Scientists turn to fireflies to improve OLED efficiency

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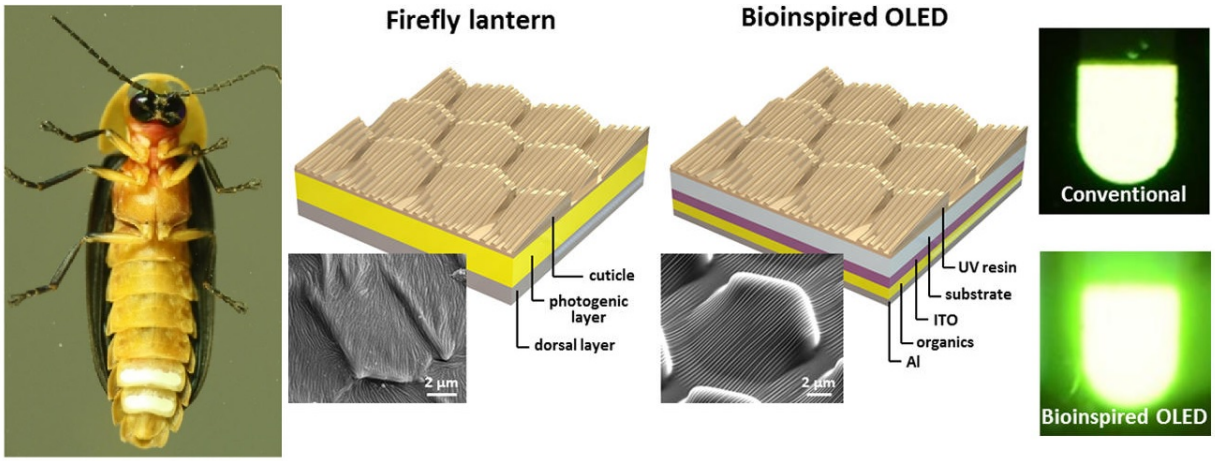

The biologically inspired OLED is patterned with hierarchical structures very similar to those on a firefly. Credit: Kim, et al. ©2016 American Chemical Society

(Phys.org)—Many insects, birds, fish, and amphibians emit light as a way to communicate with each other, but the species that produces light most efficiently is the firefly. In a new study, researchers have investigated the optical properties of the firefly's light-emitting cuticle, which is not smooth like most human-made lights, but instead is patterned with tiny hierarchical structures. Inspired by these features, the researchers replicated the patterns to create a bioinspired organic light-emitting diode (OLED), resulting in a 60% increase in the light

extraction efficiency and 15% wider angle of illumination.

The scientists, led by Ki-Hun Jeong at the Korea Advanced Institute of Science and Technology (KAIST), have published a paper on the firefly -inspired OLEDs in a recent issue of *Nano Letters*.

"This work reports the first observation of hierarchical structures, i.e., inclined microstructures with nanostructures existing on the cuticular ultrastructures of a firefly's lantern," Jeong told *Phys.org*. "Based on our large-scale photonic calculation, it was clearly revealed that the function of asymmetric and hierarchical structures substantially contributes to the efficient extraction and wide angular illumination of bioluminescent light that would otherwise be entrapped in the firefly lantern. The knowledge learned from firefly lanterns has been successfully utilized for next-generation OLEDs."

The work builds on previous research (some by the same authors) that has shown that firefly cuticles have nanostructures that improve light transmission. The cuticles also have tiny structures that increase light extraction (the amount of light that actually exits the animal) by reducing internal reflection. The problem of internal reflection is one of the biggest challenges facing LEDs, where often more than half of the light produced is reflected back into the device rather than being emitted. Scientists have already mimicked these nano- and microstructures in LED design to improve light transmission and extraction.

In the new study, the researchers have discovered that the asymmetric and hierarchical nature of the cuticle structures also plays a key role in the firefly's light-emitting ability. The researchers created precise molds of these structures to use as the optical layer of an OLED. Consequently, the same features that help fireflies communicate their courtship signals have turned out to also contribute to improving advanced lighting and display applications.

"Our breakthrough technology is the large-scale fabrication of inclined microstructures and highly ordered nanostructures on each inclined microstructure," Jeong said. "We strongly believe that these biologically inspired OLEDs open a new paradigm for engineering biomimetics for lighting applications."

The firefly light may become a commercial reality in the near future.

"We are looking for an industrial OLED partner who is interested in commercializing our novel idea, and we will also continue to work on biologically inspired photonics for engineering applications," Jeong said.

More information: Jae-Jun Kim, et al. "Biologically Inspired Organic Light-Emitting Diodes." *Nano Letters*. DOI: 10.1021/acs.nanolett.5b05183