Nanoimprint mold fabrication by nanosphere self-assembly for QLED light extraction

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Quantum dot light-emitting devices (QLED) have attracted a lot of research interests in recent years due to its attractive features like tunable emission wavelength, high color purity and high stability[1]. These properties make QLED promising to realize a large color gamut for next generation flat-panel displays[2]. In the past decade, research progress on new material development and device structure designs have improved QLED performance tremendously. However, in terms of light extraction improvement, most researches only focus on design of nanostructures on devices external surface[3,4]. Despite this strategy works effectively in enhancing light extraction efficiency (LEE), it also increases the surface roughness of QLED, which adds to potential difficulties in practical application. Meanwhile, researchers also investigate using internal nanostructures to enhance LEE[5], the difficulties lie in structure design and high fabrication cost.

In this work, we present a fabrication strategy combining low-cost nanosphere self-assembly and nanoimprinting technology to obtain large-area nanoimprinting mold for LEE enhancement in QLED. Finite-Difference Time-Domain (FDTD) simulations are conducted to ensure that the internal nanostructures can achieve higher LEE compared to QLED without the internal nanostructures. The nanoimprint mold fabrication is done by templating from large-area self-assembly of monolayer polystyrene micro and nanospheres. Close-packed nanospheres are firstly prepared on silicone substrate by a LB self-assembly equipment, followed by nickel deposition on the nanospheres' surface. The convex surface pattern of the self-assembled nanosphere monolayer is then transferred to the nickel mold after electroplating. Subsequently the nickel mold is used to replicate the pattern on soft substrates (like PC, PDMS) via roll-to-roll nanoimprinting. After the nanoimprinting step, a proper metal is evaporated on the patterned soft substrate to form an electrode substrate for the QLED.

We will report experimental details and results on the fabrication of large-area nanoimprint mold by nanosphere self-assembly. We also report the fabrication and characterization of the QLED with the internal nanostructures. The large-area nanoimprint mold can also be used in other low-cost optical applications such as highly reflective surface, micro-lenses array and structural color surface.

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