Ultra-stable, record high brightness perovskite LEDs with promising applications

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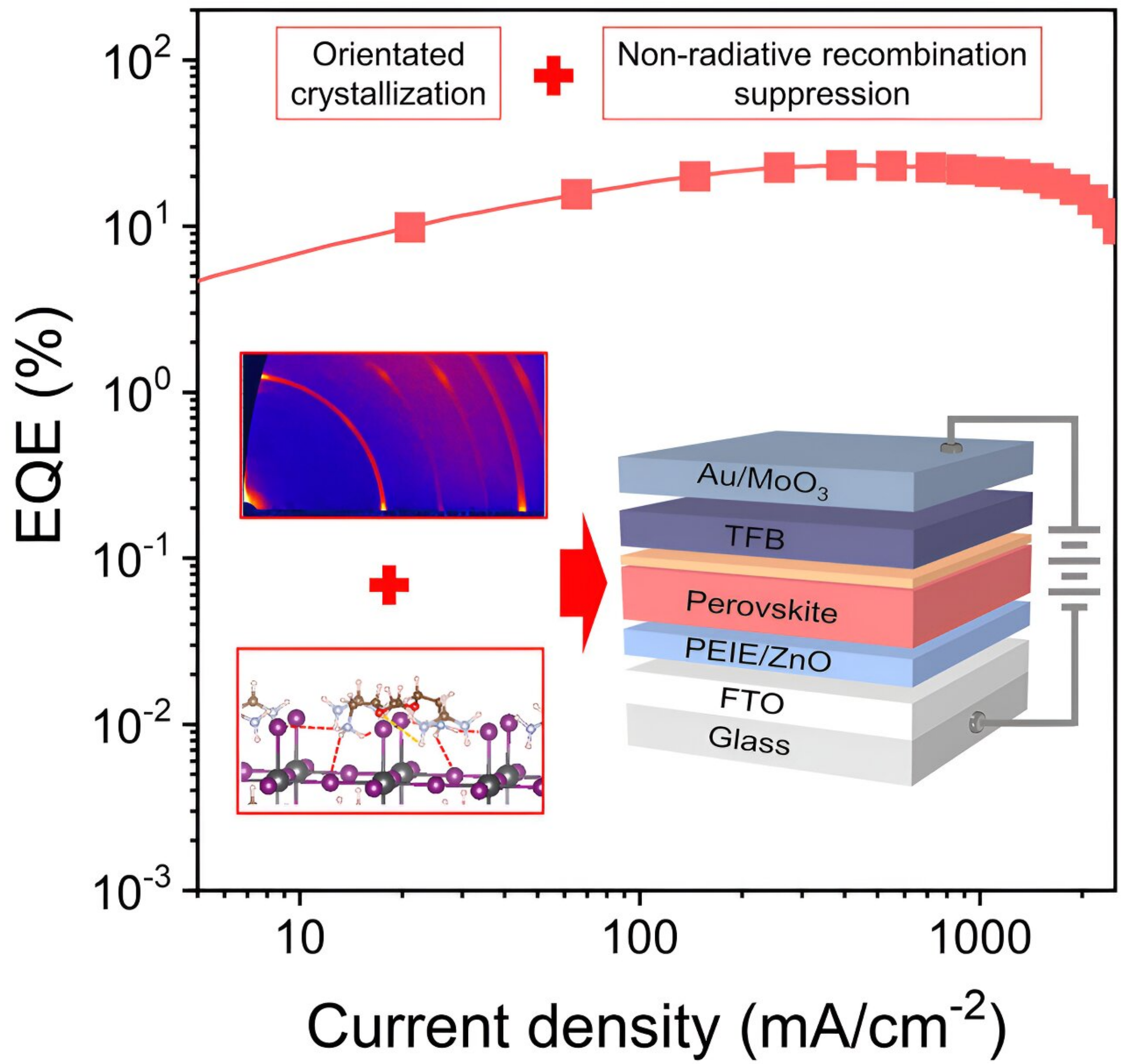

Credit: *Joule* (2024). DOI: 10.1016/j.joule.2024.03.004

Perovskite materials are significant for enhancing the development and performance of light-emitting diodes (LEDs). However, there are certain technological limitations in advancing overall device efficiency, brightness and lifetime, with the operational stability of perovskite LEDs (PeLEDs) remaining a major challenge.

Researchers from The Hong Kong Polytechnic University (PolyU) have made a breakthrough by developing a $3DFAPbI_3$ perovskite material system that enables high brightness, efficiency and a long device lifetime simultaneously.

Prof. Li Gang, Sir Sze-yuen Chung Endowed Professor in Renewable Energy, Chair Professor of Energy Conversion Technology of the Department of Electrical and Electronic Engineering of PolyU, together with Postdoctoral Fellow Dr. Zhiqi Li, Research Assistant Professor Dr. Zhiwei Ren, and the rest of the research team, have engineered a novel technology using an alkyl-chain-length-dependent ammonium salt molecule modulation strategy.

They elucidated the roles of alkylammonium salts in managing crystal orientation, controlling grain size, suppressing non-radiative recombination, and thereby enhancing device performance. This represents a critical leap toward future applications and commercialization of efficient and ultra-stable PeLEDs with record brightness.

The research team have achieved efficient, ultra-bright, and stable PeLEDs simultaneously, with high Electroluminescence External Quantum Efficiency of 23.2%, a record radiance of 1,593 W sr^{-1} m^{-2}

and a much improved record lifetime of 227 h (at a high current density of 100 mA cm^{-2}). This demonstrates the best performance for DC-drive near-infrared PeLEDs at high-brightness and stability levels.

Their research "Grain orientation management and recombination suppression for ultra-stable PeLEDs with record brightness," has recently been published in the journal *Joule*.

Prof. Li Gang said, "This strategy suggests that PeLEDs are not only high-efficiency devices in the laboratory but also promising candidates for commercial high-brightness lighting and display applications, competing with commercially available quantum-dot-based and organic LEDs."

The research team revealed that the performance of PeLEDs is strongly affected by the balance among oriented crystallization, grain size control and suppression of non-radiative recombination. The key to resolving this dilemma lies in adjusting the molecular interaction between the long-chain alkylammonium salts and perovskite nuclei.

Alkylammoniums promote oriented crystallization of perovskite film for lighting, while the molecular interaction between alkylammonium and perovskite affects PeLEDs performance. Notably, the team has successfully utilized molecular engineering of long-chain alkylammonium salts to modulate crystallization kinetics. This breakthrough strategy enables the production of high-efficiency and ultra-brightness near-infrared PeLEDs with ultralong stability, even under large current excitation.

In the development of LEDs, PeLEDs possess substantial advantages, including pure color, a wider display color gamut range, cost effectiveness and solution processability, offering greater flexibility in production. The team's discovery contributes significantly to the advancement of PeLEDs and their technological impact.

More information: Zhiqi Li et al, Grain orientation management and recombination suppression for ultra-stable PeLEDs with record brightness, *Joule* (2024). [DOI: 10.1016/j.joule.2024.03.004](https://dx.doi.org/10.1016/j.joule.2024.03.004)

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