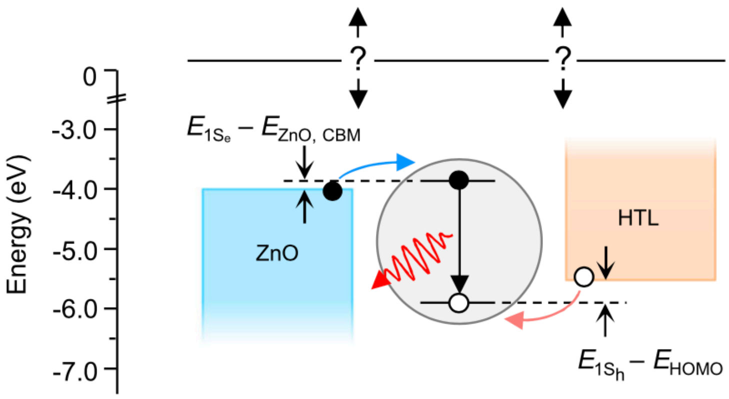
Enhancing Quantum Dot Light Emitting Devices: Sub-Bandgap Turn-On and Electrobrightening via Advanced Charge Transport Layer Engineering

Doh C. Lee[1]

1 – Korea Advanced Institute of Science and Technology (KAIST), 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Korea

dclee@kaist.edu

Over the past decade, QD-LEDs have experienced remarkable improvements in device efficiency, yet the mechanism behind barrierless hole injection at voltages below the bandgap remained elusive. Our research team has identified the Fermi level alignment, influenced by surface states, as the key factor enabling this phenomenon. This alignment, coupled with the macroscopic electrostatic potential gain from the restructured energy environment, facilitates hole injection into quantum dots. Contrary to previous assumptions, we demonstrate that the energy level alignment significantly outweighs the local carrier injection barrier alteration caused by the Coulombic force of a charge in quantum dots. Our findings elucidate the mechanism of barrierless carrier injection in QD-LEDs and propose a broader design principle for efficient electroluminescent systems utilizing nanocrystal emitters. Additionally, I will discuss the electrobrightening effect observed in quantum dots using ZnMgO as an electron transport layer instead of ZnO.



$$V_J \approx V_L \approx E_g/e + (E_{1S_e} - E_{CBM,\,ZnO})/e + (E_{1S_h} - E_{HOMO,\,HTL})/e \geq E_g/e$$

References

[1] H. Lee, B. G. Jeong, W. K. Bae, D. C. Lee, J. Lim, *Surface state-induced barrierless carrier injection in quantum dot electroluminescent devices*. Nature Communications **12**, 5669 (2021).