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ABSTRACT

THE DEVELOPMENT OF PHOSPHORESCENT NANoclusters FOR
LIGHT EMITTING DiODES

By

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Organic light emitting diodes (OLEDs) are undoubtedly the most mature organic optoelectronic devices as they have been commercialized in cell phones, televisions, and wearable electronics displays and may potentially become a leading solid-state lighting technology. OLEDs continue to attract new applications and their market value is expected to grow to 50 billion USD by 2023 owing to their lower power consumption, ultra-thin form factor, fast response time, and unrivaled color rendering properties. However, several challenges are preventing OLEDs from achieving their full potential. These include a decrease in performance at higher brightness, lower light outcoupling efficiency, limited efficiency in the near-infrared, and the high cost associated with the heavy metal complex based phosphorescent emitters. In the first part of this thesis we seek to understand the factors determining recombination dynamics of charge carriers in OLEDs as they play a crucial role in device performance and lifetime. We develop a method utilizing sensing layers to probe recombination in OLEDs with various emissive layer architectures. We identify the factors that control recombination and provide profiles that can improve the quantum efficiency at higher brightness. The second aim of this thesis is to develop efficient, inexpensive phosphorescent emitters as alternatives to the widely used platinum and iridium complexes. We therefore have developed novel earth abundant metal halide based phosphorescent nanoclusters and demonstrate their application in optically and electrically pumped nanocluster light emitting diodes (NCLEDs). We utilize transient dynamics and density functional theory (DFT) calculations and identify host quenching and exciton formation efficiency as key factors for improving electrically pumped devices. Based on this understanding, we have developed molybdenum nanoclusters and report the highest electrically-driven NCLED efficiency through modification of apical ligands. This work demonstrates the promising potential of phosphorescent, earth abundant and inexpensive metal halide nanoclusters that can extend deeper into the near-infrared and expand the catalog of emitters for low-cost optoelectronic applications.
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