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Senior Researcher Chang-Lyoul Lee's team improves perovskite quantum dot stability for implementation of high-resolution displays

▫ GIST (Gwangju Institute of Science and Technology, President Kiseon Kim) Advanced Photonics Research Institute (Director Yeung Lak Lee) Senior Researcher Chang-Lyoul Lee's research team developed a perovskite quantum dot material with significantly improved atmospheric and chemical stability by suppressing the generation of surface crystal defects through the addition of photo-initiators* and photo-crosslinking** ligands***. In addition, a white electroluminescent device with a resolution of 1 micrometer (um) was realized through an inkjet printing process.

* photo-initiator: a substance that helps the crosslinking reaction of a photo-crosslinking material (polymer or ligand) occur efficiently by forming radicals under UV or visible light

** photo-crosslinking: a chemical reaction that hardens when exposed to light, and in the case of a material that has undergone a photocrosslinking reaction, it exhibits high stability against moisture, oxygen, and light energy

*** ligands: surfactants with various carbon lengths are attached to the surface of quantum dots so that quantum dots can be stably dispersed in solution

- Perovskite* quantum dot material has recently been spotlighted as a next-generation display material that can replace organic light emitting diodes (OLEDs) due to its high luminous efficiency and high color purity.

  - However, perovskite quantum dot materials have the disadvantage of ionic bond properties that make it difficult to maintain luminescence efficiency and color purity for a long period of time and difficult to apply photolithography semiconductor processes for high-resolution display implementation.

    * perovskite: rather than a name for a specific substance, it refers to a substance that has a cubic structure consisting of cations of two elements of different sizes and anions combined with them.

- This research team improved the stability of the perovskite quantum dot solution and thin film by adding a photo-initiator and a photo-crosslinking ligand to the perovskite quantum dot solution synthesized through the precipitation method. The added photo-initiator and photo-crosslinking ligand suppressed the generation of surface defects that deteriorated the light emitting properties and structural stability of the perovskite quantum dot material through ligand equilibrium* state control such as ligand dissociation and binding.

    * ligand equilibrium: It refers to a phenomenon in which a ligand repeats binding and dissociation between the surface of a quantum dot and a solution. At this time, because the speed of change proceeding in two different directions is the same, it is a state in which it appears that no change is occurring.

  - Through the photo-crosslinking reaction of the ligand bound to the surface of the perovskite quantum dot using UV exposure, the crystallinity of the material and the stability of polar molecules such as moisture and oxygen on the thin film were greatly improved as well as the resistance to polar solvents. A circular pattern with a resolution of 20 micrometers (um) was implemented using the stability difference.

- In addition, green and red perovskite quantum dot inks capable of inkjet printing were developed by controlling the rheological elements of ligands in perovskite

quantum dot solutions, and a white electroluminescent device having a resolution of 1 micrometer (um) was implemented.

- The photo-crosslinking ligand treatment method has an advantage that it can produce perovskite quantum dot thin films that maintain high luminous efficiency and color purity for a long time by suppressing the generation of defects on the perovskite quantum dot surface and improving thin film uniformity and atmospheric stability through photocrosslinking.

- GIST Dr. Chang-Lyoul Lee said, "The development of a high-efficiency perovskite quantum dot material with long-term stability through the introduction of a newly developed photo-crosslinking ligand system and the implementation of an electroluminescent device with 1 micrometer (um) resolution using inkjet printing will be the future of perovskite quantum dot materials. It is an important step forward for the commercialization of next-generation displays."

- This research was led by GIST Dr. Chang-Lyoul Lee (corresponding author) and GIST Dr. Hanleem Lee (first author) with support from the Basic Science Research Program of National Research Foundation of Korea and the GIST Research Institute and was published online on May 3, 2021, in *Advanced Materials*, a renowned journal in the field of materials.

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