奈米半導體之製作與特性研究

蔡宗晏、武東星 ; 韓斌

E-mail: 9121531@mail.dyu.edu.tw

摘 要

本篇論文主要是研究以有機金屬化學氣相磊晶(MOCVD)系統成長氮化鎵(GaN)奈米線於單晶矽基板上，我們所採用之成長機制以氣-液-固(VLS)生長法為主，一般而言，大多數以氣-液-固(VLS)生長法成長奈米線皆有使用催化物，如成長砷化鎵奈米線時有人用金作為催化物，而成長氮化鎵奈米線時以鐵為催化物，而有些以回填法成長氮化鎵奈米線時也有使用銦作為催化物，而我們成長氮化鎵奈米線時並無使用其它之金屬而是將鎵通入腔體使其沈積於基板上再通入氨氣以成長氮化鎵奈米線。 我們成長氮化鎵奈米線是先利用液滴磊晶法(Droplet Epitaxy)之方式先於矽基板上均勻灑上鎵顆粒，就是先單獨於700℃通入三甲基鎵(TMGa)(16sccm) 原料於腔體中通入時間為6秒，這樣可以先於矽基板上產生直徑約150 nm密度為1.35 × 109 cm-2的鎵顆粒，而灑上鎵顆粒後再於800℃通入氨氣使其分解出氮原子與鎵顆粒產生反應以成長出氮化鎵奈米線，而產生出來之氮化鎵奈米線其直徑約為25 nm。

關鍵詞 : 有機金屬化學氣相磊晶 ; 氮化鎵奈米線 ; 氣-液- 固(VLS)生長法 ; 液滴磊晶法

目錄

參考文獻

[1] 張立德 牟季美,“ 奈米材料與奈米結構 ”, 科學出版社(2001) [2] 張立德 牟季美,“ 奈米材料學 ”, 通寧科技出版社(1994) [3] 黃德歡,“ 改變世界的奈米技術 ”, 美國瀛舟出版社(2002) [4] P. Yang, C. M. Lieber,“ Nanorod-superconductor composites: A pathway to materials with high critical current densities ”, Science, 273, 1836(1996) [5] P. Yang, C. M. Lieber,“ Columnar defect formation in nanorod/Tl2Ba2Ca2Cu3Oz superconducting composites ”, Appl. Phys. Lett. , 70, 3158(1997) [6] G. Fasol, K. Runge,“ Selective electrodeposition of nanometer scale magnetic wires ”, Appl. Phys. Lett. , 70, 2467(1997) [7] G. Fasol,“ Nanowires: Small is beautiful ”, Science, 280, 545(1998) [8] A. M. Morales and C. M. Lieber,“ A laser ablation method for the synthesis of crystalline semiconductor nanowires ”, Science, 279, 208(1998) [9] K. Hiruma, T. Katsuyama, K. Ogawa, M. Koguchi, H. Kakibayashi, and G. P. Morgan,“ Quantum size microcrystals grown using organometallic vapor phase epitaxy ” Appl. Phys. Lett. , 59, 431(1991) [10] K. Hiruma, M. Yazawa, T. Katsuyama, K. Ogawa, K. Haraguchi, M. Koguchi, and H. Kakibayashi,“ Growth and optical properties of nanometer-scale GaAs and InAs whiskers ”, J. Appl. Phys. , 77, 447(1995) [11] M. Yazawa, M. Koguchi, and K. Hiruma,“ Heteroepitaxial ultrafine wire-like growth of InAs on GaAs substrates ”, Appl. Phys. Lett. , 58, 1080(1991) [12] T. J. Trentler and K. M. Hickman,“ Solution-liquid-solid growth of crystalline III-V semiconductors ”, Science, 270, 1791(1995) [13] D. P. Yu, Z. G. Bai, S. Q. Feng, C. S. Lee, I. Bello, X. S. Sun, Y. H. Tang, G. W. Zhou, Z. Zhang,“ Synthesis of nano-scale silicon wires by excimer laser ablation at high temperature ”, Sol. Stat. Commun. , 105, 403(1998) [14] N. Wang, Y. H. Tang, Y. F. Zhang, D. P. Yu, C. S. Lee, I. Bello, S. T. Lee,

