InGaAs/InP heterojunction band-offset measurement by electrochemical C-V (ECV) technique

陳江龍、黃俊達

E-mail: 9223689@mail.dyu.edu.tw

ABSTRACT

InGaAs ternary alloy lattice match to InP at the indium fraction of x=0.53 has a band gap of 0.73 ev at room temperature. It has been used as the photo absorption layer in pin photodiodes (PIN-PDs) and avalanche photodiodes (APDs) for wavelengths of up to 1.6 μ m. The most important fundamental property of an abrupt semiconductor heterointerface is the mutual alignment or lineup of conduction and valence bands at the interface. The differences in the band edges at interface, △Ev and△Ec are call valence and conduction band offset, also called band discontinuities. Magnitudes of band offset can be determined by (1)electrical measuremen(2) optical measurement and (3) ultraviolet and x-ray photoelectron spectroscopy(XPS) measurement. That the C-V profiling technique, as was suggested by Kroemer et al. This paper describes the InxGa1-xAs/InP n-N heterojunction band-offset measurement by electrochemical C-V technique (ECV). In this technique unlike metal semiconductor contact technique, is take semiconductor/electrolyte contact. The capacitance is measured at fixed reverse bias voltage while the sample is electrochemical etched can be profiled to any depth don ’ t limitation depth of profiling by the reverse breakdown voltage of the Schottky diode. We determine Si-In0.53Ga0.47As/InP n-N heterojunction band-offset △Ec=0.239 ev △Ec/△Eg=0.399 and density of interface charges σ i=1.77×1011 cm-2

Keywords : InGaAs/InP，band offset，ECV

Table of Contents

第一章 緒論..............................0 第二章 異質接面能隙......................3 2.1 簡介...............................3 2.2 異質接面能隙.......................3 2.3 異質接面能帶探討...................4 第三章 電化學電容電壓ECV量測法...........8 3.1 各種摻雜濃度量測法................8 3.2 電化學電容電壓ECV量測原理.........9 3.3 化學電容電壓ECV蝕刻原理...........10 3.4 電化學電容電壓ECV等效電路.........12 第四章　實驗與討論.....................14 4.1 實驗前準備........................14 4.2 能隙量測.........................14 4.3 C-V量測外插法.....................15 第五章　結論............................17 參考文獻................................19

REFERENCES

[1] OSAMU WADA, HDEKI HASEGAWA,“ InP-Based Materials and Devices ” , John Wiley, 1999.
[2] T. P. Pearsall,GaInAsP Alloy Semiconductor (Wiley,New York,1982).
[3] S. R. Forrest, P.H. Schmidt,R.B. Wilson, and M.L.Kaplan, Appl. Phys. Lett.45(1984)1199.
[4] M. Ogura, M. Mizuts, K. Onaka, and H. Kukimoto, Jpn.J.Appl.Phys.22(1983)1502.
[5] K. Steiner, R. Schmitt, R. Zuleeg,L.M.F. Kaufmann,K.Heime,E. Kuphal, amd J. Wonlter, Surf.Sci.174(1986)331.
[6] H. Temkin, M.B. Panish, P.M. Petroff, R.A. Hamm, J.M. Vandenberg, and S. Sumski, Appl. Phys. Lett.47(1985)394.
[7] H. Kroemer, Wu-Yi Chien, J.S. Harris Jr., D.D. Edwall, Appl. Phys. Lett.36(1980)295.
[8] H. Kroemer, Appl. Phys. Lett.46(1985)504.
[9] Robert F. Pierret,Semiconductor Device Fundamental,Addison-Wesley Company,1996 [10] D.V. Lang, M.B. Panish, F. Capasso, J. Allaw, R.A.Hanm, A.M. Sergent, and W.T.Tsang,Appl.Phys.lett.23(1987)736.
[11] R. People, J.Appl. Phys.6(1987)2551.
[12] BIORAD PN4300 Semiconductor Profile Plotter ,Instruction Manual,1989 [13] P.E. Brunemeier, D.G. Deppe, and N. Holonyak, Jr. Appl. Phys. Lett.46(1986)755.
[14] OSAMU WADA, HDEKI HASEGAWA,“ InP-Based Materials and Devices ” , John Wiley, 1999.
[15] S.R. Forrest, in: F. Capasso, G. Margaritondo (Eds.), ” HeterojunctionBand Discontinuities ” , North Holland, 1987, Chap. 8., pp. 311 [16] V. Swaminathan, A. T. Macrander,“ Materials Aspects of GaAs and InP Based Structures ” , Prentice Hall, 1991, Chap. 3, pp. 181 [17] M. T. Furtado, M. S. S. Lourai. and C. Sachs, ” Measurement of conduction band offsets in Ga0.94Al0.06As/Ga0.57Al0.43As heterojunction by electrochemical C-V profiling ” J. Appl. Phys. 62 (1987) 4926-4928 [18] P. Blood, J.W. Orton,“ Capacitance-Voltage profiling and the characterization of III- V semiconductors using electrolyte barriers ” ,Rep. Prog. Phys. 41 (1978) 157 – 182 [19] Accent PN4300PCElectrochemical

