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SELF-ASSEMBLY REQUIRED

Harvard team uses patterned assembly to fabricate cylindrical LED display

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Throw 100 or so light-emitting diodes (LEDs) into a vial of water, add a patterned substrate coated with a low-melting solder, heat and shake the contents gently for a few minutes, and voilà--a tiny LED display assembles itself as if by magic. But it's not magic--it's patterned assembly, a process that a Harvard University research team has now demonstrated can be used to fabricate flexible, cylindrical displays that light up in any desired pattern [*Science,* **296,** 323 (2002)].

The team, headed by chemistry professor George M. Whitesides, also reports using this strategy to assemble a curved 5-cm^2 array of about 1,560 small silicon cubes, which were used as stand-ins for microelectronic devices. The array was generated in minutes.

"This is definitely a 'wow' paper," comments Gregory T. A. Kovacs, an associate professor of electrical engineering at Stanford University. It's "very exciting," he says, because "it shows the potential for mass-fabrication of flexible, active, electronic systems."

To make the LED displays, Whitesides and coworkers Heiko O. Jacobs, Andrea R. Tao, Alexander Schwartz, and David H. Gracias start with a transparent polyimide sheet on which they have photolithographically fashioned an array of 113 280-mm-wide copper squares connected by parallel copper wires. The squares are coated with solder, and the sheet is curled up inside a small vial filled with water.

Then they add the LEDs--semiconductor chips the same size as the copper squares but with a layer of gold (anode) on the bottom and a small circular cathode on the top. When the water is heated, the solder melts. Gentle tumbling of the vial causes the gold bottoms of the LEDs to glom onto the liquid solder in an effort to minimize the solder's free surface area. This

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George M. Whitesides

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drives the assembly of LEDs on the solder-coated copper squares.

"The solder also provides the electrical connection required to operate the device and the mechanical bond required to hold the assembly together," the researchers explain.

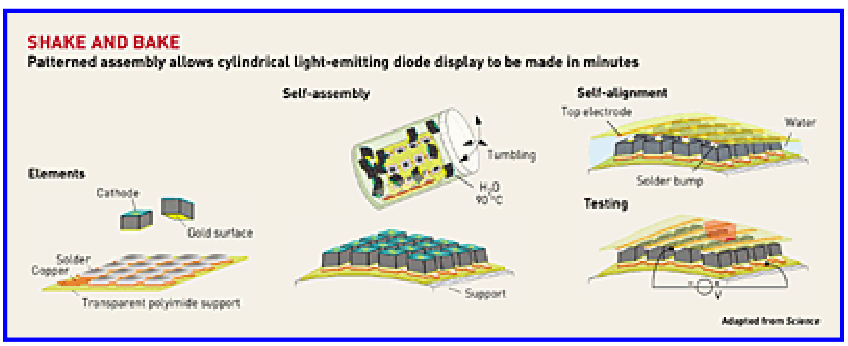
To correct defects in the assembly, the Harvard team performs a sequence of agitation steps that, in minutes, ensures that the assemblies are defect-free.

In the final fabrication operation, the researchers use dip-coating to apply solder to the top cathode of each LED and to the polyimide-supported parallel copper wires of a top electrode. This electrode is manually positioned over the LED array and fused to the individual diodes by melting the solder on the LED and wire surfaces.

By applying a potential between the top and substrate electrodes, the researchers can light up any or all of the 113 LEDs.

The LED components used in this array are 30 times smaller than components used in earlier solder-based self-assembly experiments, according to Jacobs.

In principle, Stanford's Kovacs tells C&EN, the method could be applied to fabricating systems that are more complex. "The ability to 'dock' different elements in regular arrays--such as red, green, and blue LEDs in a color display--will be key," he says. He foresees "a large number of commercial applications, from toys through high-end displays."



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