“ Transmission electron microscopy evidence of the defect structure in Si nanowires synthesized by laser ablation ” , Chem. Phys. Lett. , 283, 368(1998) [15] D. P. Yu, Q. L. Hang, Y. Ding, H. Z. Zhang, Z. G. Bai, J. J. Wang, Y. H. Zou, W. Qian, G. C. Xiong, and S. Q. Feng, “ Amorphous silica nanowires: Intensive blue light emitters ” , Appl. Phys. Lett. , 73, 3076(1998) [16] G. W. Zhou, Z. Zhang, Z. G. Bai, S. Q. Feng, and D. P. Yu, “ Transmission electron microscopy study of Si nanowires ” , Appl. Phys. Lett. , 73, 677(1998) [17] H. Z. Zhang, D. P. Yu, Y. Ding, Z. G. Bai, Q. L. Hang, and S. Q. Feng, “ Dependence of the silicon nanowire diameter on ambient pressure ” , Appl. Phys. Lett. , 73, 3396(1998) [18] D. P. Yu, Z. G. Bai, Y. Ding, Q. L. Hang, H. Z. Zhang, J. J. Wang, Y. H. Zou, W. Qian, G. C. Xiong, H. T. Zhou, and S. Q. Feng, “ Nanoscale silicon wires synthesized using simple physical evaporation ” , Appl. Phys. Lett. , 72, 3458(1998) [19] G. S. Cheng, L. D. Zhang, Y. Zhu, G. T. Fei, L. Li, C. M. Mo, and Y. Q. Mao, “ Large-scale synthesis of single crystalline gallium nitride nanowires ” , Appl. Phys. Lett. , 75, 2455(1999) [20] J. M. Lee, K. D. Hyun, H. Hong, J. C. Woo, S. J. Park, “ Growth of InAs nanocrystals on GaAs(100) by droplet epitaxy ” , J. Cryst. Growth. , 212, 67(2000) [21] T. Mano, K. Watanabe, S. Tsukamoto, H. Fujioka, M. Oshima, N. Koguchi, “ Fabrication of InGaAs quantum dots on GaAs(001) by droplet epitaxy ” , J. Cryst. Growth. , 209, 504(2000) [22] Y. Hasegawa, T. Egawa, T. Jimbo, and M. Umeno, “ AlGaAs/GaAs light-emitting diode on a Si substrate with a self-formed GaAs islands active region grown by droplet epitaxy ” , Appl. Phys. Lett. , 68, 523(1996) [23] M. He, P. Zhou, S. N. Mohammad, G. L. Harris, J. B. Halpern, R. Jacobs, W. L. Sarney, “ Growth of GaN nanowire by direct reaction of Ga with NH3 ” , J. Cryst. Growth. , 357, 231(2001) [24] J. Y. Li, X. L. Chen, Z. Y. Qiao, M. He, T. Xu, “ Synthesis of aligned gallium nitride nanowire quasi-arrays ” , Appl. Phys. A. , 10, 1007(2000) [25] J. Zhang, X. S. Peng, X. F. Wang, Y. W. Wang, L. D. Zhang, “ Micro-Raman investigation of GaN nanowire prepared by direct reaction Ga with NH3 ” , Chem. Phys. Lett. , 372, 345(2001) [26] C. C. Chen, C. C. Yeh, “ Large-Scale Catalytic Synthesis of Crystalline Gallium Nitride Nanowires ” , Adv. Mater. , 738, 10(2000) [27] M. S. Gudiksen, L. J. Lauhon, J. Wang, D. C. Smith, C. M. Lieber, “ Growth of nanowire superlattice structure for nanoscale photonics and electronics ” , Nature. , 617, 415(2002) [28] X. Duan, Y. Huang, Y. Cui, J. Wang, C. M. Lieber, “ Indium phosphide nanowire as building blocks for nanoscale electronic and optoelectronic devices ” , Nature. , 66, 409(2001) [29] L. Sellami, M. Aubin, C. Carlone, “ Effect of intrinsic defects on the electron mobility of gallium arsenide grown by molecular beam epitaxy and metal organic chemical vapor deposition ” , J. Appl. Phys. , 9887, 91(2002) [30] M. Barbic, J. J. Mock, D. R. Smith, S. Schultz, “ Single crystal silver nanowires prepared by the metal amplification method ” , J. Appl. Phys. , 9341, 91(2002) [31] L. M. Cao, K. Hahn, C. Scheu, M. Ruhle, Y. Q. Wang, Z. Zhang, C. X. Gao, Y. C. Li, “ Template-catalyst-free growth of highly ordered boron nanowire arrays ” , Appl. Phys. Lett. , 4226, 80(2002) [32] H. Masuda, K. Fukuda, “ Ordered Metal Nanohole Arrays Made by a Two-Step Replication of Honeycomb Structures of Anodic Alumina ” , Science. , 1466, 268(1995) [33] X. Duan, C. M. Lieber, “ Laser-Assisted Catalytic Growth of Single Crystal GaN Nanowires ” , J. Am. Chem. , 188, 122(2000) [34] W. S. Shi, Y. F. Zhang, C. S. Lee, S. T. Lee, “ Microstructure of gallium nitride nanowires synthesized by oxide-assisted method ” , Chem. Phys. Lett. , 377, 345(2001) [35] M. H. Huang, S. Mao, H. Feick, H. Yan, Y. Wu, H. kind, E. Weber, R. Russo, P. Tang, “ Room-Temperature Ultraviolet Nanowire Nanolasers ” , Science. , 1879, 292(2001) [36] X. C. Wu, W. H. Song, W. D. Huang, M. H. Pu, B. Zhao, Y. P. Sun, J. J. Du, “ Crystalline Gallium oxide nanowires: intensive blue light emitters ” , Chem. Phys. Lett. , 5, 328(2000) [37] H. L. Liu, C. C. Chen, C. T. Chia, C. C. Yeh, C. H. Chen, M. Y. Yu, S. Keller, S. P. DenBaars, “ Infrared and Raman-scattering studies in single-crystalline GaN nanowires ” , Chem. Phys. Lett. , 245, 345(2001) [38] H. Y. Peng, X. T. Zhou, N. Wang, Y. F. Zheng, L. S. Liao, W. S. Shi, C. S. Lee, S. T. Lee, “ Bulk-quantity GaN nanowires synthesized from hot filament chemical vapor deposition ” , Chem. Phys. Lett. , 263, 327(2000)