利用分子束磊晶系統研究氮化鎵磊晶成長在
藍寶石(0 0 0 1)和矽(1 1 1)基板上

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摘要

利用分子束磊晶系統已經成功的將高品質的氮化鎵磊晶成長在藍寶石和矽基板上。為了在藍寶石基板上獲得高品質的氮化鎵磊晶層 ，藍寶石表面的氮化處理是必須的。我們也研究氮化處理的溫度對氮化鎵磊晶層品質的影響，發現高溫的氮化處理可以使穿透差排密度大幅的減低。接著，我們利用兩種方法來進一步降低氮化鎵磊晶層的穿透差排密度：偏角度的藍寶石基板和在氮化鎵磊晶層中插入氮化鋁中間層。

我們利用含有鋁預沉積層之氮化鋁/α相氮化矽緩衝結構和新穎的氮化鎵奈米柱緩衝層將氮化鎵磊晶成長在矽基板上。鋁預沉積層可以大幅改善氮化鎵磊晶成長在矽基板上的結晶品質，並且在成長氮化鋁緩衝層時同時形成單晶的α相氮化矽，氮化鋁/α相氮化矽緩衝結構可以降低晶格的不匹配，進而獲得高品質的氮化鎵磊晶層。氮化鎵奈米柱的深寬比決定於成長溫度和氮/鎵比例。我們發現在高度氮富含的條件下，氮化鎵奈米柱有較大的深寬比，並且氮化鎵奈米柱的特徵螢光光譜(3.30~3.40eV)有藍位移至高能量的現象發生。接著我們利用分子束磊晶系統和有機金屬化學氣相沉積系統分別在氮化鎵奈米柱緩衝層上磊晶成長出高品質無殘餘應力的氮化鎵磊晶層。

Study of GaN Epitaxial Growth on Sapphire (0 0 0 1) and Silicon (1 1 1) by Molecule Beam Epitaxy System

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ABSTRACT

The high quality of GaN epilayer successfully was grown on sapphire and silicon substrates by Molecule Beam Epitaxy (MBE) system. To achieve high quality GaN epilayer on sapphire, the nitridation treatment is necessary for growing GaN epilayer. The overall threading dislocation density would reduce with increase of temperature of nitridation treatment. To improve the crystal quality of GaN epitaxy layer further, the methods of vicinal sapphire substrates and GaN inserted by AlN interlayer have been applied to obtain high quality GaN epilayer.

In the part of GaN epilayer on Si (111), the simultaneous AlN/α-Si_3N_4 buffer structure with Al pre-seeding layer and novel substrate engineering (GaN-nanorods buffer) was applied to grow high quality GaN epilayer on Si (111) substrates. The Al pre-seeding layer would improve the crystal quality of the GaN epilayer on Si (111) substrates and the crystal α-Si_3N_4 layer was also accompanied with AlN buffer layer growth process. The simultaneous AlN/α-Si_3N_4 buffer structure could reduce lattice mismatch to obtain high quality GaN epilayer on Si (111). We have investigated the growth condition, i.e. growth temperature and Ⅴ/Ⅲ ratio, influence on the formation of the self-assembled GaN nanorods grown on Si (111) substrates. From slightly N-rich condition to highly N-rich condition, the aspect ratio of GaN nanorods increased and the PL spectra of GaN nanorods characteristics peak around

3.30~3.40eV presents the blue-shift to higher energy. Using novel substrate engineering (GaN-nanorods buffer), the high quality and strain-free GaN epilayer have been grown on GaN nanorods by MBE and MOCVD systems.