Discrete Emissive States of Quantum Dot Electroluminescence Device

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Core/shell colloidal quantum dot (QDs) are one of emerging materials in electroluminescence (EL) device for future information displays owing to facile band gap (E_g) tunability, high color purity and quantum efficiency. However, the biphasic morphology of QDs isolated by wide E_g shells makes emissive states in individual QDs discrete and unable to exchange carriers injected. We unveil the discrete nature of QDs in EL devices by manipulating carrier injection events. Adopting hole transport layers with varied ionization energy enable holes to be injected to the entire QD ensembles, but electrons to be introduced to specific QDs. The red-shifted and asymmetric EL spectra represent selective injection of electrons into narrow E_g QDs with smaller electron injection barriers. The spectrally-resolved, E_g-dependent EL intensity – current reveals that the wide E_g QDs become optically dark due to excess holes while the narrow E_g QDs accepts electrons and holes in balanced manner. Our finding suggests the general mechanistic picture on QLEDs operation that is governed by the nature of individual QDs, not by averaged characteristics of ensembled QDs.