Scattering particle layers for light extraction in OLEDs: numerical design and experiment

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Scattering particles have been shown to increase the efficiency of OLED devices by a number of authors e.g.[1]. For real life applications of OLED efficiency is only one figure of merit, accurate modelling of the colour appearance and stability under various angles is equally important. We present a complete simulation model and experimental validation for OLEDs with scattering particle extraction layers. Including modeling of the colour coordinates. Additionally we present a joint optimization of the OLED and the scattering layer (concentration, size, host & particle material) The modelling was performed using Setfos 4.1[2].

Scattering particles embedded inside a host layer with modest concentration can be modeled using Mie theory [3]. This theory is combined with the dipole emission model for OLEDs using a net radiation approach [4]. Simulation of both internal and external outcoupling layers or a combination of both are possible.

Experimentally we have compared 3 top emitting OLED devices. 2 scattering films were used) with respective haze of 9 and 49% (Dupont Tejin films, UK).The device were top emitting OLEDs covered with a thin film encapsulation. The outcoupling film was applied to the OLED using an index matched gel.

In figure 1a we compare the measured and simulated luminance versus the angle in air for the bare device and using 9 and 59% haze films. Figure 1b shows the measured and simulated CIE x colour coordinate. The simulated lumince and colour coordinate corresponds very well to the measured values. For the 49% haze film we see the measured CIE x coordinate is slightly higher than the simulated value. It is also noteworthy that by applying the outcoupling film the CIE x coordinate changes significantly from blue to white.

Figure 2 shows an optimization of the total luminous flux exiting the device versus the concentration of scattering particles inside the outcoupling film. By adding some scattering particles a large increase in light extraction is obtained but for larger concentration increased back-scattering reduces the efficiency again. For this film thickness we find an optimum concentration of 0.25%, corresponding to a haze of 67%.

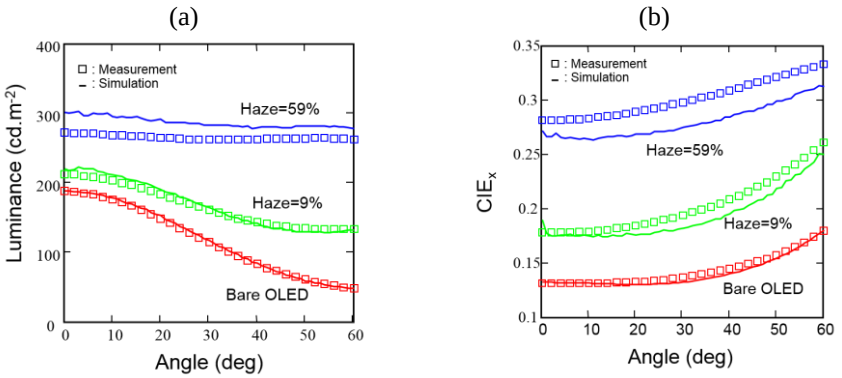

Fig. 1. Measured and simulated luminance and CIE x coordinate versus viewing angle for top emitting OLEDs with different outcoupling films.

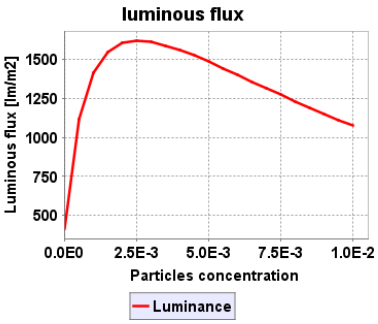

Fig. 2 Simulated luminous flux in function of particle concentration.

References

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