Highly efficient organic light emitting diodes with transparent electrode adopting low refractive index material

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In organic light emitting diodes (OLEDs), indium tin oxide (ITO) has been widely used as transparent electrode for several decades due to its low sheet resistance and excellent transparency. [1] In spite of its great opto-electrical properties, it has been pointed out that the waveguide of emitting light, caused by the difference of refractive index (*n*) between ITO (*n* =~1.8) and glass substrate (n=~1.5), is a main obstacle to reduce external quantum efficiency of OLEDs. [2] To solve this issue, transparent electrode consists of dielectric/thin metal/dielectric (DMD) structures, such as WO_3/Au/WO_3 or Ta_2O_5/Ag/WO_3, were successfully employed to OLEDs for enhancing optical out-coupling efficiency. [3] However, the refractive index difference between dielectric layer and glass substrate is a still bottleneck to achieve highly efficient OLEDs.

Here, we demonstrated highly efficient OLED with transparent electrode employing soft material, whose refractive index is very similar with that of glass, replacing the bottom dielectric layer having high refractive indices. To enhance the efficiency of OLEDs, we replaced ITO to thin Ag film sandwiched by soft material (1 um) and 25 nm of 4,4'-Cyclohexylidenebis[N,N-bis(4-methylphenyl)benzenamine] (TAPC) doped by molybdenum oxide(MoO3, 25%, volume ratio). The thickness of TAPC layer was determined by a simulation result using green phosphorescent OLEDs with phenylpyridinato-N,C2')acetylacetonate ($(ppy)_2Ir(acac)$) doped in 4, 4′-Bis(N-carbazolyl)-1,1′-biphenyl(CBP). In the Fig. 1, the device with transparent electrode using low refractive index material showed current efficiency of 148.8 cd/A at 1000 cd/m^2, indicating light outcoupling enhancement of more than 300 % compared to that of ITO anode (43.5 cd/A). This enhancement is attributed to the increased light extracting efficiency arose from the reduced waveguide mode in the transparent electrode, soft material/Ag/MoO3 doped TAPC.

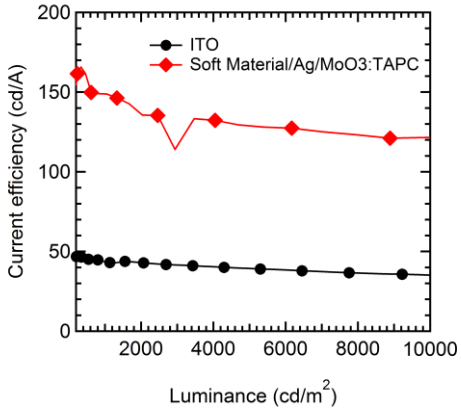

Fig. 1. Current efficiency characteristics of OLED with ITO and soft materials/Ag/MoO_3:TAPC electrode

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References

1. H. Cho, C. Yun and S. Yoo, *Opt.Express*, 18(4), 3404 (2010)
2. K. Hong and J-L. Lee, *Electron.Mater.Lett*. 7(2), 77 (2011)
3. H. Pang, Y. Yuan, Y. Zhou, J. Lian, L. Cao, J. Zhang and X. Zhou, *J.Lumin*. 122-123, 587 (2007)