

High Efficiency Low Color Temperature White Organic  
Light-Emitting Diodes by Exciton Management  
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White organic light-emitting diode (WOLED) is presently under extensive research and development globally as a promising new generation light source to replace energy-wasting incandescent bulbs and non-eco-friendly fluorescent tubes. One of the main challenges in front of WOLED is to obtain high energy efficiency and psychologically-friendly low color temperature concurrently to make the technology competitive against alternative technologies such as inorganic light-emitting diodes. In this work, we demonstrate all-phosphor, multi-colored WOLEDs using a novel design principle featuring intra-zone energy transfer, i.e. energy transfer within common organic emissive layers, to achieve remarkable external quantum efficiencies (EQEs) of  $> 20\%$  at low color temperatures of  $< 3300\text{K}$  using commercially available standard phosphors. The EQEs achieved are among the highest reported to date among WOLEDs of single or multiple emitters exhibiting such low color temperatures, which represent a considerable advancement for WOLEDs in solid-state lighting.