Manufacturing method paves way for commercially viable quantum dot-based LEDs

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University of Florida researchers may help resolve the public debate over America's future light source of choice: Edison's incandescent bulb or the more energy efficient compact fluorescent lamp. It could be neither.

Instead, America's future lighting needs may be supplied by a new breed of light emitting diode, or LED, that conjures light from the invisible world of quantum dots. According to an article in the current online issue of the journal Nature Photonics, moving a QD LED from the lab to market is a step closer to reality thanks to a new manufacturing process pioneered by two research teams in UF's department of materials science and engineering.

"Our work paves the way to manufacture efficient and stable quantum dot-based LEDs with really low cost, which is very important if we want to see wide-spread commercial use of these LEDs in large-area, full-color flat-panel displays or as solid-state lighting sources to replace the existing incandescent and fluorescent lights," said Jiangeng Xue, the research leader and an associate professor of material science and engineering "Manufacturing costs will be significantly reduced for these solution-processed devices, compared to the conventional way of making semiconductor LED devices."

A significant part of the research carried out by Xue's team focused on

improving existing organic LEDs. These semiconductors are multilayered structures made up of paper thin organic materials, such as polymer plastics, used to light up display systems in computer monitors, television screens, as well as smaller devices such as MP3 players, mobile phones, watches, and other handheld electronic devices. OLEDs are also becoming more popular with manufacturers because they use less power and generate crisper, brighter images than those produced by conventional LCDs (liquid crystal displays). Ultra-thin OLED panels are also used as replacements for traditional light bulbs and may be the next big thing in 3-D imaging.

Complementing Xue's team is another headed by Paul Holloway, distinguished professor of materials science and engineering at UF, which delved into quantum dots, or QDs. These nano-particles are tiny crystals just a few nanometers (billionths of a meter) wide, comprised of a combination of sulfur, zinc, selenium and cadmium atoms. When excited by electricity, QDs emit an array of colored light. The individual colors vary depending on the size of the dots. Tuning, or "adjusting," the colors is achieved by controlling the size of the QDs during the synthetic process.

By integrating the work of both teams, researchers created a high-performance hybrid LED, comprised of both organic and QD-based layers. Until recently, however, engineers at UF and elsewhere have been vexed by a manufacturing problem that hindered commercial development. An industrial process known as vacuum deposition is the common way to put the necessary organic molecules in place to carry electricity into the QDs. However, a different manufacturing process called spin-coating, is used to create a very thin layer of QDs. Having to use two separate processes slows down production and drives up manufacturing costs.

According to the Nature Photonics article, UF researchers overcame this

obstacle with a patented device structure that allows for depositing all the particles and molecules needed onto the LED entirely with spin-coating. Such a device structure also yields significantly improved device efficiency and lifetime compared to previously reported QD-based LED devices.

Spin-coating may not be the final manufacturing solution, however.

"In terms of actual product manufacturing, there are many other high through-put, continuous "roll-to-roll" printing or coating processes that we could use to fabricate large area displays or lighting devices," Xue said. "That will remain as a future research and development topic for the university and a start-up company, NanoPhotonica, that has licensed the technology and is in the midst of a technology development program to capitalize on the manufacturing breakthrough."

Provided by University of Florida