氧化銦錫透明導電層於磷化鋁鎵銦發光二極體的應用

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摘 要

氧化銦錫(Indium-Tin Oxide, ITO)對可見光具高度透明度及電傳導性，常當做一個透明電極，被廣泛地使用在發光元件上。在傳統磷化鋁鎵銦(AlGaInP)材料的發光二極體上(Light-Emitting Diode, LED)，會有ITO與磷化鎵窗戶層(GaP window layer)難以形成良好歐姆接觸的問題，為解決這麼問題，本研究使用Ni/ITO層來與GaP形成良好的歐姆接觸。

本研究使用電子束蒸鍍系統在載玻片上面分別蒸鍍ITO(230 nm)與Ni(6 nm)/ITO(230 nm)，進行穿透率和片電阻的量測，接著鍍在AlGaInP的LED上，與GaP和GaP/ITO結構的LED進行I-V和L-I的光電特性分析。

在本實驗中光波長630 nm下Ni/ITO薄膜穿透率可達91%。Ni/ITO膜在450 ℃空氣環境中以爐管退火15分鐘，得到最低的片電阻值，應用在AlGaInP LEDs當作window layer的接觸層，在20 mA驅動電流下，GaP/Ni/ITO結構的LED操作電壓分別比GaP和GaP/ITO結構LED降低0.04 V和0.13 V。在100 mA的驅動電流下，GaP/Ni/ITO結構的LED分別比GaP和GaP/ITO結構LED的亮度增加23%和61.5%。

關鍵詞 : 氧化銦錫、磷化鋁鎵銦、發光二極體

目錄

參考文獻

[1]Th. Gessmann and E. F. Schubert,“ High-efficiency AlGaInP light-emitting diodes for solid-state lighting applications, ” J. Appl. Phys., Vol. 95, p. 2203, 2004.
[2]D. A. VANDERWATER, I. H. TAN, G. E. HO? FLER, D. C. DEFEVERE, and F. A. KISH,“ High-brightness AlGaInP light-emitting diodes, ” IEEE, Vol. 85, p. 1740, 1999.
[3]W. Shockley,“ Electrons and Holes in Semiconductors ”, Van Nostrand, Princeton, 1950.
[4]C. T. Sah, R. N. Noyce, and W. Shockley,“ Carrier generation and recombination in p-n-junctions and p-n-junction characteristics, ” Proc. IRE, Vol. 45, p. 1228, 1957.
[5]史光國,“ 現代半導體發光及雷射二極體材料技術, P.3-57 ”, 全華科技圖書股份有限公司.
[6]D. V. Morgan, I. M. Al-Ofi and Y. H. Aliyu,“ Indium tin oxide spreading layers for AlGaInP visible LEDs ”, Semicond. Sci. Yechnol. 15 (2000) 67-72. Printed in the UK.
[7]Kadoiwa K, Kato M, Motoda T, Ishida T, Fujii N, Hayafuji N, Tsugami M, Sonoda T, Takamiya S and Mitsui S 1994 J. Crystal Growth 145 147 – 52.
[8]Gaw CA, Ariz S, Rode DL, Louis St. Electrical Contact for an LED. U.S. Pat. No. 4 864 370, Sep. 5, 1989.
[9]Sugawara H, Ishikawa M, Yoshihiro N, Nishikawa Y, Naritsuka S. Semiconductor Light Emitting Device. U.S. Patent 5 048 035, Sep. 10, 1991.
[10]H. Sugawara, M. Ishikawa, and G. Hatakoshi,“ High-efficiency InGaAlP/GaAs visible light-emitting diodes, ” Appl. Phys. Lett., vol.58, p. 1010, 1991.
[11]R. M. Fletcher, K.-H. Huang, C. P. Kuo, J. Yu, and T. D. Osentowski,“ Light-emitting diode with a thick transparent layer, ” U.S. Patent 5 233 204, 1993.
[12]H. Sugawara, K. Itaya, H. Nozaki, and G. Hatakoshi,“ High-brightness InGaAlP green light-emitting diodes, ” Appl. Phys. Lett., vol. 61, p. 1775, 1992.
[13]M. C. Wu, J. F. Lin, M. J. Jou, C. M. Chang, B. J. Lee,“ High reliability of AlGaInP LED's with efficient transparent contacts for spatially uniform light emission, ” IEEE Electron Devices Letter, vol. 16, p. 482, 1995.
[14]Y. H. Aliyu, D.V. Morgan, H. Thomas, and S.W. Bland,“ AlGaInP LEDs using reactive thermally evaporated transparent conducting Indium Tin Oxide(ITO), ” Electron. Lett., vol. 31, pp. 2210 – 2212, 1995.
[15]J. F. Lin, M. C. Wu, M. J. Jou, C. M. Chang, B. J. Lee, and Y. T. Tsai,“ Highly reliable operation of indium tin oxide AlGaInP orange lightemitting diodes, ” Electron. Lett., vol. 30, pp. 1793 – 1794, 1994.
[16]H. C. Wang, Y. K. Su, C. L. Lin, W. B. Chen, and S. M. Chen,“ Improvement of AlInP – AlGaInP MQW Light-Emitting Diode by Meshed Contact Layer ”, IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 14, NO. 11, NOVEMBER 2002.
[17]Hsin-Chuan Wang, Yan-Kuin Su, Chun-Liang Lin, Wen-Ben Chen, Shi-Ming Chen and Wen-Liang Li,“ Improvement of AlGaInP Multiple-Quantum-Well Light-Emitting Diodes by Modification of Ohmic Contact Layer ”, Japanese Journal of Applied Physics Vol. 43, No. 4B, 2004, pp. 1934 – 1936.
[18]Chih-Hung Yen, Yi-Jung Liu, Nan-Yi Huang, Kuo-Hui Yu, Tzu-Pin Chen, Li-Yang Chen, Tsung-Han Tsai, Chong-Yi Lee, and Wen-Chau Liu, "A New AlGaInP Multiple-Quantum-Well Light-Emitting Diode With a Thin Carbon-Doped GaP Contact Layer Structure", IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 20, NO. 23, DECEMBER 1, 2008.
[19]Shun-Cheng HSU, Dong-Sing WUU, Xinhe ZHENG, Ray-Hua HORNG, and Juh-Yuh SU,“ High-Performance AlGaInP/GaAs Light-Emitting Diodes with a Carbon-Doped GaP/Indium – Tin Oxide Contact Layer ”, Japanese Journal of Applied Physics Vol. 47, No. 9, 2008, pp. 7023 – 7025.

