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Blue LED Developed by Si-Quantum-Dot/Polymer Hybrid Material: High Current Density and Optical Power Density

Yunzi Xin,[1] Kazuyuki Nishio,[1] and Ken-ichi Saitow[1,2]
[1]Graduate School of Science, Hiroshima University
[2]Natural Science Center for Basic R&D (N-BARD), Hiroshima University

A light-emitting diode (LED) consisting of organic polymer and inorganic materials has recently attracted much attention in material science and industrial applications. Such a LED is called hybrid LED (HLED) and expected as a next-generation luminescent device. This is because the easy solution process of polymer and the stability of inorganic material are accomplished at the same time. In addition, the luminescence wavelength of quantum dot (QD) can be tuned easily from UV to near IR region by changing the size. Thus, the QD/Polymer HLED could generate almost any colors by utilizing solution processes. On the other hand, Silicon (Si), as one of the most abundant elements on the earth, becomes an efficient light emitter under a low-dimensional system. Here, we developed a blue HLED, composed of both Si-QDs and conductive polymer, using solution processes.

The Si-QDs were synthesized by pulsed laser ablation, and we have reported the Si-QDs photoluminescence (PL) in RGB colors or white light continuum [1, 2]. The size distribution of Si-QDs dispersed in a solution was measured by dynamic light scattering. The Si-QDs concentration was analyzed by an inductively coupled plasma optical emission spectrometer. The PL of Si-QDs was measured with a fluorescence spectrometer. The HLED we fabricated consisted of ITO anode, PEDOT:PSS as a hole injection layer, PolyTPD as a hole transport layer, the emissive layer of Si-QDs, Alq3 as an electron transport layer, and Al cathode. The optimized structure of HLED was investigated as functions of annealing condition, film thickness, and Si-QDs concentration. As a result, we succeeded in obtaining the electroluminescence from the Si-QDs at the low applied voltage (< 6 V). The optical output power of the Si-QD/polymer HLED was about 20 times higher than that of a reported Si-QD/polymer HLED [3]. Note that the HLED shows the blue luminescence. In addition, the maximum current density at 6 V was 170 mA/cm^2, whose value was 85 times larger than the reported data [3]. Such the high current density and optical power were attributed to the efficient emission of Si-QDs and high carrier mobility in the hybrid films.

Reference

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