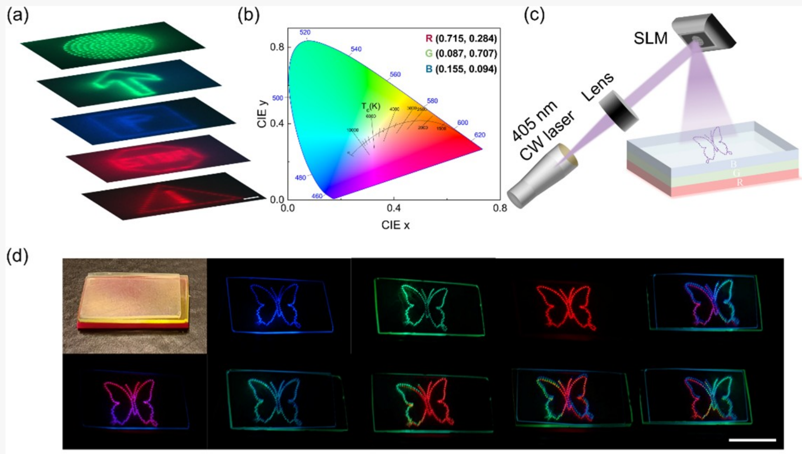
Perovskite Nanocrystals in Glass for High-Efficiency and Ultra-High Resolution Dynamic Displays

Fluoride-engineered perovskite nanocrystal glass enables high-efficiency, full-color emission and ultra-high-resolution holographic displays



A fluoride-assisted strategy enhances $CsPbX_3$ perovskite nanocrystals embedded in glass, enabling stable, high-efficiency full-spectrum emission, including improved blue output. Integrated with spatial light modulation and holography, the system achieves s

CLARE, CLARE, IRELAND, April 20, 2026 /EINPresswire.com/ -- A fluoride-assisted strategy improves perovskite nanocrystals embedded in glass, enabling stable, high-efficiency full-spectrum emission, including record blue performance. The material supports tunable RGB output under a single excitation source. Integrated with holographic techniques and spatial light modulation, it achieves ultra-high pixel density (~20,000 PPI). A vertically stacked RGB design further enhances light utilization and resolution, offering a promising route toward energy-efficient, next-generation multicolor display technologies.

With the rapid growth of digital and intelligent systems, display technologies have become a primary medium for delivering information and enabling human–machine interaction. Two metrics sit at the core of display performance: luminance and efficiency. Luminance determines how well a display remains visible under strong ambient light, whereas efficiency directly affects power consumption, battery life, and thermal management. For these reasons, improving both luminance and efficiency is a central task for next-generation display technologies.

High-quality displays also require reliable multicolor output. While in frontier applications, such as dynamic holographic displays, multicolor displays are commonly achieved by using lasers of different wavelengths-either by rapidly switching among lasers of different colors or by combining multiple beams shaped by separate spatial light modulators (SLMs), which increase system complexity and cost. Mainstream display technologies face their own limitations as well:

liquid crystal displays (LCDs) typically rely on backlights, which leads to high power consumption and low contrast, while Quantum Dots light-emitting diodes (QLEDs) have limitations in reducing manufacturing costs and meeting high-resolution requirements. A more appealing approach is to use single excitation beam to “light up” a luminescent material capable of emitting multiple colors, allowing the material to perform color conversion and reducing dependence on multiple light sources and optical paths. Yet achieving “complete color coverage, ultra-dense pixels, high luminance, and high efficiency” simultaneously remains materials-limited and challenging.

All-inorganic lead halide perovskite nanocrystals (PNCs) have been considered as ideal candidates for displays because of their outstanding photoluminescence (PL) properties–high luminescence efficiency, widely tunable optical properties, and a narrow emission bandwidth, driving the development of modern information display technologies. However, their bottleneck to commercialization is inherent environmental instability and the absence of efficient, pure-blue emitters. Embedding CsPbX3 (X = Cl, Br, I) PNCs within an inorganic glass matrix has emerged as an effective strategy to overcome this stability issue. However, simultaneously achieving high luminance and high PL quantum efficiency is still challenge due to the strong self-absorption. Therefore, a key challenge in the field is how to enhance full-spectrum emission efficiency while maintaining environmental stability—ultimately enabling ultra-high resolution multicolor display driven by single wavelength excitation.

The research group of Professor Dezhi Tan from Zhejiang University, China, proposes a new strategy to depolymerize the glass network via fluoride (introduced by NaF doping). Fluorine can loosen the originally compact three-dimensional glass framework, thereby lowering the glass transition temperature. This creates a more favorable environment for the crystallization of CsPbX3, promoting its in-situ nucleation and growth in glass, consequently, improving the photoluminescence quantum yield (PLQY) of full-spectrum PNCs embedded in the glass matrix. Experiments show that the emission wavelength of this series of glass composites can be continuously tuned from ~459 nm (blue) to 663 nm (red). Notably, the PNCs-glass samples suitable for RGB primary color applications all exhibit high PLQY values of 72.4% (648 nm), 78.3% (510 nm), and 36.0% (479 nm), respectively. In particular, PLQY of the pure-blue emitting PNCs-glass reaches the highest value reported to date, providing crucial materials support for the blue-emission component—often the most challenging part of multicolor displays.

Building on this high-performance glass platform, the team integrated the luminescent glass with an SLM and computer-generated holography (CGH) to construct a dynamic multicolor holographic display driven by single excitation wavelength (405 nm), achieving a pixel density as high as 2 × 104 PPI. More importantly, they further proposed and validated a multilayer full-color architecture based on vertically stacked RGB glasses: RGB-emitting glasses are stacked in sequence, and selective excitation of a specific color layer is realized by adjusting the laser focal depth and the phase pattern. This approach excites color fluorescent pixels while transforming RGB pixels from side-by-side planar arrangement to vertical stacking. It not only avoids the light utilization loss associated with conventional color filters, but also fundamentally improves in plane spatial utilization, allowing the full-color resolution to approach that of monochrome displays. In response to the growing demand for high-energy efficiency and ultra-high resolution in future display technologies, this work offers a highly promising new paradigm.

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