C-V Profiler User Manual Issue 4.0 [20] L. Hulenyi-R. Kinder- A. Stka, ” Determination of Implanted Layer Depth in Silicon by Electrochemical C-V Technique ” .IEEE,315-318,2000 [21]R. Kinder,B. Paszkiewicz,B. Sciana,L. Hulenyi, ” The infiuence of the electrolyte-semiconductor interface on the doping profile measurement of a GaAs structure ” ,IEEE,335-338,2000 [22]T. Ambridge and M. M. Faktor, J. Appl. Electrochem. 5,319 (1975).

[23]T. Ambridge and M. M.Faktor, Inst. Phys. ConI. Ser. 24, 300 (1975).

[24]P. Blood, Semicond. Sci. Technol. 1, 7 (1986).

[25]M. A. Haase, J. Qiu, J. DePuydt, and H. Cheng, Appl. Phys. Lett. 59,1272 (1991).

[26]H. Jean, J. Ding, W. Patterson, A. U. Nurmikko, W. Xie, D. C. Grillo,M. Kobayashi, and R. L. Gunshor, Appl. Phys. Lett. 59, 3619 (1991).

[27]Y. Wang, J. Simpson, H. Stewart, J. M. Wallace, K. A. Prior, and B.C. Cavenett, Appl. Phys. L&t. 61, 506 (1992).

[28]S. Y. Wang, F. Haran, J. Simpson, H. Stewart, J. M. Wallace, K. A.Prior, and B. C. Cavenett, Appl. Phys. Lett. 60, 344 (1992).

[29]J. M. Wallace, I. Simpson, S. Y. Wang, H. Stewart, J. J. Hunter, S. J.A. Adams, K. A. Prior, and B. C. Cavenett, J. Cryst. Growth 117, 320(1992).

[30]I. C. Mayes, Bio-Rad Semiconductor Notes, No. 201 (1985).

[31]J. Simpson, J. M. Wallace, S. Y. Wang, H. Stewart, J. J. Hunter, S. J.A. Adams, K. A. Prior, and B. C. Cavenett, Semicond. Sci. Technol. 7,464 (1992).

[32] IT. S. Hodnyi, P. Tiittii, and G. EndrCdi, Appl. Surf. Sci. 50, 143(1991).

[33]R. B. Heslop and P. L. Robinson, Inorganic Chemistry (Elsevier, Am-sterdam, 1967), p. 488.

[34] F. D. Hughes, R. F. Headen, and M. Wilson, J. Phys. E Sci. Instrum.5, 295, (1972).

[35]T. Ambridge and M. M. Faktor, J. Appl. Electrochem. 5, 319 (1975).

[36]MM. R. Melloch, M. S. Carpenter, T. E. Dungan, D. Li, and N. Otsuka,Appl. Phys. Lett. 56, 1064 (1990).

[37]J. M. DePuydt, M. A. Haase, H. Cheng, and J. E. Potts, Appl. Phys.Lett. 55, 1103 (1989).

[38]R. M. Park, M. B. Troffer, C. M. Rouleau, J. M. DePuydt, and M. A.Haase, Appl. Phys. Lett. 57, 2127 (1990).

[39]J. M. Wallace, J. Simpson, S. Y. Wang, H. Stewart, J. J. Hunter, S. J.A. Adams, K. A. Prior, and B. C. Cavenett, J. Cryst. Growth (inpress).