Long-range order enabled stability in quantum dot light-emitting diodes

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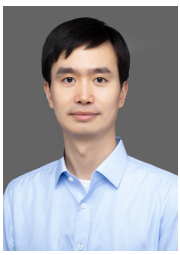
Light-emitting diodes (LEDs) based on perovskite quantum dots have produced external quantum efficiencies (EQEs) of over 25% with narrowband emission, but these LEDs suffer from limited operating lifetimes. We posit that poor long-range ordering in perovskite quantum dot (QD) films – variations in dot size, surface ligand density and dot-to-dot stacking – inhibits carrier injection, resulting in inferior operating stability due to the large bias required to produce emission in these LEDs. Here we report a chemical treatment to improve the long-range order of perovskite QD films: the diffraction intensity from the repeating QD units increases 3-fold compared controls. We achieve this using a synergistic dual ligand approach: an iodide-rich agent (aniline hydroiodide) for anion exchange and a chemically-reactive agent (bromotrimethylsilane) that produces a strong acid which in situ dissolves smaller QDs to regulate size and more effectively removes less conductive ligands to enable compact, uniform and defect-free films. These films exhibit high conductivity (4 Ч 10-4 S m-1), which is 2.5-fold higher than that of the control, and represents the highest conductivity recorded among perovskite QDs. The high conductivity ensures efficient charge transportation, enabling red perovskite QD-LEDs that generate a luminance of 1000 cd m-2 at a record-low voltage of 2.8 V. The EQE at this luminance is over 20%. Furthermore, the stability of the operating device is 100x better than prior red perovskite LEDs at EQEs of >20%.



Short Bio:

Ya-Kun Wang obtained his Ph.D. in Chemistry from Soochow University (International Visiting Graduate Student in Edward Sargent group from 2018-2020). He is now an associate professor at Soochow University. He has published >50 peer-reviewed journal papers, including first-author papers in *Nature*, *Nature Nanotechnology*. His research focuses on leveraging emerging quantum dots (QDs) to develop high-performance light-emitting diodes (LEDs) in the shortwave IR region.