Harnessing Flexoelectric Effects for Energy-Efficient Displays

We believe this work enhances flexoelectric analysis in nematic liquid crystals and contributes to sustainable innovation in the display industry.

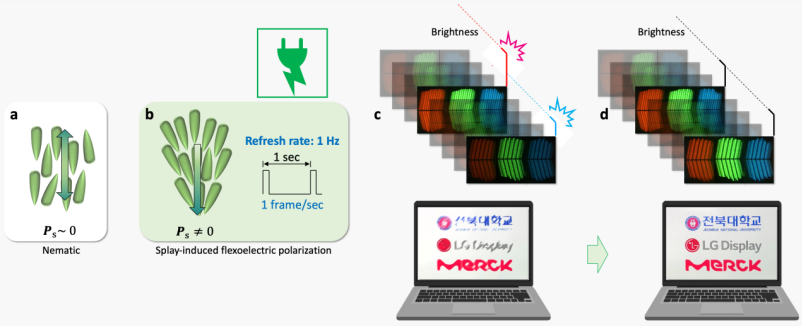

Fig 1. Schematic representation of molecular orientation and the low-frequency power-saving mode in fringe-field switching liquid crystal displays (FFS-LCDs). (a) Molecular alignment in the nematic phase. (b) Flexoelectric polarization induced at low flow frequencies.

CHENGDU, SICHUAN, CHINA, September 12, 2025 / EINPresswire.com/ -- Liquid crystal displays (LCDs) are ubiquitous today, and reducing their power consumption offers significant potential for global energy savings. However, lowering power usage often degrades display performance, which users find unacceptable. Among various LCD technologies, fringe-field switching (FFS) liquid crystal devices provide some of the highest image quality available. In an FFS device, liquid crystals are sandwiched between substrates and controlled by an applied electrical potential. In their nematic phase, liquid crystals have an almost zero net polarization due to their molecular alignment (Figure 1a).

However, under low-frequency AC operation, the interaction between mechanical deformation and the polarity of the applied voltage induces a net polarization (Figure 1b). This flexoelectric effect alters the liquid crystals' response, becoming especially pronounced when the display operates at ultra-low refresh rates, such as 1 Hz, which is sufficient for static text images and significantly reduces power consumption. Positive dielectric anisotropic liquid crystals can deliver excellent display performance and tunability, but their pronounced flexoelectric coupling can cause luminance variations between frames, resulting in image flicker (Figure 1c).

To achieve stable 1 Hz operation, it is essential to develop liquid crystal mixtures with low flexoelectric coefficients while maintaining excellent electro-optical properties. This study proposes a novel method for evaluating liquid crystal performance by combining optical and electrical measurements, a technique demonstrated here for the first time. This approach is expected to accelerate the development of next-generation, energy-efficient LCDs without

compromising the high performance that FFS technology offers.

About the Authors:
The research group led by Professor Seung Hee Lee at Jeonbuk National University, in collaboration with two industry partners: LG Display, a leading panel manufacturer, and Merck Performance Materials, a liquid crystal producer proposes an effective evaluation method for liquid crystals with low flexoelectric coefficients used in fringe-field switching (FFS) LCDs, the dominant technology in today's display applications. Conventional fringe-field switching (FFS) LCDs operate at frame rates of 60 Hz or higher (typically 120 Hz or 240 Hz) for video content and around 24 Hz for text displays. To significantly reduce power consumption, operation at 1 Hz is desirable. However, FFS LCDs especially those using liquid crystals with positive dielectric anisotropy often suffer from image flickering at such low frequencies due to the flexoelectric effect. The collaborative research led to develop the optimized liquid crystal materials that significantly reduced flickering under low-frequency operation. In the current landscape of strong competition between non-emissive LCDs and emissive displays, energy-efficient FFS LCDs offer distinct advantages to users by combining high performance with reduced power consumption.

Dr. Junho Jung's research has focused on enhancing the performance of fringe-field switching liquid crystal displays (FFS-LCDs). He is currently a senior engineer at LG Display, where he works on advanced panel technologies and cell material development.

The Information Displays and Energy Laboratory, led by Professor Seung Hee Lee, who invented and commercialized FFS LCDs during his tenure at an LCD company was established in 2001. The laboratory conducts research across a broad range of areas, including liquid crystal displays (LCDs), emissive nanomaterials and electroluminescent (EL) displays, tunable smart windows and optical films, as well as battery technologies.

Dr. MinSu Kim is a research professor in the Department of Nano Convergence Engineering at Jeonbuk National University, working with Professor Seung Hee Lee. In this study, he proposed novel methods for measuring flexoelectric coefficients, building on his extensive expertise in this field. He has published approximately six SCIE papers on this topic in journals such as Scientific Reports, Optics Express, Advanced Optical Materials, and Opto-Electronic Advances. In addition, Dr. Kim has authored more than 50 publications covering liquid crystals, polymers, and nanomaterials, with research spanning composites, self-assembly, tunable photonic devices, and organic/inorganic quantum dots for photo- and electroluminescent applications, including polarized emission materials. He is also developing strategies for internal structural control in soft matter thin membranes for energy storage applications.

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