发光学报
CHINESE JOURNAL OF LUMINESCENCE
中文核心期刊
主管：中国科学院
主办：中国科学院长春光学精密机械与物理研究所
中国物理学会发光分会
主编：申德振

发光学报 2013, 34(5) 623-628 ISSN: 1000-7032 CN: 22-1116/O4

器件制备及器件物理

近紫外380 nm发光二极管的量子阱结构优化

李梅娇, 李凯, 朱明军, 郭志友, 孙慧卿

广东省微纳光子功能材料与器件重点实验室 华南师范大学光电子材料与技术研究所, 广东 广州 510631

PDF 下载 引用本文

摘要： 模拟分析了有源区不同垒层对380 nm近紫外发光二极管的内量子效率、电子空穴浓度分布、辐射复合效率等产生的影响。有源区垒层材料分别选用GaN、$Al_{0.1}Ga_{0.9}N$、$Al_{0.1}Ga_{0.9}N/Al_{0.15}Ga_{0.85}N/Al_{0.1}Ga_{0.9}N$,其中3层AlGaN的厚度比分别为6 nm/8 nm/6 nm和7 nm/6 nm/7 nm。对比分析发现,与GaN垒层相比,选用AlGaN系列垒层可以将更多的载流子限制在有源区内,空穴浓度可以提高近一个数量级,辐射复合效率可以提高2~10倍;3层AlGaN垒层相对于单一AlGaN垒层,载流子分布更加均匀,辐射复合效率可以提高7倍以上,内量子效率可以提高14.5%;采用不同厚度比的3层AlGaN垒层结构可以微调能带的倾斜程度,进一步减小极化效应。可以调节合适的厚度比减小极化效应对于载流子分布及内量子效率的影响。

关键词： 近紫外发光二极管 多量子阱 垒层 AlGaN

Structure Optimization of Multiple Quantum Wells in Near Ultraviolet Light Emitting Diodes with 380 nm Wavelength

LI Mei-jiao, LI Kai, ZHU Ming-jun, GUO Zhi-you, SUN Hui-qing

Laboratory of Nanophotonic Functional Materials and Devices, Institute of Opto-Electronic Materials and Technology, South China Normal University, Guangzhou 510631, China

Abstract: The influence of multiple quantum wells with different barriers on the characteristics of the near ultraviolet light emitting diodes was numerically investigated. Using single GaN, single $Al_{0.1}Ga_{0.9}N$, trilaminar $Al_{0.1}Ga_{0.9}N/Al_{0.15}Ga_{0.85}N/Al_{0.1}Ga_{0.9}N$ as barriers to study the characteristics of internal quantum efficiency, carriers concentration and radiative recombination rate. For trilaminar $Al_{0.1}Ga_{0.9}N/Al_{0.15}Ga_{0.85}N/Al_{0.1}Ga_{0.9}N$ barrier, choose two different thickness ratio, 6 nm/8 nm/6 nm and 7 nm/6 nm/7 nm. The simulation results show that LEDs with AlGaN barriers have better performance than GaN barrier LED. For AlGaN barrier LEDs, more carriers can be confined in active region, especially hole concentration, can improve one order of magnitude approximately. The radiative recombination rate can increase 2~10 times. Compared with single AlGaN barrier LED, in trilaminar AlGaN barrier LEDs the carriers concentration is more uniform. And the radiative recombination rate increases about 7 times, the internal quantum efficiency improves 14.5%. The different thickness ratio of trilaminar AlGaN barrier LED can fine adjust the inclination of energy band, then reduce the negative effects on carriers concentration and internal efficiency caused by polarization.

Keywords: near ultra-violet LED multiple quantum wells barrier AlGaN

收稿日期 2013-02-08 修回日期 2013-04-02 网络版发布日期 2013-03-22

基金项目:

广东省战略性新兴产业专项资金LED产业项目(2011A081301004,2012A080304006);广州市科技计划(2010U1-D00131)资助项目。

通讯作者:

作者简介: 李梅娇(1987-),女,山东烟台人,主要从事GaN基LED发光器件研究及应用。E-mail:meijiao4@126.com

作者Email:

参考文献：

[1] Strite S, Morkoc H. GaN, AlN, and InN: A review [J]. *J. Vac. Sci. Technol.* B, 10(4):1237-1267.

[2] Pearton S J, Zolper J C, Shul R J, *et al.* GaN:Processing, defects, and devices [J]. *J. Appl. Phys.,* 1999, 86 (1):1-78.

[3] Jain S C, Willander M, Narayan J, *et al.* Ⅲ-nitrides:Growth, characterization, and properties [J]. *J. Appl. Phys.,* 2000, 87(3):965-1007.

[4] Kong L,Gan S C,Hong G Y,*et al.* Luminescence properties of YAG:Ce co-doped with Pr^{3+}or Sm^{3+} [J]. *Chin. J. Lumin.(发光学报),* 2007, 28(3):393-396 (in Chinese).

[5] Pan Y X, Wang W, Liu G K, *et al.* Correlation between structure variation and luminescence red shift in YAG:Ce [J]. *J. Alloys Compd.,* 2009, 488(2):638-642.

[6] Song G H, Jiang Bin, Miao J W,*et al.* White LEDs from near-ultraviolet chip precoated with RGB phosphor [J]. *J. Optoelectronics • Laser* (光电子 • 激光), 2011, 22(12):1779-1782 (in Chinese).

