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Chemistry On Display

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Electronics makers try out new materials to make our gadgets lightweight and efficient.

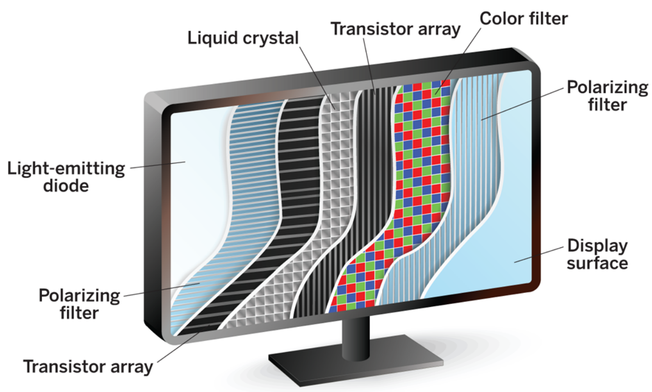
Some people can spend almost every waking hour staring at displays on their cell phones, tablets, televisions, and computers. Most of these mesmerizing screens are liquid-crystal displays, or LCDs. Electronics companies manufacture them on tremendous scales, sometimes on sheets of glass larger than garage doors that are then sliced into individual screens. LCDs currently are inexpensive to manufacture, but they're power hungry, significantly lowering battery lifetimes.

LCDs are so widespread and made on such huge scales that they're practically commodities, making it difficult for companies to get any edge over their competitors, says Paul Semenza, an independent display industry analyst. But with a push from the market and a lot of help from chemistry, display technologies are making strides in improving efficiencies and resolution.

Standard LCDs consist of many layers. First, a white light-emitting diode shines light toward the front of the display, generating each pixel. The pixels actually consist of three subpixels, one for each color—red, blue, and green. These subpixels are made up of a liquid-crystal layer and the appropriate color filter sandwiched between two polarizing light filters. Transistor arrays switch the structural states of the liquid crystals to control whether or not a subpixel gets lit up, which in turn produces all the colors in an image.

These displays waste a lot of power because much of the light produced by the backlight never reaches a viewer's eyes. Even in the on state, the polarizing and color filters in each subpixel block significant amounts of light before it travels out of the display.

A less power-hungry alternative to the LCD is the organic light-emitting diode, or OLED, display. OLEDs do not require polarizers, filters, or backlights. The subpixels in OLEDs contain organic molecules that emit red, green, or blue light when an electric voltage is applied by an underlying transistor.



Liquid-crystal displays (LCDs) consist of multiple layers. Light produced by a light-emitting diode passes through polarizing filters, color filters, and a liquid-crystal layer to produce an image. Credit: Adapted from Shutterstock.

Samsung's Galaxy cell phones, tablets, and smart watches use this technology.

"The OLED just has electrodes and active material, so it's much thinner than an LCD", says Zhenan Bao, a materials scientist at Stanford University who works on organic electronic materials. This makes OLEDs compatible with very thin, even flexible, foldable, or curved devices. LCDs are heavy and cannot be folded or bent—any shape other than a rigid, flat plane would disrupt the path of light from the backlight. Some companies have started testing flexible displays: Samsung and LG have built OLED televisions with fixed curves.

Still, many display makers are sticking with LCDs, but using new chemistry to gain an edge. Some companies have enlisted the help of versatile light-emitting nanostructures called quantum dots to improve the color quality and power use of LCDs. These materials take advantage of optical effects that emerge when semiconductors are made on the nanoscale. Once a material like cadmium selenide is confined in a nanoscale sphere, the wavelength of light it emits becomes tied to its size, allowing for easy tuning of its optical properties.

Many companies are working on quantum-dot boosters to couple with a blue LED backlight. Some use liquid quantum-dot suspensions placed next to the LED; others use

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polymer films embedded with the nanocrystals. In both cases, the quantum dots convert some of the blue light into a mix of red and green so that less light is blocked when passing through the LCD color filters. Nanosys, a quantum dot company in Palo Alto, Calif., has partnered with 3M to sell a quantum-dot-embedded film that is part of the LCD found in devices such as the Kindle Fire HD.

Tinkering with the light-emitting parts of LCDs is not the only way to improve performance. Apple's high-resolution Retina display uses a new kind of transistor array, or backplane, based on metal oxide materials rather than conventional amorphous silicon.

"Electrons just don't move fast enough in amorphous silicon for some of the emerging display technologies, so that material is running out of steam", says John F. Wager, an electrical engineer at Oregon State University who specializes in electronic materials. The faster electrons move through a transistor material, the smaller that transistor can be. And denser packing of transistors means display makers can pack more pixels into their high-resolution displays. The metal oxide most commonly used for these new backplanes is indium gallium zinc oxide, or IGZO, which has an electron mobility 20 to 40 times greater than that of amorphous silicon.

Also, metal oxides are transparent, so they've been used in prototype displays that can give information on a car window or bathroom mirror.

So thanks to all of these new materials, we all may get long battery lives and crisp pictures from those screens we spend so much time staring at.

Katherine Bourzac is a freelance contributor to Chemical & Engineering News, the weekly newsmagazine of the American Chemical Society.

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