以表面粗化及藍寶石基板幾何形狀化技術提升氮化鎵覆晶發光二極體之外部量子效率

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摘要

在本篇論文中,主要是探討覆晶發光二極體在藍寶石背面製作微米柱陣列以及在藍寶石背面製作幾何形狀化結構的製程技術及特性量測。在第一部分,我們成功的利用乾蝕刻製程技術在藍寶石背面製作出微米柱陣列,使得光萃取效率得以提升。微米柱的深度分別是 1.1、1.8、2.7 和 3.2 微米,在量測結果部分,發光波長在 460 奈米下,有製作微米柱陣列的覆晶發光二極體的光輸出增加了 10%~68%相較於傳統的覆晶發光二極體。

在第二部分中為了提升光功率輸出,我們成功的利用化學濕蝕刻製程技術在藍寶石背面製作出幾何形狀化結構,經過濕蝕刻製程技術,我們在藍寶石背面蝕刻出(1-106)、(11-25)和(1-102)的晶格面,相較於(0001) c 軸而言角度分別是 30°、50°和 60°,深度有 100 微米左右,這些晶格傾斜面和相當厚的藍寶石視窗層對光萃取效率的提升有很大的幫助。在量測的結果部分,在電流 350 毫安培下,有製作幾何形狀化的覆晶發光二極體的光功率輸出增加了 55%。

Efficiency enhancement of GaN based FC-LEDs by surface roughness and geometric sapphire shaping structures

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Abstract

In the thesis, we report the flip-chip light-emitting diodes (FC-LEDs) with micro-pillar-array structure and the FC-LEDs with geometric oblique sapphire structure. In the first part, the micro pillar arrays structure is formed on the bottom side of sapphire substrate by dry etching process to increase the light-extraction efficiency. The light output power of the FC-LED is increased by 68% for a 3.2 μm textured micro pillar on the bottom side of the sapphire substrate. Our work offers promising potential for enhancing output powers of commercial light-emitting devices.

In the second part, the sapphire shaping structure is formed on the bottom side of sapphire substrate by chemical wet etching technique for light extraction purpose. The crystallography-etched facets are (1-106), (11-25) and (1-102) plane against the (0001) c-axis with the angles range between ~30°-~60°. These large slope oblique sidewalls and greatly thick sapphire windows layer are useful for enhancing light extraction efficiency. The light output power of sapphire shaping FC-LEDs (SSFC-LEDs) was increased 55 % (@ 350 mA current injection) compared to that of conventional FC-LEDs (CFC-LEDs).