GIST-Seoul National University, develop high-efficiency green perovskite LED achieving world-class performance by simultaneously controlling light-emitting body and interface defects

- Introduction of nucleophilic additives, simultaneous suppression of internal defects in perovskite emitters and interface defects between the emitting layer and the hole transport layer... Achieving the highest external quantum efficiency (23.46%) among single cation-based green perovskite LEDs

- “Both emitter and interface defects can be effectively controlled with just one additive... Expected to contribute to the development and commercialization of high-efficiency perovskite LEDs” Published in the international academic journal《Small》

The Gwangju Institute of Science and Technology (GIST, President Kichul Lim) announced that a joint research team led by Professor Hobeom Kim of the Department of Materials Science and Engineering and Professor Tae-Woo Lee of the Department of Materials Science and Engineering at Seoul National University developed a green perovskite LED* with significantly improved performance by simultaneously controlling internal defects* of the perovskite light-emitting body and interface defects between the light-emitting layer and hole transport layer* using a strong nucleophilic substance.

* defect: A part that deviates from the ideal atomic arrangement in the crystal structure. Perovskite defects are known to impair the optoelectronic properties and structural stability of perovskite materials.

* perovskite LED: An LED that uses metal halide perovskite materials as the light-emitting layer. It is attracting attention as a next-generation display device due to its high color purity, ease of process, and high luminous efficiency.

* hole transport layer: A layer inserted between the anode and the light-emitting layer to ensure that the holes injected from the anode are well injected into the light-emitting layer.

Perovskite LEDs are attracting attention as next-generation display devices following OLED and QLED due to their high color purity, ease of process, and high luminous efficiency.

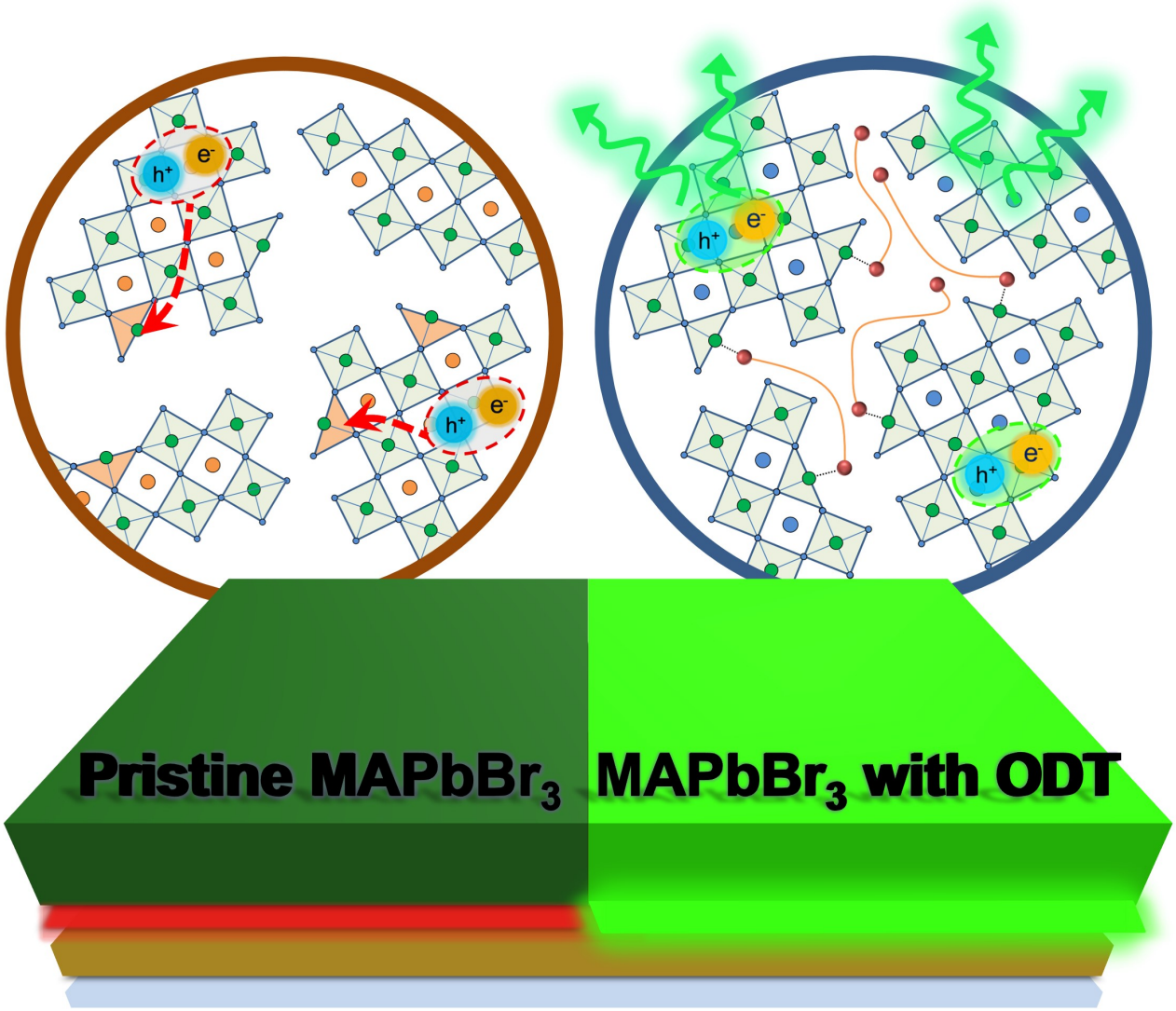
However, internal defects in the perovskite emitter and defects at the interface between the emitting layer and the hole transport layer have been known to be major factors that hinder the luminous efficiency and stability of perovskite LEDs.

