

Emission Characteristic of PtOEP Phosphor in Single- and Multi-layer Electroluminescence Devices

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Abstract

We report the electroluminescence properties of single- and multi-layer electroluminescence devices using PtOEP phosphor. Weak emission bands with peaks at 540 and 567 nm are observed in the former and latter devices, respectively, besides the well-known 648 nm PtOEP emission. The 540 nm emission increases in proportion to the third power of current density, while the 648 nm emission band increases linearly. Discussion is made on a reason for a much smaller luminance of PtOEP compared with Ir(ppy)₃ phosphor.

Considerable amounts of organic light-emitting small-molecules and polymers have been investigated.¹ There are two kinds of materials. One is fluorescent molecules with decay time of ns order, the other is phosphorescent molecules with emission decay time of more than 1 ms. In the former molecules, electronic transition from the singlet spin excited state (singlet exciton) to the singlet ground state gives rise to luminescence, while transition from triplet spin excited state (triplet exciton) gives rise to emission in the latter molecules. Although the latter emission is caused by spin-forbidden transition and very inefficient, the probability of the triplet exciton formation is three times larger than that of the singlet excitons. The triplet emission is partially allowed by the spin-orbit interaction with the singlet states. Therefore, if the spin-orbit coupling is much stronger in

some molecules, the phosphorescence intensity is expected to be strong, indicating that the triplet-emitter materials are also useful.

The relatively strong spin-orbit interaction is caused by heavy metal ion (e.g. Pt²⁺ and Ir³⁺). Platinum octaethyl porphine (called PtOEP) and *fac* tris(2-phenylpyridine) iridium (Ir(ppy)₃) small-molecules have been paid much attention as high external quantum efficient triplet-emitter materials.^{2,3} In fact, high luminance efficiency and high luminance at low operating voltage and long driving lifetime of OEL device have been achieved using Ir(ppy)₃.⁴ Unlike Ir(ppy)₃ OEL device, much lower luminance has been obtained for PtOEP.³ To obtain the high efficient PtOEP device, the fundamental properties (singlet and triplet energy levels, relaxation process, and guest-host energy transfer, etc.) of PtOEP is investigated and compared with the case of Ir(ppy)₃.

We have also investigated the electroluminescence of 100% PtOEP layer (i.e. PtOEP molecules without doping in any host molecule) in ITO/PtOEP/LiF/Al single layer device and ITO/NPD(60nm)/PtOEP(45nm)/BALq(20nm)/Alq₃(55nm)/LiF/Al multi-layer device. The BALq was installed as the hole-blocking layer. In the single layer device, a weak emission band with a peak at 540 nm was observed besides the well-known 648 nm PtOEP emission band. It was observed that the 540 nm emission

increases in proportion to the third power of current density, while the main 648 nm emission increases linearly. It might be possible that the 540 nm emission is associated with the emission from the spin-singlet excited state. In the multi-layer device, not only an emission band at 567 nm but also the emission bands by Alq₃ and BAlq are observed besides the 648 nm PtOEP emission band, suggesting that electron-hole recombination occurs in not only the PtOEP emission layer but also in hole-blocking and electron-transport layers.

The PtOEP molecule has a double-structure absorption band at 547 nm (called Q band) and intense Soret band at 371 nm.³ Like the case of the Soret band, the 547 nm Q band is attributed to the spin-singlet metal-to-ligand charge transfer ¹MLCT state. The spin-triplet ³MLCT state is not found because of too weak absorption band which is expected to appear at the low energy tail of the 547 nm band. On the other hand, the absorption band associated with the ³MLCT state of Ir(ppy)₃ is observed at about 480 nm.³

The phosphorescence decay time has been estimated to be 110 μs for PtOEP, while

0.8 μs for Ir(ppy)₃.² The decay time is considerably longer in PtOEP than in Ir(ppy)₃. It is conceivable that such a long lifetime at the ³MLCT state gives rise to much smaller luminance for PtOEP because of energy dissipation from the ³MLCT state.

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References

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