Self-Aligning Liquid Crystal Technique Could Simplify Manufacture of Display Devices

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A new technique for creating vertical alignment among liquid crystal molecules could allow development of less-costly flexible displays and lead to a better understanding of the factors that govern operation of the popular liquid crystal display systems.

Liquid crystals are a key component of the displays used in most laptop computers and the increasingly-popular flat panel televisions. Controlled by a network of transistors, the liquid crystals change their optical characteristics in response to electrical signals to create the text and images we see.

Manufacture of the panels is complex, requiring multiple steps that can introduce defects. Among the steps is the application of a polymer film – the so-called alignment layer – to the two pieces of glass between which the liquid crystals operate. The film, which must be rubbed after being coated on the glass, anchors the crystals with a fixed alignment. The process of rubbing to create the necessary alignment can damage some of the transistors and introduce dust, producing defects that can reduce the manufacturing yield of the panels.

By adding side chains to the polymer molecules, researchers at the Georgia Institute of Technology have found a way to eliminate the polymer rubbing step. Instead, they use the in-situ photopolymerization of alkyl acrylate monomers in the presence of nematic liquid crystals to provide a cellular matrix of liquid crystalline droplets in which the chemical structure of the encapsulating polymer controls the liquid crystal alignment.

“Small changes in the chemical nature of the polymer will change the alignment of the molecules at surfaces,” said Mohan Srinivasarao, a professor in Georgia Tech’s School of Polymer, Textile and Fiber Engineering. “It turns out that this can be done over a fairly large area, and it is reproducible. This would be an alternative way to create the alignment that is needed in these devices.”

Srinivasarao described the self-aligning of liquid crystals Sept 14 at the 232nd national meeting of the American Chemical Society in San Francisco. His presentation was part of the session “Organic Thin Films for Photonic Applications.”

Beyond the potential for simplifying the manufacture of liquid crystal devices, the self-aligning technique could also be used in new types of diffraction gratings.

Srinivasarao and collaborators Jung Ok Park and Jian Zhou have used the technique and a nematic material with negative dielectric anisotropy to fabricate highly flexible liquid crystal devices that have high contrast and fast response times – without using an alignment layer. Control is obtained by variation of the alkyl side chains and through copolymerization of two dissimilar monofunctional acrylates.

Beyond simplifying the fabrication process and potentially increasing device yield, the technique also offers other advantages. Because devices are based on vertical alignment of the liquid crystals, their "off" state can be made completely dark. In addition, the liquid crystals provide strong binding between the two substrate surfaces, making the resulting display less sensitive to mechanical deformations and pressure – ideal for flexible displays that lack the structure provided by glass plates.

Though the technique developed at Georgia Tech offers advantages over existing systems, Srinivasarao doesn't expect a change in the way the current generation of laptop screens and televisions are made. That's because existing manufacturing processes are mature and changing them probably can't be justified economically.

But beyond applications to future flexible displays, what the researchers learn from their approach could apply to the next generation of display devices based on liquid crystals.

"When we make this polymer, the molecules automatically generate the alignment," Srinivasarao said. "We are interested now in figuring out what is responsible for making that happen. We want to link the chemical nature of these polymeric materials to how the liquid crystal molecules behave at the surface."

Current displays use polyimides for an alignment layer because these materials are heat resistant and can be used over a broad range of temperatures for extended periods of time. The alkyl acrylates that Srinivasarao and his colleagues are using lack that same robustness, so material improvements would be needed before they could be used to manufacture flexible displays.

"If we can show similar results – switching times faster than 30 milliseconds and high contrast ratios – with more robust polymeric materials, then we could say that this approach would be viable," he said.

Source: Georgia Institute of Technology

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