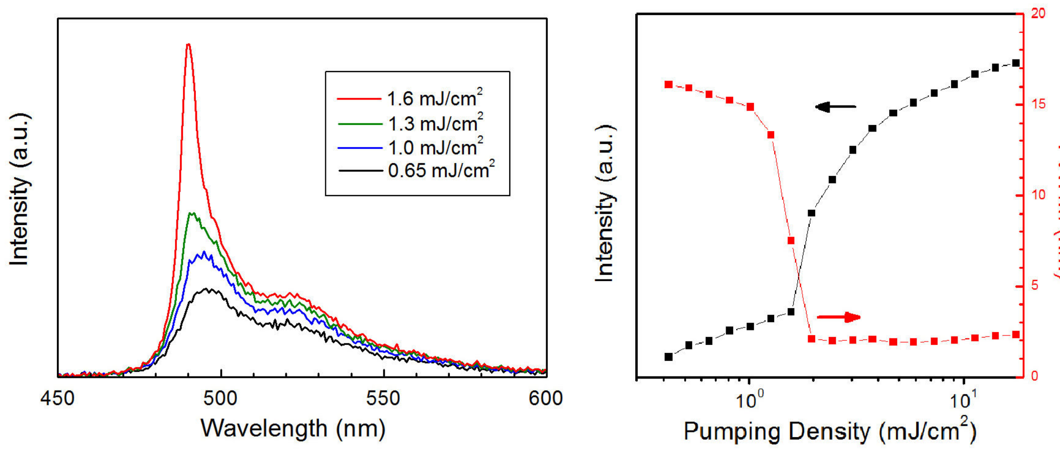


Figure 2 Laser-pumped emission spectra and ASE analysis of 5% doped co-single crystal.