Enhanced efficiency of organic light-emitting diodes using TiO_2 nanoparticles via a microcavity effect

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Organic light emitting diodes (OLEDs) have attracted attention as a future display. This attention stems from their properties including a fast response time, a broad color gamut, and an infinite contrast ratio. Above all, they offer strong potential for transparent and flexible displays. However, low optical efficiency is a remaining problem that should be resolved. In efforts to improve the optical efficiency of OLEDs, numerous studies have been performed. One of the research direction is using nanoparticles. This approach is inexpensive and involves an easy fabrication method, in contrast with previous methods. Most studies have used metal nanoparticles or oxide nanoparticles. Some of the studies have used more than two kinds of the nanoparticles together. Localized surface plasmons is the main effect manifested by metal nanoparticles whereas oxide nanoparticles produce a scattering effect.

In this study, we have used TiO_2 nanoparticles to increase the microcavity effect that occurs inside the OLED to obtain improved optical efficiency. TiO_2 nanoparticles were spin-coated onto an ITO anode, and they were evenly coated without agglomeration, producing a layer having a low surface roughness. Because of the low surface roughness, the scattering transmittance was not noticeably different from the normal direction transmittance, and this suggests that the scattering from the nanoparticles was not a main effect in this study. A microcavity simulation was carried out using MATLAB and it was used to analyze the device. The electroluminescence spectrum enhancement ratio from a simulation and experiments showed a similar tendency, reflecting the microcavity effect that occured from the TiO_2 nanoparticles. Enhanced current efficiency, external quantum efficiency, and power efficiency were observed from the OLED device incorporating TiO_2 nanoparticles. The electrical characteristics were not changed with optimized density of the TiO_2 nanoparticles and the pixels were clear. This indicates that the additional fabrication step of incorporating TiO_2 nanoparticles in the OLED enhances the optical efficiency. Furthermore, this method has advantages including easy fabrication by use of a spin-coating process and low cost by the use of TiO_2 nanoparticles.

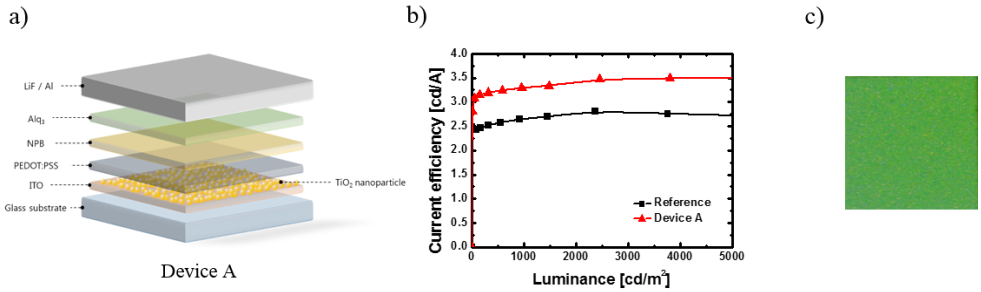

Fig. 1. a) A schematic illustration of the OLED device including TiO_2 nanoparticles, b) current efficiency versus luminance graph, c) pixel image of device A.

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