Super-flexible liquid crystal device for bendable and rollable displays

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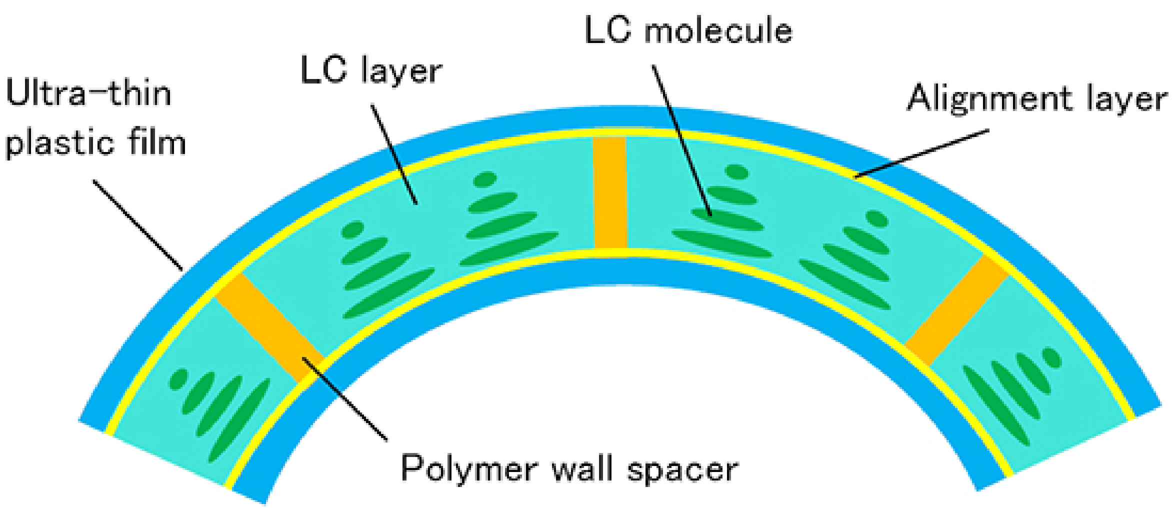


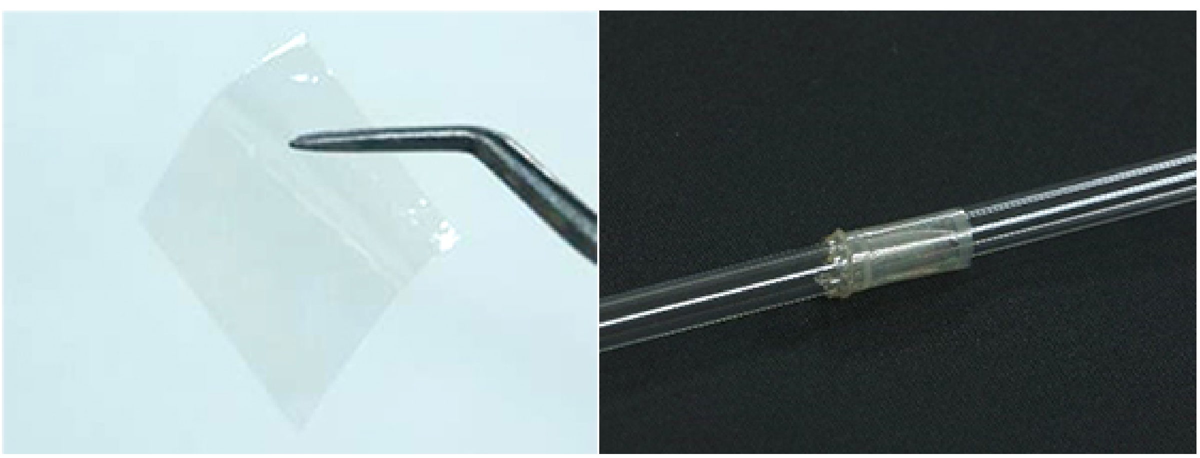
The structure of super-flexible LC device is created by ultra-thin plastic substrates bonded by polymer wall spacers. Credit: ResearchSEA

Researchers at Tohoku University have developed a super flexible liquid crystal (LC) device, in which two ultra-thin plastic substrates are firmly bonded by polymer wall spacers.

The team, led by Professor Hideo Fujikake and Associate Professor Takahiro Ishinabe of the School of Engineering, hopes the new organic materials will help make electronic displays and devices more flexible, increasing their portability and all round versatility. New usage concepts with flexibility and high quality display could offer endless possibilities in near-future information services.

Previous attempts to create a flexible display using an organic light-emitting diode (OLED) device with a thin plastic substrate were said to be promising, but unstable. The plastic substrates are poor gas-barriers for oxygen and water vapor, and the OLED materials can seriously be damaged by their gasses. As for flexible OLEDs, there has also been no device fabrication technology established so far for large-area, high-resolution and low-cost displays.

To overcome these challenges, Fujikake's research team decided to try making existing LC displays flexible by replacing the conventional thick glass substrates, which are both rigid and heavy, with the plastic substrates, because LC materials do not deteriorate even for poor gas barrier of flexible substrates.



The ultra-thin polyimide film (left) was formed by coating and debonding processes, and the roll-up resistance (right) was tested for developing super-flexible LC devices. Credit: ResearchSEA

Flexible LC displays have many advantages, such as established production methods for large-area displays. The material itself, which is inexpensive, can be mass produced and shows little quality degradation over time.

However, in conventional flexible LC displays, one important problem remains. The gap of plastic substrates (100 µm thick) sandwiching an LC layer becomes non-uniformed when the LC device is bent, causing the display image to be distorted.

In their study, Fujikake's team developed a super-flexible LC device by bonding two ultra-thin transparent polyimide substrates (10 µm thick approximately) together, using robust polymer wall spacers.

The ultra-thin transparent substrate is made using the coating and debonding processes of a polyimide solution supplied by Mitsui Chemicals. The result is a flexible sheet, similar to food-wrapping cling film.

Credit: ResearchSEA

The substrate has the attractive features of heat resistance, and the ability to form fine pixel structures, including transparent electrodes and colour filters. The refractive index anisotropy is extremely small, making wide viewing angles and high contrast ratio possible.

The polymer wall spacers bonding substrates are formed by irradiating a twisted-alignment LC layer including monomer component with patterned ultra-violet light through single thin substrate. While the substrate gap is more variable as the substrate thickness is decreased, the stabilization of ultra-thin substrates becomes possible by small pitch polymer walls.

The research team also demonstrated that the device uniformity is kept without breaking spacers even after a roll-up test to a curvature radius of 3mm for rollable and foldable applications.

The above research results show that LC displays with large-area, high-resolution and excellent stability can be as flexible as OLED displays. The super-flexible LC technology is applicable to mobile information terminals, wearable devices, in-vehicle displays and large digital signage.

Moving forward, the team plans to form image pixels and soften the peripheral components of polarizing films, and a thin light-guide sheet for backlight.

Part of the results of this research was first announced at the International Symposium on Society for Information Display held in San Francisco, USA, in May, 2016.

Provided by Tohoku University