

The Study of Ohmic Contact to GaN and Investigations on Metal-Oxide-Semiconductor Photodetectors

楊國輝、黃俊達

E-mail: 229500@mail.dyu.edu.tw

ABSTRACT

The main goal of this dissertation is to investigate the techniques of a low-resistance and high-transparency Ti/indium tin oxide and Ti ohmic contacts to n-type GaN by using plasma pre-treatment. Next, we also focused on the study of GaN metal-insulator-semiconductor photo-detectors (MIS-PDs) with liquid phase deposition oxide (LPD-oxide). We investigated the mechanism of the dark current for n-type GaN MIS. The responsivity of electrical and optical properties were also studied. Final, one- and two-step rapid-thermal-annealing (RTA) annealing in pure O₂ and air ambient has been proposed to activate the Mg-doped p-type GaN films.

This dissertation is divided into four parts. It is addressed as follows:

Part 1(Chapter 1 and 2) investigates nonalloyed transparent Ti/indium tin oxide (ITO) and Ti-only contacts on n-type GaN using plasma pre-treatment. It was found that the ITO/Ti/n-GaN and Ti/n-GaN samples show very low specific contact resistances of $3.2 \times 10^{-6} \text{ } \Omega\text{-cm}^2$ and $8.7 \times 10^{-7} \text{ } \Omega\text{-cm}^2$, respectively. Plasma treatments were performed by using a sputtering system at a substrate temperature of 25 °C in Ar gas and 30 W plasma power. A novel transparent indium tin oxide (ITO) ohmic contact to n-type GaN with a specific contact resistance of $4.2 \times 10^{-6} \text{ } \Omega\text{-cm}^2$ has been obtained. The interfacial properties involving with ITO to n-GaN ohmic contact are different from those of previous reported. Conventionally, ITO films were prepared using electron-beam evaporator and a Schottky contact was thereafter obtained with a barrier height of 0.68 eV. However, in our studies we relied on different deposition technique instead by sputtering the ITO films onto n-type GaN using a RF sputtering system and in result I-V curve revealed a linear behavior.

Part 2 (Chapter 3) demonstrated an efficient and low cost approach to deposit silicon dioxide on gallium nitride by using liquid phase deposition(LPD) at low temperature (30~50 °C). The LPD technique, utilizing supersaturated H₂SiF₆ as a source liquid and H₃BO₃ as a deposition rate controller, has been in detail studied in our work. The effects of different concentrations of H₂SiF₆ (1 and 0.5M) and H₃BO₃ (0.01 and 0.005 M) on the LPD-SiO₂ thickness and leakage current density were also approached. A maximum SiO₂ growth rate of 50.5 nm/hr.

Part 3 (Chapter 4) concentrates on nitride-based ultraviolet MIS-PDs with liquid phase deposition oxide. The minimum interface-trap density, D_{it}, of a metal-insulator-semiconductor (MIS) capacitor with a structure of Al/20 nm LPD-SiO₂/n-GaN was estimated to be $8.4 \times 10^{11} \text{ cm}^{-2} \text{ V}^{-1}$. After annealed in vacuum at 800 °C for 60 mins, the D_{it} was reduced to a value of $1.75 \times 10^{10} \text{ cm}^{-2} \text{ eV}^{-1}$. The dark current density was as low as $4.41 \times 10^{-6} \text{ A/cm}^2$ for an applied field of 4 MV/cm. A maximum responsivity of 0.112 A/W was observed for incident ultraviolet light of 366 nm with an intensity of 4.15 mW/cm². A large photocurrent to dark-current contrast ratio higher than four orders of magnitude and a maximum responsivity of 0.65 A/W were observed from the fabricated ITO/LPD-SiO₂/GaN MIS UV photo-detectors.

Part 4 (Chapter 5) discusses one- and two-step rapid thermal annealing (RTA) for activating Mg-doped P-type GaN films had been performed to compare with conventional furnace annealing (CFA). The two-step annealing process consists of two annealing steps: the first step is performed at 750 °C for 1 minute and the second step is performed at 600 °C for 5 minutes in pure O₂ or air ambient. Compared to one-step RTA annealing and CFA annealing, the samples with two-step annealing exhibit higher hole concentration and lower resistivity.

