Freeing light shines promise on energy-efficient lighting

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(PhysOrg.com) -- The latest bright idea in energy-efficient lighting for homes and offices uses big science in nano-small packages to dim the future Edison's light bulb.

In the August issue of *Nature Photonics,* available online, scientists at the University of Michigan and Princeton University announce a discovery that pushes more appealing white light from organic light-emitting devices.

More white light is the holy grail of the next generation of lighting. The innovation in the paper "Enhanced Light Out-Coupling of Organic Light-Emitting Devices Using Embedded Low-Index Grids" describes a way to deliver significantly more bright light from a watt than incandescent bulbs.

"Our demonstration here shows that OLEDs are a very exciting technology for use in interior illumination," said Stephen Forrest, U-M professor of electrical engineering and physics and vice president for research. "We hope that white emitting OLEDs will play a major role in the world of energy conservation."

Forrest and co-author Yuri Sun, visiting U-M from Princeton University, have wrestled with a classic problem in the new generation of lighting called white organic light-emitting devices, or WOLED: Freeing the light generated, but mostly trapped, inside the device.

A lighting primer: Incandescent light bulbs give off light as a by-product of heat. The light is appealing, but inefficient, putting out 15 lumens of light for every watt or electricity.

The best fluorescent tube lights put out some 90 lumens of light per watt, but the light can be harsh, the fixtures are expensive, and the tubes lose their efficiency with age. And they rely on many environmentally unfriendly substances such as mercury.

WOLEDs show promise of providing a light that's much easier to manipulate, while being long lasting and able to provide in different shapes, from panels to bulbs and more. WOLEDs generate white light by using electricity to send an electron into nanometer thick layers of organic materials that serve as semiconductors. These carbon-based materials are dyes, the ones used in photographic prints and car paint, so they are very inexpensive, and can be put on plastic sheets or metal foils, further reducing costs.

The excited electron in these layers casts bright white light. The bad news, Forrest said, has been that some 60 percent of it is trapped inside the layers, much the way light under water reflects back into the pool, making the water surface seem like a mirror when viewed from underneath.

The *Nature Photonics* paper describes a tandem system of organic grids and micro lenses that guide the light out of the thin layers and into the air. The grids refract the trapped light, bouncing it into a layer of dome-shaped lenses that then pull the light out.

This process---all of which is packed into a lighting sandwich roughly the thickness of a sheet of paper---was shown to emit approximately 70 lumens from a single watt of power.

More light out means getting more bang for the electricity buck, a crucial question since 22 percent of the U.S. electricity consumption is lighting.

"If you can change the light efficiency by just a few percentage points, there's a few less coal plants you'll need," Forrest said.

Reducing the amount of coal-generated electricity and finding more efficient ways to power appliances and lighting is one of the focuses of U-M's Michigan Memorial Phoenix Energy Institute, and the WOLED work is one example of how science can open new doors in conservation, said Gary Was, institute director.

"That energy efficient lighting can be made from the same materials as car paint and that they can be made in such thin, formable sheets boggles the mind," Was said. "This is one of many exciting creations that research is giving us in the pursuit of energy efficiency. This is also the kind of innovation that is required in the drive for energy sustainability.

Forrest said WOLED work isn't done yet. The fun part, he said, is that WOLEDs can be framed in different forms.

"Plugging into a wall at low voltage, putting it on a flexible metal foil, or on plastic that won't break when you drop it," Forrest said. "This is what makes it so fun because it's such a unique lighting source."

The research was funded by the U.S. Department of Energy through a subcontract from the University of Southern California and by Universal Display Corp.

Forrest is part of the Michigan Memorial Phoenix Energy Institute, which develops, coordinates and promotes multidisciplinary energy research and education at U-M. He also is on the scientific advisory board of Universal Display Corp.

The next challenge, he said, is to reduce the cost, which currently is too high to be commercially competitive.

"You have to be able to do this dirt cheap, Forrest said. "People don't spend much for their light bulbs."

Provided by University of Michigan

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