World's first high refractive index glass substrate for OLED lighting produced by over flow down draw process

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OLED lighting is one of a promising candidate as the next generation energy-saving light source. Compared to fluorescent lamps, however, luminous efficiency of commercial OLED is still not high. The low luminous efficiency of OLED lighting is attributed to low light-extraction efficiency from the refractive index (nd) mismatch between organic layers (nd≒1.9) and glass substrate (nd=1.52), and also between glass substrate and air. The refractive index mismatch causes light reflection at their interfaces, and then only 20% of emitted light from organic layers is extracted into the air. Therefore, increasing the light-extraction efficiency is quite important for OLED lighting.

A high refractive index glass substrate, HX-1, has been newly developed for OLED lighting with the aim of increasing light-extraction efficiency by decreasing refractive index mismatch. HX-1 is designed for production by the Over Flow Down Draw method, which is a ideal technology for manufacturing thin and large glass substrates. The refractive index of HX-1 is 1.63. That is to say, by using HX-1 instead of conventional glass (nd=1.52), it is possible to extract more light from the organic layers into HX-1 and to improve the light-extraction efficiency of OLED lighting devices. To investigate the relationship between the light-extraction efficiency of the OLED and refractive index of glass substrates, HX-1 and OA-10G (conventional glass substrate) were used. Green phosphorescent OLED to be used with these glass substrates is made as well. OLED structure is as follows; Glass / ITO, 100nm/HIL, 40nm/NPD, 50nm/Ir $(ppy)_3$ + CBP [6%], 30nm/BAlq, 10nm/Alq, 30nm/LiF, 0.8nm/Al, 150nm. The light-extraction efficiency of the OLED devices with out-coupling film or without the film is measured at $0.9 mA/cm^2$. The refractive index of out-coupling film is 1.5. Fig. 1 shows the luminous efficiency ratio vs. the refractive index of glass without/with film. As shown in Fig. 1, without the out-coupling film, the luminous efficiency of HX-1 is 7% higher than that of OA-10G. On the other hand, with the out-coupling film, the luminous efficiency of HX-1 is 24% higher than that of OA-10G. This proves that improvement of luminous efficiency is achieved with HX-1. From the results, it can be seen that out-coupling film is not used, luminous efficiency becomes slightly higher. We speculate that the slight enhancement of luminous efficiency is attributed to the decrease of the refractive index mismatch between organic layers and glass. By using out-coupling film, even though the refractive index mismatch between the glass and film still exists, the trapped light is extracted into air, resulting in greatly improved luminous efficiency. The result shows that improvement of luminous efficiency is successfully achieved by the high refractive index of HX-1. As mentioned above, the refractive index of out-coupling film is not the same as that of HX-1. We expect that the luminous efficiency of OLED could be higher if we used the out-coupling film with the same refractive index as HX-1. In conclusion, we consider that HX-1 is capable of improving luminous efficiency and is thus an ideal substrate for high luminous efficiency OLED lighting devices.

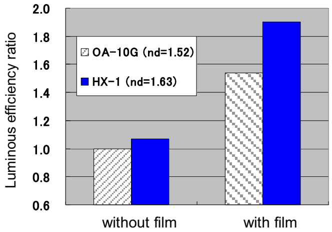

Fig. 1. Luminous efficiency ratio versus refractive index (nd) of glass without/with film.