Keywords : GaN、 photo-detectors、 photo-current

Table of Contents

TABLE OF CONTENTS

SIGNATURE PAGE

LETTER OF AUTHORITY iii

ENGLISH ABSTRACT iv

CHINESE ABSTRACT vi

ACKNOWLEDGMENTS	viii
TABLE OF CONTENTS	ix
LIST OF FIGURES	xi
LIST OF TABLES	xiv
Chapter 1 Nonalloyed Ti/indium tin oxide and Ti ohmic contacts to n-type GaN using plasma pre-treatment	1
1.1 Introduction	1
1.2 Experimental Techniques	2
1.3 Results and Discussions	3
Chapter 2 A novel transparent ohmic contacts of indium tin oxide to n-type GaN	11
2.1 Introduction	11
2.2 Experimental Techniques	12
2.3 Results and Discussions	12
Chapter 3 Extremely low temperature growth of silicon dioxide on gallium nitride by using liquid phase deposition	21
3.1 Introduction	21
3.2 Experimental Techniques	22
3.3 Results and Discussions	23
3.3.1 Dependence of thickness	
3.3.2 Leakage current density	24
3.3.3 Investigations of EDX, XPS and Auger depth-profile	25
Chapter 4 Nitride-Based UV Metal-Insulator-Semiconductor Photo-detector with Liquid-Phase-Deposition Oxide	38
4.1 Al-gate/SiO ₂ /n-GaN MIS photo-detectors	39
4.1.1 Introduction	40
4.1.2 Experimental Techniques	42
4.1.3 Results and discussion	42
4.2 ITO-gate/SiO ₂ /n-GaN MIS photo-detectors	43
4.2.1 Introduction	44
4.2.2 Experimental Techniques	45
4.2.3 Results and discussion	46
Chapter 5 Activation of Mg-doped P-GaN by using two-step annealing	58
5.1 Introduction	58
5.2 Experimental Techniques	59
5.3 Results and Discussions	60
Chapter 6 Conclusions	61
References	71
Bibliography	78

List of Figures

Fig. 1-1 RF sputtering system	6
Fig. 1-2 I-V characteristics of ITO/Ti/n-GaN and Ti/n-GaN samples	7

