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Letter to the Editor

Comment on "Improving Light Outcoupling Efficiency for OLEDs with Microlens Array Fabricated on Transparent Substrate"

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The recently published research article, titled "Improving Light Outcoupling Efficiency for OLEDs with Microlens Array Fabricated on Transparent Substrate," provides a significant design rule for the high extraction efficiency of OLED devices [1]. According to the simulation results, the authors proposed that a well-organized microlens-embedding structure may increase 80% light output efficiency. For an experimental demonstration, about 30% luminance enhancement was induced by a microlens-arrayed substrate. The optical lens design was applied and revealed a noticeable improvement of OLED performances. The authors demonstrated the improved OLED performances by using geometric designs of microlens arrays, which are formed on a glass substrate. The microlens arrays were formed by photoresist material. The photoresist film showed high transmittance above 90% for longer wavelengths ($\lambda > 500$ nm); however, the photoresist microlens arrays have no electrical advantages for carrier transportation.

Meanwhile, we also consider an electrical aspect for further significant enhancement for photoelectric devices, including LEDs and solar cells [2–7]. A distinctive feature between LEDs and solar cells is a way to utilize energy conversion. LEDs convert the electric energy to light emission and solar cells generate electric power from the incident photon energy. This basic and important understanding may provide mutual applications of photoelectric devices [8, 9].

Previously, we have investigated an indium-tin-oxide (ITO) transparent conducting layer to focus the incident light into the light-reactive semiconducting material. The nanoscale ITO nanodome arrays efficiently focus the incoming light resulting in the enhanced solar cell performances, based on the enlarged current value. This was caused by the optical design to manipulate the light penetration through the Si material. Additionally, the electrical aspect also contributed to increase in current value due to excellent electrical conductivity of the ITO layer, providing an efficient route to collect photogenerated carriers, effectively.

This optically and electrically balanced design may be applied in the microlens-arrayed OLED devices. Instead of using the electrically nonconductive material, electrically conductive materials, such as ITO, can be considered for the light-modulating structure. This design would spontaneously provide the electrical advantages and maintain the optical benefit of light manipulation of the patterned structure. To realize these optical and electrical features, one may think of the patterned ITO arrays, which sit on the ITO anode layer. The carriers from organic (light-active) layers can easily reach the ITO anode and the emitted light can efficiently propagate through the patterned ITO arrays.

Figure 1 is one of the possible schemes of the functional ITO patterns for efficient OLED. Double anode layers are proposed, where the film ITO is a conventional anode figure and the patterned ITO-array structure is for the functional light extraction. Besides the light management from the patterned ITO-array structure, the electrical conductivity would be enhanced according to double ITO layers. One

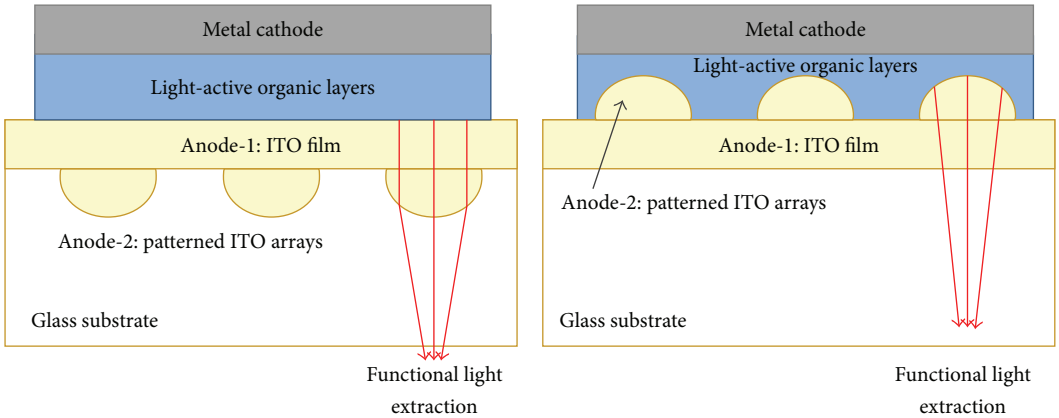

Figure 1: Suggested scheme: double ITO layers for an anode layer. The patterned ITO arrays efficiently extract light from the light-active layer and also contribute to reduction of the electrical resistance.

may also consider that organic layer coating on the ITO arrays (Figure 1, left), if the organic materials can easily and uniformly be coated on the ITO arrays. As we achieve better performances from the double ITO layer designs, the metal insertion between two ITO layers is a promising approach to improve further electrical properties [4].

Conflict of Interests

The author declares that there is no conflict of interests of commercial or financial relationships.

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References

[1] J. Wang, W. Li, and C. Wang, "Improving light outcoupling efficiency for OLEDs with microlens array fabricated on transparent substrate," *Journal of Nanomaterials*, vol. 2014, Article ID 289752, 6 pages, 2014.

[2] J. H. Yun, E. Lee, H. H. Park et al., "Incident light adjustable solar cell by periodic nanolens architecture," *Scientific Reports*, vol. 4, article 6879, 2014.

[3] J.-H. Yun, J. Kim, and Y. C. Park, "Transparent conductor-Si pillars heterojunction photodetector," *Journal of Applied Physics*, vol. 116, no. 6, Article ID 064904, 2014.

[4] J.-H. Yun, M. M. D. Kumar, Y. C. Park, and J. Kim, "Transparent conductors with an ultrathin nickel layer for high-performance photoelectric device applications," *Materials Science in Semiconductor Processing*, vol. 31, pp. 334–339, 2015.

[5] C. O'Dwyer, M. Szachowicz, G. Visimberga, V. Lavayen, S. B. Newcomb, and C. M. S. Torres, "Bottom-up growth of fully transparent contact layers of indium tin oxide nanowires for light-emitting devices," *Nature Nanotechnology*, vol. 4, no. 4, pp. 239–244, 2009.

[6] J. Kim, J.-H. Yun, H. Kim et al., "Transparent conductor-embedding nanocones for selective emitters: optical and electrical improvements of Si solar cells," *Scientific Reports*, vol. 5, article 9256, 2015.

[7] H.-H. Park, X. Zhang, Y. Cho et al., "Wafer-scale surface roughening for enhanced light extraction of high power AlGaInP-based light-emitting diodes," *Optics Express*, vol. 22, no. 3, pp. A723–A734, 2014.

[8] J. Gao, R. Chen, D. H. Li et al., "UV light emitting transparent conducting tin-doped indium oxide (ITO) nanowires," *Nanotechnology*, vol. 22, no. 19, Article ID 195706, 2011.

[9] H. Kim, J. Yun, H. Park, M. David Kumar, and J. Kim, "Three-dimensional nanodome-printed transparent conductors for high-performing Si photodetectors," *Materials Letters*, vol. 148, pp. 174–177, 2015.