IW-004

Eco-Friendly Light Emitting Diodes Based on Graphene Quantum Dots and III-V Colloidal Quantum Dots

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In this talk, I will introduce two topics. The first topic is the polymer light emitting diodes (PLEDs) using graphene oxide quantum dots as emissive center. More specifically, the energy transfer mechanism as well as the origin of white electroluminescence in the PLED were investigated. The second topic is the facile synthesis of eco-friendly III-V colloidal quantum dots and their application to light emitting diodes.

Polymer (organic) light emitting diodes (PLEDs) using quantum dots (QDs) as emissive materials have received much attention as promising components for next-generation displays. Despite their outstanding properties, toxic and hazardous nature of QDs is a serious impediment to their use in future eco-friendly opto-electronic device applications. Owing to the desires to develop new types of nanomaterial without health and environmental effects but with strong opto-electrical properties similar to QDs, graphene quantum dots (GQDs) have attracted great interest as promising luminophores. However, the origin of electroluminescence (EL) from GQDs incorporated PLEDs is unclear. Herein, we synthesized graphene oxide quantum dots (GOQDs) using a modified hydrothermal deoxidization method and characterized the PLED performance using GOQDs blended poly(N-vinyl carbazole) (PVK) as emissive layer. Simple device structure was used to reveal the origin of EL by excluding the contribution of and contamination from other layers. The energy transfer and interaction between the PVK host and GOQDs guest were investigated using steady-state PL, time-correlated single photon counting (TCSPC) and density functional theory (DFT) calculations. Experiments revealed that white EL emission from the PLED originated from the hybridized GOQD-PVK complex emission with the contributions from the individual GOQDs and PVK emissions. (Sci Rep., 5, 11032, 2015).

New III-V colloidal quantum dots (CQDs) were synthesized using the hot-injection method and the QD-light emitting diodes (QLEDs) using these CQDs as emissive layer were demonstrated for the first time. The band gaps of the III-V CQDs were varied by varying the metal fraction and by particle size control. The X-ray absorption fine structure (XAFS) results show that the crystal states of the III-V CQDs consist of multi-phase states; multi-peak photoluminescence (PL) resulted from these multi-phase states. Inverted structured QLED shows green EL emission and a maximum luminance of ~45 cd/m2. This result shows that III-V CQDs can be a good substitute for conventional cadmium-containing CQDs in various opto-electronic applications, e.g., eco-friendly displays. (Un-published results).

Keywords: Graphene Quantum Dots, III-V Colloidal Quantum Dots, Eco-Friendly Light Emitting Diodes