

Organic Light Emitting Devices Based on Low Symmetry Coordination Structured Lanthanide Complexes

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Abstract : The need to reduce energy consumption has prompted a considerable research effort for developing alternative energy-efficient lighting systems to replace conventional light sources (i.e., incandescent and fluorescent lamps). Organic light emitting device (OLED) technology offers the distinctive possibility to fabricate large area flat devices by vacuum or solution processing. Lanthanide β -diketonates complexes, due to unique photophysical properties of Ln(III) ions, have been explored as emitting layers in OLED displays and in solid-state lighting (SSL) in order to achieve high efficiency and color purity. For such applications, the excellent photoluminescence quantum yield (PLQY) and stability are the two key points that can be achieved simply by selecting the proper organic ligands around the Ln ion in a coordination sphere. Regarding the strategies to enhance the PLQY, the most common is the suppression of the radiationless deactivation pathways due to the presence of high-frequency oscillators (e.g., OH, -CH groups) around the Ln centre. Recently, a different approach to maximize the PLQY of Ln(β -DKs) has been proposed (named 'Escalate Coordination Anisotropy', ECA). It is based on the assumption that coordinating the Ln ion with different ligands will break the centrosymmetry of the molecule leading to less forbidden transitions (loosening the constraints of the Laporte rule). The OLEDs based on such complexes are available, but with low efficiency and stability. In order to get efficient devices, there is a need to develop some new Ln complexes with enhanced PLQYs and stabilities. For this purpose, the Ln complexes, both visible and (NIR) emitting, of variant coordination structures based on the various fluorinated/non-fluorinated β -diketones and O/N-donor neutral ligands were synthesized using a one step in situ method. In this method, the β -diketones, base, $\text{LnCl}_3 \cdot n\text{H}_2\text{O}$ and neutral ligands were mixed in a 3:3:1:1 M ratio in ethanol that gave air and moisture stable complexes. Further, they were characterized by means of elemental analysis, NMR spectroscopy and single crystal X-ray diffraction. Thereafter, their photophysical properties were studied to select the best complexes for the fabrication of stable and efficient OLEDs. Finally, the OLEDs were fabricated and investigated using these complexes as emitting layers along with other organic layers like NPB, N,N'-Di(1-naphthyl)-N,N'-diphenyl-(1,1'-biphenyl)-4,4'-diamine (hole-transporting layer), BCP, 2,9-Dimethyl-4,7-diphenyl-1,10-phenanthroline (hole-blocker) and Alq3 (electron-transporting layer). The layers were sequentially deposited under high vacuum environment by thermal evaporation onto ITO glass substrates. Moreover, co-deposition techniques were used to improve charge transport in the devices and to avoid quenching phenomena. The devices show strong electroluminescence at 612, 998, 1064 and 1534 nm corresponding to $^5\text{D}_0 \rightarrow ^7\text{F}_2$ (Eu), $^2\text{F}_{5/2} \rightarrow ^2\text{F}_{7/2}$ (Yb), $^4\text{F}_{3/2} \rightarrow ^4\text{I}_{9/2}$ (Nd) and $^4\text{I}_{13/2} \rightarrow ^4\text{I}_{15/2}$ (Er). All the devices fabricated show good efficiency as well as stability.

Keywords : electroluminescence, lanthanides, paramagnetic NMR, photoluminescence

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