[7] Kwon K H, Im W B, Jang H S, *et al.* Luminescence properties and energy transfer of site-sensitive $Ca_{6-x-y}Mg_{x-z}(PO_4)_4$: $Eu^{2+}{}_y$, $Mn^{2+}{}_z$ phosphors and their application to near-UV LED-based white LEDs [J]. *Inorg.*

本刊中的类似文章

1. SiO_2纳米颗粒对*a*-AlGaN金属-半导体-金属结构紫外探测器的影响[J]. 2012,33(8): 879-882
2. 六方系InAlGaN晶体的长波长光学声子研究[J]. 2012,33(8): 808-811
3. AlN插入层对*a*-AlGaN的外延生长的影响[J]. 2012,(5): 519-524
4. 量子阱数量变化对InGaN/AlGaN LED的影响[J] 2012,33(12): 1368-1372
5. 组份变化的InGaAsSb/AlGaAsSb多量子阱结构对其X射线衍射及发光性质的影响[J]. 2012,33 (1): 68-71
6. 极化效应对InGaN/GaN多量子阱结构光电特性的影响[J]. 2011,32(3): 266-271
7. 具有超晶格应力调制结构的绿光InGaN/GaN多量子阱的发光特性[J]. 2011,32(11): 1152-1158
8. 界面生长中断对GaAs (111)衬底上AlGaAs/GaAs量子阱电子自旋寿命的影响[J]. 2009,30(2): 214-218
9. GaAs/AlAs量子阱中受主束缚能和光致发光[J]. 2008,29(1): 156-160
10. GaAlAs/GaAs非均匀阱宽多量子阱超辐射发光管材料制备及表征[J]. 2007,28(6): 885-889
11. 退火对AlGaInP/GaInP多量子阱LED外延片性能的影响[J]. 2004,(5): 510-514
12. Si掺杂对AlGaInP/GaInP多量子阱性能的影响[J]. 2004,25(4): 375-378
13. Si掺杂对AlGaInP/GaInP多量子阱性能的影响[J]. 2004,25(4): 375-378
14. Si掺杂对AlGaInP/GaInP多量子阱性能的影响[J]. 2004,25(4): 375-378
15. MOCVD生长InGaN/AlGaN双异质结构与GaN过渡层的工艺与特性[J]. 2000,21(4): 324-329
16. a-Si/SiO_2多量子阱材料制备及其晶化和发光[J]. 1997,18(3): 217-222
17. ZnCdTe-ZnTe多量子阱的电场效应[J]. 1997,18(2): 122-126
18. 低压-MOCVD方法制备CdS-ZnS应变多量子阱[J]. 1997,18(2): 95-99
19. ZnCdTe-ZnTe多量子阱的光泵受激发射[J]. 1997,18(2): 105-109
20. $ZnSe_{0.93}Te_{0.07}$-ZnSe多量子阱的光泵受激发

Chem., 2009, 48(11):11525-11532.

[8] Chiaria S, Furno E, Goano M, *et al.* Design criteria for near-ultraviolet gan-based light-emitting diodes [J]. *IEEE Trans. Electron Dev.,* 2010, 57(1):60-70.

[9] Yu S F, Lin R M, Chang S J, *et al.* Efficiency droop characteristics in InGaN-based near ultraviolet-to-blue light-emitting diodes [J]. *Appl. Phys. Exp.,* 2012, 5(2):022102-1-3.

[10] Kohno T, Sudo Y, Yamauchi M, *et al.* Internal quantum efficiency and nonradiative recombination rate in InGaN-based near-ultraviolet light-emitting diodes [J]. *Jpn. J. Appl. Phys.,* 2012, 51(7):072102-1-7.

[11] Kuo Y K, Shih Y H, Tsai M C, *et al.* Improvement in electron overflow of near-ultraviolet InGaN leds by specific design on last barrier [J]. *IEEE Photon. Technol. Lett.,* 2011, 23(21):1630-1632.

[12] Kuo Y K, Chen Y H, Chang J Y, *et al.* Numerical analysis on the effects of bandgap energy and polarization of electron blocking layer in near-ultraviolet light emitting diodes [J]. *Appl. Phys. Lett.,* 2012, 100 (4):043513-1-3.

[13] Knauer A, Wenzel H, Kolbe T, *et al.* Effect of the barrier composition on the polarization fields in near UV InGaN light emitting diodes [J]. *Appl. Phys. Lett.,* 2008, 92(19):191912-1-3.

[14] Fu Y K, Jiang R H, Lu Y H. The effect of trimethylgallium flows in the AlInGaN barrier on optoelectronic characteristics of near ultraviolet light-emitting diodes grown by atmospheric pressure metalorganic vapor phase epitaxy [J]. *Appl. Phys. Lett.,* 2011, 98(12):121115-1-3.

[15] Tu P M, Chang C Y, Huang S C, *et al.* Investigation of efficiency droop for InGaN-based UV light-emitting diodes with InAlGaN barrier [J]. *Appl. Phys. Lett.,* 2011, 98(21):211107-1-3.

[16] Kuo Y K,, Wang T H, Chang J Y. Advantages of blue InGaN light-emitting diodes with InGaN-AlGaN-InGaN barriers [J]. *Appl. Phys. Lett.,* 2012, 100(3):031112-1-3.

射[J]. 1997,18(1): 81-83