The research team simultaneously controlled defects within the perovskite crystal and defects at the interface between the emitting layer and the hole transport layer by introducing a strong nucleophilic substance, ODT (1,8-octanedithiol), and developed a high-performance perovskite LED device by applying this.

ODT with high nucleophilicity can effectively control defects through interaction with uncoordinated lead ions (Pb^{2+}) in $MAPbBr_3$ perovskite used as a light-emitting body.

In addition, ODT can spatially confine excitons by making perovskite crystal grains smaller, and it is mainly located at the interface between the emitting layer and the hole injection layer, thereby preventing exciton annihilation at the interface, thereby improving the luminescence properties of perovskite.

* exciton: A quasi-particle in which electrons and holes are combined as a single particle by electrical attraction, and emit light when recombined.



▲ Schematic showing the improvement of luminescence characteristics of MAPbBr3 perovskite through the introduction of ODT. In pure MAPbBr3, excitons are annihilated by internal defects and interface defects in the perovskite (left). ODT controls internal defects in MAPbBr3 perovskite, spatially confines excitons within the crystal, and prevents exciton annihilation between the perovskite and the hole transport layer, thereby improving luminescence characteristics (right).

The research team applied the perovskite light-emitting diode (ODT) to an LED device and achieved an external quantum efficiency* of 23.46%, the world's highest among single-cation-based green perovskite LEDs.

* exciton: A quasi-particle in which electrons and holes are combined as a single particle by electrical attraction, emitting light when recombined.

* external quantum efficiency: The ratio of injected electrons and holes that are converted into light. A key performance indicator of LED devices, if it exceeds 20%, it is considered an excellent perovskite LED.

Professor Hobeom Kim said, "This study effectively controls not only defects in the perovskite crystal but also defects at the interface between the emitting layer and the hole transport layer through a single additive. It is expected to help develop and commercialize high-efficiency perovskite light-emitting diodes in the future."

This research, led by Professor Hobeom Kim of the Department of Materials Science and Engineering at GIST and Professor Tae-Woo Lee of the Department of Materials Science and Engineering at Seoul National University, was conducted with the support of the National Research Foundation of Korea (NRF) and the European Union Horizon 2020 research and innovation program.

The results of this study were published online in the international academic journal Small on September 25, 2024.