Cheap, efficient white light LEDs new design

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Light produced by a new type of light emitting diode (LED) made from inexpensive, plastic-like organic materials. Photo by Ma Dongge

Roughly 20 percent of the electricity consumed worldwide is used to light homes, businesses, and other private and public spaces. Though this consumption represents a large drain on resources, it also presents a tremendous opportunity for savings. Improving the efficiency of commercially available light bulbs -- even a little -- could translate into dramatically lower energy usage if implemented widely.

In the latest issue of *Journal of Applied Physics*, published by the American Institute of Physics (AIP), a group of scientists at the Chinese Academy of Sciences is reporting an important step towards that goal with their development of a new type of light emitting diode (LED) made from inexpensive, plastic like organic materials. Designed with a simplified "tandem" structure, it can produce twice as much light as a normal LED -- including the white light desired for home and office lighting.

"This work is important because it is the realization of rather high efficiency white emission by a tandem structure," says Dongge Ma, who led the research with his colleagues at the Changchun Institute of Applied Chemistry at the Chinese Academy of Sciences.

Found in everything from brake lights to computer displays, LEDs are more environmentally friendly and much more efficient than other types of light bulbs. Incandescent bulbs produce light by sending electricity through a thin metal filament that glows red hot. Only about five percent of the energy is turned into light, however. The rest is wasted as heat. Compact fluorescent bulbs, which send electricity through a gas inside a tube, tend to do much better. They typically turn 20 percent or more of the electricity pumped through them into light. But compact fluorescents also contain small amounts of mercury vapor, an environmental toxin.

LEDs on the other hand, are made from thin wafers of material flanked by electrodes. When an electric current is sent through the wafers, it liberates electrons from the atoms therein, leaving behind vacancies or "holes." When some of the wandering electrons and holes recombine, they create a parcel of light, or photon. These photons emerge from the side of the wafer as visible light. This turns 20 to 50 percent, or even more, of the input energy into light. LEDs also concentrate a lot of light in a small space.

Producing LEDs that can compete with traditional light bulbs for cost and efficiency is one thing. Making LEDs that consumers want to use to light their homes is quite another. One of the main barriers to the widespread use of LED lights is the light itself. LEDs can easily be manufactured to produce light of a single color -- like red -- with applications such as traffic lights and auto brake lights. Indoor lighting though, requires "natural" white light. This quality is measured by the color-rendering index (CRI), which assigns a value based on the light source's ability to reproduce the true color of the object being lit. For reading light, a CRI value of 70 or more is optimal. LEDs can produce white light by combining a mixture of blue, green, and red light, or by sending colored light through a filter or a thin layer of phosphors -- chemicals that glow with several colors when excited. However, these solutions increase costs. To reach a larger market, scientists would like to make inexpensive LEDs that can produce white light on their own.

The authors of this paper report important advances towards this goal. First, they built LEDs from organic, carbon-based materials, like plastic, rather than from more expensive semiconducting materials such as gallium, which also require more complicated manufacturing processes. Second, they demonstrated, for the first time, an organic white-light LED operating within only a single active layer, rather than several sophisticated layers. Moreover, by putting two of these single-layer LEDs together in a tandem unit, even higher efficiency is achieved. The authors report that their LED was able to achieve a CRI rating of nearly 70 -- almost good enough to read by. Progress in this area promises further reduction in the price of organic LEDs.

More information: "A high-performance tandem white organic LED combining highly effective white units and their interconnection layer" by Qi Wang et al. was published online on April 6, 2009 [J. Appl. Phys. 105, 076101 (2009)]. link.aip.org/link/?JAPIAU/105/076101/1

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