Fig. 1-3 Surface AES data for sample C and D	8
Fig. 1- 4 Transmittance of the ITO films in our studies	9
Fig. 1-5 A representative cross section of Ti and Ti/ITO ohmic contacts to n-type GaN	10
Fig. 2-1 I-V curves of ITO/n-GaN devices for sample A, B, and C	11
Fig. 2-2 Surface AES data for sample D and E	12
Fig. 2-3 Transmittance of sputtered ITO films with non-annealed and 500 °C annealed samples	13
Fig. 2-4 A representative ITO/n-type GaN cross section	14
Fig. 3-1 The preparation of the saturated solution of LPD-SiO ₂ and the deposition flowchart	21
Fig. 3-2 The thickness of LPD-SiO ₂ as a function of growth temperature for immersion time of 1 hour	22
Fig. 3-3 The thickness of LPD-SiO ₂ versus deposition times for different concentrations of H ₂ SiF ₆ and H ₃ BO ₃	23
Fig. 3-4 The annealing effect, 800 °C in N ₂ ambient for 1 hour, on thickness of LPD-SiO ₂ films	24
Fig. 3-5 The leakage current density as a function of electric field for different concentrations of H ₃ BO ₃ (0.01 and 0.005M), but H ₂ SiF ₆ was kept at 0.5M	25
Fig. 3-6 The leakage current density as a function of electric field for different concentrations of H ₃ BO ₃ (0.01 and 0.005M), but H ₂ SiF ₆ was kept at 1M	26
Fig. 3-7 Annealing effect on leakage current density	27
Fig. 3-8 Element analysis of LPD-SiO ₂ by using EDX	28
Fig. 3-9 Composition analysis of LPD-SiO ₂ by using XPS	29
Fig. 3-10 Auger depth-profile for (a) as-grown and (b) annealed LPD-SiO ₂ films on GaN	30
Fig. 3-11 The Growth model of LPD-SiO ₂ on GaN	31
Fig. 4-1 Device structure of n-type GaN MIS photo-detector	47
Fig. 4-2 LPD-SiO ₂ thickness vs growth time under different growth temperatures for concentrations of H ₂ SiF ₆ (0.5 M) and H ₃ BO ₃ (0.01 M)	48
Fig. 4-3 AFM image of 20- nm- thick LPD-SiO ₂	49
Fig. 4-4 Film thickness versus growth time under different concentrations of H ₃ BO ₃ while H ₂ SiF ₆ in held constant at 0.5 M for nonannealed and annealed samples	50
Fig. 4-5 XPS spectrum of Si 2p core level for LPD-SiO ₂	51
Fig. 4-6 Dark I-V characteristic of Al/20nm LPD-SiO ₂ /n-GaN MIS capacitor	52
Fig. 4-7 Responsivity vs different reverse bias for MIS PD with 10-nm-thick LPD-SiO ₂ . The inset shows the current densities vs different applied bias for dark and photoilluminated PD	53
Fig. 4-8 Band diagram for defect-assisted tunneling. The holes tunnel through donorlike defects in LPD-SiO ₂ toward the Al gate electrode	54
Fig. 4-9 XPS spectrum of (a) Si2p and (b) O1s for LPD-SiO ₂ on GaN	55
Fig. 4-10 I-V characteristics of ITO/10-nm LPD-SiO ₂ /GaN MIS and ITO/GaN photodetectors measured in dark and under 366-nm illumination	56
Fig. 4-11 Spectral responsivity of GaN MIS UV photodetectors	57
Fig. 5-1 A representative cross section of Ni and Au ohmic contacts to p-type GaN	64
Fig. 5-2 I-V curves corresponding to different annealing cases	65
Fig. 5-3 Resistivity as a function of different annealing cases	66
Fig. 5-4 Concentration of different annealing cases	67
Fig. 5-5 SIMS profiles of hydrogen in as-deposited and case D sample	68
Fig. 5-6 PL spectrum for GaN samples annealed in a pure O ₂ ambient	69

List of Tables

Table 2-1 Different treatments of GaN samples and its specific contact resistance . 16

Table 5-1 Six sets of different experimental cases for activating Mg-doped p-type GaN film 63

