Rare-Earth-Free Silicon-Based Organic Molecules for Solid-State Lighting Applications

Zhang, Lisa (School: Providence High School)

Commercial white-light LED lamps are typically made with InGaN blue LEDs coated with yellow phosphors containing rare-earth elements, such as cerium-doped yttrium aluminum garnet (YAG:Ce3+). It is of great interest to develop rare-earth-free phosphors to reduce the synthesis cost and more importantly the long-term adverse effects on the environment associated with the extraction and processing of the rare-earth materials. In recent years, a new group of Si based molecules, namely Si(bzimpy)2 and its analogs, has been developed for applications in OLEDs and OPVs where the molecules serve as active layers (either as emitters or absorbers), with prototype devices successfully demonstrated. In this project, based on the observed strong emission under UV illumination, I proposed to explore a very different way of using these molecules, i.e., using them as phosphors for the blue LEDs. The molecules were embedded in silicone to form the phosphor composites which were then placed on top of the blue LED chip to examine the color mixing of the blue LED light and the photoluminescence of the molecules excited by the blue light. For Si(Me4bzimpy)2, white light emission of different color temperatures, from warm to cool white, have been achieved by adjusting the phosphor layer thickness, with their emission spectra measured and white-light LED lamps demonstrated. This molecule has great potential to become a highly efficient new phosphor that is also earth-abundant, non-toxic, and low-cost for applications in solid-state lighting and display.

Awards Won:
Fourth Award of $500