

**Section of
Public Affairs**Mi-Yeon Kim
Section Chief
(+82) 62-715-2020Nayeong Lee
Senior Administrator
(+82) 62-715-2024**Contact Person
for this Article**Dr. Chang-Lyoul Lee, Researcher
Advanced Photonics Research Institute
(+82) 62-715-3347**Release Date**

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Dr. Chang-Lyoul Lee's joint research team develops perovskite thermochromic device utilizing quantum confinement effect at the atomic level

- GIST (President Kiseon Kim) – Advanced Photonics Research Institute (APRI, Director Hyyong Suk) Dr. Chang-Lyoul Lee and Ajou University Professor Jong-hyun Kim have successfully implemented the quantum confinement effect * by isolating the crystalline parts involved in luminescence into Cs atom ** by controlling the crystal structure of the perovskite material.

* Quantum confinement effect: changing electrical and optical properties of a material by reducing the size of a specific inorganic compound to several nanometers

** Cs atom: cesium atom

- The perovskite material synthesized from this research achieves high luminous efficiency and high temperature stability because of the quantum confinement effect and the high crystal structure stability, and this makes it possible to use it as a temperature sensor through thermal discoloration.
- Thermal distortion is a characteristic of changing the color of the material according to the temperature change. When materials with thermal change characteristics are used, temperature change

can be checked simply without additional power. Therefore, temperature sensors can easily be used in everyday life by utilizing the heat sensitive color characteristics of the perovskite developed through this study.

- Perovskite materials are attracting attention as the next generation electronic materials due to their excellent electrical properties, high extinction coefficient, and ease of emission wavelength control. However, the perovskite material of the existing CsPbX_3 ($\text{X} = \text{Cl}, \text{Br}, \text{I}$) crystal structure has low thermal stability and low binding energy of electron-hole pairs, which are easily dissociated by external heat. Therefore, applications for the perovskite material as a heat-sensitive color changing element was very limited.

- The researchers synthesized perovskite material with a Cs_4PbBr_6 crystal structure that had high thermal stability whose crystal structure does not change with temperature. The Cs_4PbBr_6 crystal structure showed a quantum confinement effect because the luminescent region was isolated at the atomic level within the three-dimensional structure as the crystal part of the octahedron in which the luminescence occurs is spatially separated by the Cs atom. Through the quantum confinement effect, Cs_4PbBr_6 perovskite material exhibited high luminescence efficiency due to an increase in the binding energy of electron-hole pairs and less dissociation of electron-hole pairs at room temperature.
 - Cs_4PbBr_6 perovskite material maintains stable luminescence characteristics as the temperature rises. It has a rapid luminescence efficiency degradation characteristic through electron-hole pair dissociation at a high temperature of 100° C or more, allowing application of heat-modified temperature sensors with a contrast of more than 20 times higher.

- GIST Dr. Chang-Lyoul Lee said, "By controlling the crystal structure of perovskite materials, the application of materials with high luminous efficiency and high thermal stability at room temperature

has been expanded to thermal discoloration devices of perovskite materials."

- Ajou University Professor Jong-hyun Kim said, "This research suggests another principle to develop thermally stable light-emitting perovskite materials, and it is expected to be used as a basic technology in the development of thermostable perovskite displays in the future."

□ This research was led by GIST APRI Dr. Chang-Lyoul Lee (co-corresponding author), Ajou University Professor Jong-hyun Kim (co-corresponding author), and GIST APRI Dr. Jin Woo Choi (first author) and was supported by the Basic Science Research Program through the National Research Foundation of Korea, which is funded by the Ministry of Education, and by the Research on Advanced Optical Science and Technology at GIST. The research was published on February 16, 2019, in *Nanoscale*, a renowned academic journal in the field of chemistry.

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