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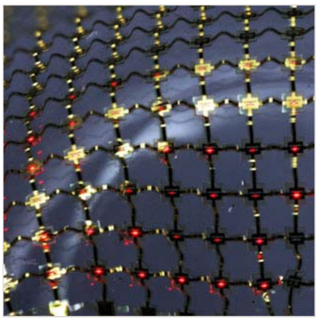
Brighter Idea: Next-Generation Inorganic LEDs Promise Longer Lives and More Lumens [Slide Show]

New ways of making light-emitting diodes (LEDs) could lead to brighter, more energy-efficient video screens and lighting

By Larry Greenemeier



BRILLIANT Researchers from the University of Illinois, Northwestern University, the Institute of High Performance Computing in Singapore, and Tsinghua University in Beijing report having found a better way of producing inorganic LEDs (ILEDs).
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Lights and video displays made with energy-efficient light-emitting diodes (LEDs) are already making strong inroads in consumer and industrial markets long dominated by fluorescent bulbs and liquid crystal displays (LCDs). Although the majority of these LEDs get their electroluminescence from layers of film made from carbon-containing organic compounds, such organic LEDs (OLEDs) may be superseded by LEDs made from inorganic compounds that shine brighter and last longer than OLEDs.

The life spans of inorganic LEDs (ILEDs) can be 100,000 hours or more, much longer than OLEDs. (Some television-makers promote sets with OLEDs lasting 30,000 hours or so—that's about 3.5 years of continuous run-time.) Now, an international team of researchers is reporting success developing a process for making ILEDs that could put them on equal footing with OLEDs, the latter of which currently can be made smaller, cheaper and in a larger number of configurations. (ILEDs have so far be used primarily in large outdoor digital displays that do not require high resolution.)

View a slide show of experimental ILED devices

The new approach to ILED-making offers a more effective means of fabricating and assembling smaller, thinner ILEDs, says John Rogers, a University of Illinois at Urbana–Champaign professor of materials science and engineering. Rogers and colleagues from Northwestern University, the Institute of High Performance Computing in Singapore, and Tsinghua University in Beijing describe their work—funded by Ford Motor Co., the National Science Foundation, and the U.S. Department of Energy—in the August 21 issue of the journal *Science*.

LEDs generally are made up of several layers of organic or inorganic compounds that emit light when an electric current flows through them. These layers include the emissive layer that gives off the light, a conductive layer and a substrate, along with anode and cathode terminals that provide the electric charge. ILEDs are used today to make large display screens but cannot easily be made small enough to be packed into arrays that work well for indoor lighting or for video screens (several different brands of televisions, computer monitors and smart phones already use OLEDs).

ILEDs are "ridiculously bright, with the strongest emitting the equivalent of about one tenth the brightness of the sun," says Ioannis Kymissis, an assistant professor of electrical engineering at Columbia University in New York City who is also studying ways to make ILEDs more practical, separate from Rogers's research.

Whereas OLEDs can be made atop relatively inexpensive materials such as plastic or glass, ILEDs must be created on top of more expensive crystal wafers (made from, for example, gallium arsenide or gallium nitride, both of which are semiconductors). For ILEDs, thin films are grown to generate crystals on the surfaces of these wafers, which are typically circular in shape, with thicknesses a little less than 0.5 millimeter and with diameters between five and 10 centimeters.

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ILED wafers cannot be reused because the normal process is to saw apart the newly formed ILED crystals—while also cutting through the underlying wafer. (OLEDs have always been able to reuse their substrates, one of the reasons they have cost less than ILEDs.) After the ILED crystals have been separated they are picked up by a robotic device so they can be packaged, wired and used as tiles to make jumbotrons and other large, mostly outdoor displays. The robotic device is unable to pick up crystals that are smaller than about 100 microns per side, which prevents ILEDs from being made smaller.

The process that Rogers and his colleagues described in their research uses a different approach to cutting apart and transferring the ILED crystals. "We've found a way to take the inorganic material you grow on the wafer and embed a sacrificial base," he says. The researchers then make a lithographic imprint on the newly formed crystals. Instead of using a saw or a robotic "picker," the researchers use a rubber stamp to separate and lift the individual crystals—which in this new process can be as small as 20 microns on each side—so they can be arranged in tight arrays on glass, plastic, rubber or other surfaces. The underlying wafer can now be reused. (A micron is one millionth of a meter, or about 40 millionths of an inch.)

With this new process, the ILEDs can be interconnected, much the way OLEDs are wired, which saves space. "It's not the individual wiring that's done with ILEDs today," Rogers says.

It's unclear exactly how much of a cost difference there will be between OLEDs and ILEDs if they are used in comparable devices such as televisions or computer monitors. Even though ILEDs cost more to make, Kymissis says, "because they're so bright, you don't need as many."

Ford funded the research in part as a way to develop flexible lighting for vehicle interiors and brake lights, although, according to Rogers, it will be at least a couple of years before his team's technology would be ready for commercial use.

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