Abstract for an Invited Paper
for the MAR09 Meeting of
The American Physical Society

Light Emitting Transistors of Organic Single Crystals

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Organic light emitting transistors (OLETs) are attracting considerable interest as a novel function of organic field effect transistors (OFETs). Besides a smallest integration of light source and current switching devices, OLETs offer a new opportunity in the fundamental research on organic light emitting devices. The OLET device structure allows us to use organic single crystals, in contrast to the organic light emitting diodes (OLEDs), the research of which have been conducted predominantly on polycrystalline or amorphous thin films. In the case of OFETs, use of single crystals have produced a significant amount of benefits in the studies of pursuit for the highest performance limit of FETs, intrinsic transport mechanism in organic semiconductors, and application of the single crystal transistors. The study on OLETs have been made predominantly on polycrystalline films or multicomponent heterojunctions, and single crystal study is still limited to tetracene [1] and rubrene [2], which are materials with relatively high mobility, but with low photoluminescence efficiency. In this paper, we report fabrication of single crystal OLETs of several kinds of highly luminescent molecules, emitting colorful light, ranging from blue to red. Our strategy is single crystallization of monomeric or oligomeric molecules, which are known to have a very high photoluminescence efficiency. Here we report the result on single crystal LETs of rubrene (red), 4,4'-bis(diphenylvinylenyl)-anthracene (green), 1,4-bis(5-phenylthiophene-2-yl)benzene (AC5) (green), and 1,3,6,8-tetraphenylpyrene (TPPy) (blue), all of which displayed ambipolar transport as well as peculiar movement of voltage controlled movement of recombination zone, not only from the surface of the crystal but also from the edges of the crystals, indicting light confinement inside the crystal. Realization of ambipolar OLET with variety of single crystals indicates that the fabrication method is quite versatile to various light emitting molecular solids, providing novel opportunities to get further insight on the intrinsic optoelectronic processes in organic semiconductors.

[1] T. Takahashi et al., Adv. Funct. Mater. 17, 1623 (2007).
[2] T. Takenobu et al., Phy. Rev. Lett. 100, 066601 (2008).