Super-low-index hole transport layers and their applications for high outcoupling of OLEDs

Daisuke Yokoyama[1], Yasutaka Suzuki[1] and Wataru Aita[1]
[1]Dept. of Org. Device Engineer., Yamagata University, Yonezawa, Yamagata 992-8510, Japan
Tel.:+81-238-26-3890, E-mail: d_yokoyama@yz.yamagata-u.ac.jp

The internal quantum efficiency of OLEDs has reached nearly 100% by using phosphorescent emitters or TADF materials, and further improvement of the external quantum efficiency (EQE) of OLEDs mainly relies on technologies for the enhancement of outcoupling efficiency. One of the promising technologies is to use horizontal orientation of emitting molecules, which can make outcoupling efficiency more than 1.5 times higher.[1] This technology is now extensively being used to achieve high-performance OLEDs.

Here we introduce another promising technology for high outcoupling of OLEDs: lowering refractive indices of amorphous organic semiconductor films. Although this concept has been theoretically discussed before,[2] it has been difficult as a practical matter to prepare a low-index film compatible with its high charge transport property. We found two effective methods to lower refractive indices of amorphous organic semiconductor films; one is to use anisotropy of refractive indices (birefringence) caused by molecular orientation,[3] and the other is to mix a low-index material with an organic semiconductor.

In this presentation, we focus on the latter of the above methods. In 2012, we reported wide-range refractive index control of organic semiconductor films and demonstrated a novel organic device that simultaneously controls both of charges and light,[4] but the charge transport properties of the low-index layer was not enough for wide applications at that time. Because most low-index materials are insulators in general, mixing them with an organic semiconductor usually brings a considerable loss of charge transport properties. Very recently, however, we found a material combination (TAPC:LYA1) that can achieve a low refractive index of <1.5 (Figure 1), which is lower than that of normal glasses, without a loss of hole transport properties of TAPC itself (Figure 2). We also applied this type of a low-index film to OLEDs and obtained an EQE higher than that of the device with a normal hole transport layer. We propose that this new technology can be another promising approach for further high outcoupling efficiency.

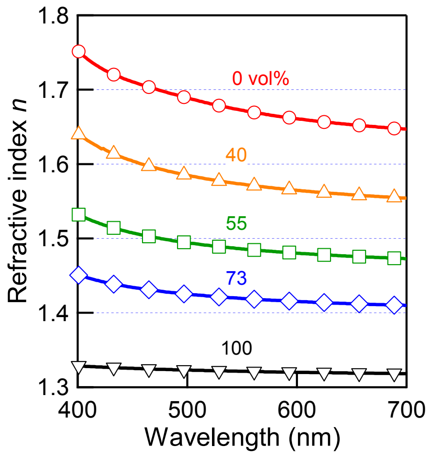

Fig. 1. Refractive indices of TAPC:LYA1 films.

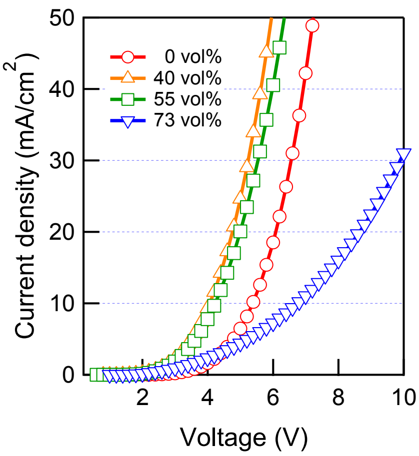

Fig. 2. *J-V* characteristics of TAPC:LYA1 films.

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References

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