[20]Chih-Hung Yen, Yi-Jung Liu, Kuo-Hui Yu, Pei-Ling Lin, Tzu-Pin Chen, Li-Yang Chen, Tsung-Han Tsai, Nan-Yi Huang, Chong-Yi Lee, and Wen-Chau Liu, “ On an AlGaInP-Based Light-Emitting Diode With an ITO Direct Ohmic Contact Structure ” , IEEE ELECTRON DEVICE LETTERS, VOL. 30, NO. 4, APRIL 2009.
[21]M. Quaas, C. Eggs, H. Wulff, “ Structural studies of ITO thin films with the Rietveld method ” , Thin Solid Films, 332, pp277-281, 1998.
[22]D. H. Zhang and H.L. Ma, ” Scattering mechanisms of charge carroers in transparent counding oxide film ” , Applied Physics A: Materials Science & Processing, 62, pp. 487-492, 1996.
[23]Y.C. Lin, S.J. Chang, Y.K. Su, T.Y. Tsai, C.S. Chang, S.C. Shei, C.W. Kuo, S.C. Chen, “ InGaN/GaN light emitting diodes with Ni/Au, Ni/ITO and ITO p-type contacts ” , Solid-State Electronics 47 (2003) 849 – 853.
[24]Chia-Sheng CHANG, Shoou-Jinn CHANG, Yan-Kuin SU, Yu-Zung CHIOU, Yi-Chao LIN, Yu-Pin HSU, Shih-Chang SHEI, Hsin-Ming LO, Jung-Chin KE, Shih-Chih CHEN and Chun-Hsing LIU, “ InGaN/GaN Light-Emitting Diodes with Rapidly Thermal-Annealed Ni/ITO p-Contacts ” , Jpn. J. Appl. Phys. Vol. 42 (2003) pp. 3324 – 3327 Part 1, No. 6A, June 2003.
[25]Ray-Hua Hornga, Dong-Sing Wuu and Yi-Chung Lien, Wen-How Lan, “ Low-resistance and high-transparency Ni/indium tin oxide ohmic contacts to p-type GaN ” , APPLIED PHYSICS LETTERS VOLUME 79, NUMBER 18 29 OCTOBER 2001.
[26]Y. C. Lin, S. J. Chang, Y. K. Su, T. Y. Tsai, C. S. Chang, S. C. Shei, S. J. Hsu, C. H. Liu, U. H. Liaw, S. C. Chen, and B. R. Huang, “ Nitride-Based Light-Emitting Diodes With Ni/ITO p-Type Ohmic Contacts ” , IEEE PHOTONICS TECHNOLOGY LETTERS, VOL. 14, NO. 12, DECEMBER 2002.