REFERENCES

- [1] S. Nakamura, M. Senoh, N. Iwasa, and S. Nagahama, *Jpn. J. Appl. Phys.* 34 (1995) L797.
- [2] S. Nakamura, T. Mokia, and M. Senoh, *Appl. Phys. Lett.* 64 (1994) 1689.
- [3] S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, and H. Kiyodo, *Appl. Phys. Lett.* 70 (1996) 868.
- [4] E. Kaninska, A. Piotrowska, M. Guziewicz, S. Kasjaniuk, A. Bracz, E. Dynowska, M. D. Bremser, O. H. Nam, and R. F. Davis, *Mater. Res. Soc. Symp. Proc.* 449 (1997) 1055.
- [5] J. D. Guo, C. I. Lin, M. S. Feng, F. M. Pan, G. C. Chi, and C. T. Lee, *Appl. Phys. Lett.* 68 (1996) 235.
- [6] M. E. Lin, Z. Ma, F. Y. Huang, Z. F. Fan, L. H. Allen, and H. Morkoc, *Appl. Phys. Lett.* 64 (1994) 100.
- [7] Zhifang Fan, S. Noor Mohammad, Wook Kim, ?zg?r Aktas, Andrei E. Botchkarev, and Hadis Morkoc, *Appl. Phys. Lett.* 68 (1996) 1672.
- [8] J. K. Sheu, Y. K. Su, G. C. Chi, M. J. Jou, and C. M. Chang, *Appl. Phys. Lett.* 72 (1998) 3317.
- [9] J. K. Sheu, Y. K. Su, G. C. Chi, M. J. Jou, and C. M. Chang, *Solid-State Electronics* 43 (1999) 2081.
- [10] D. W. Jenkins and J. D. Dow, *Phys. Rev. B* 39 (1989) 3317.
- [11] S. Nakamura, M. Senoh, N. Iwasa, and S. Nagahama, *Jpn. J. Appl. Phys., Part 2* 34L (1995) 797.
- [12] S. J. Chang, W. C. Lai, Y. K. Su, J. F. Chen, C. H. Liu, and U. H. Liaw, *IEEE J. Sel. Top. Quan. Electron.*, 8 (2002) 278.
- [13] S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, and H. Kiyodo, *Appl. Phys. Lett.* 70(1996) 868.
- [14] J. S. Foresi and T. D. Moustakas, *Appl. Phys. Lett.* 82 (1993) 2859 .
- [15] J. D. Guo, C. I. Lin, M. S. Feng, F. M. Pan, G. C. Chi, and C. T. Lee, *Appl. Phys. Lett.* 68 (1996) 235.
- [16] M. E. Lin, Z. Ma, F. Y. Huang, Z. F. Fan, L. H. Allen, and H. Morkoc, *Appl. Phys. Lett.* 64 (1994) 1003.
- [17] Z. Fan, S. N. Mohammad, W. Kim, ?. Aktas, A. E. Botchkarev, and H. Morkoc, *Appl. Phys. Lett.* 68 (1996) 1672.
- [18] Y. K. Su, S. J. Chang, C. H. Chen, J. F. Chen, G. C. Chi, J. K. Sheu, W. C. Lai, and J. M. Tsai, *IEEE Sensors Journal*, 2 (2002) 366.
- [19] J. K. Sheu, Y. K. Su, G. C. Chi, M. J. Jou, and C. M. Chang, *Solid-State Electronics* 43 (1999) 2081.
- [20] D. W. Kim, Y. J. Sung, J. W. Park, G. Y. Yeom, *Thin Solid Films*, 87 (2001) 398.
- [21] D. W. Jenkins and J. D. Dow, *Phys. Rev. B* 39 (1989) 3317.

- [22] S. J. Fonash, S. Ashok, and R. Singh, *Appl. Phys. Lett.* 39 (1981) 423.
- [23] M. J. Tsai, A. L. Fahrenbruch, and R. H. Bube, *J. appl. Phys.* 51 (1980) 2696.
- [24] S. Nakamura, M. Senoh, N. Iwasa and S. Nagahama: *Jpn. J. Appl. Phys.* 34 (1995) L797.
- [25] S. Nakamura, T. Mukai and M. Senoh: *Jpn. J. Appl. Phys.* 30 (1991) L1998.
- [26] S. J. Chang, W. C. Lai, Y. K. Su, J. F. Chen, C. H. Liu and U. H. Liaw: *IEEE J. Sel. Top. Quan. Electron.* 8 (2002) 278.
- [27] S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto and H. Kiyodo: *Appl. Phys. Lett.* 70 (1996) 868.
- [28] S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, H. Kiyoku and Y. Sugimoto: *Jpn. J. Appl. Phys.* 35 (1996) L74.
- [29] C. K. Wang, R. W. Chuang, S. J. Chang, Y. K. Su, S. C. Wei, T. K. Lin, T. K. Ko, Y. Z. Chiou and J. J. Tang: *Mater. Sci. & Eng. B* 119 (2005) 25.
- [30] C. T. Lee, H. W. Chen and H. Y. Lee, *Appl. Phys. Lett.* 82 (2003) 4304.
- [31] T. Rotter, D. Mistele, J. Stemmer, F. Fedler, J. Aderhold, J. Graul, V. Schwegler, C. Kirchner, and M. Kamp and M. Heuken: *Appl. Phys. Lett.* 76 (2000) 3923.
- [32] H. C. Casey, Jr., G. G. Fountain, R. G. Alley, B. P. Keller and Steven P. DenBaars: *Appl. Phys. Lett.* 68 (1996) 1850.
- [33] Kevin Matocha, Ronald J. Gutmann and T. Paul Chow: *IEEE Trans. Electron Devices.* 50 (2003) 1200.
- [34] S. J. Chang, Y. K. Su, F. S. Juang, C. T. Lin, C. D. Chiang and Y. T. Cherng: *IEEE J. Quantum Electron.* 36 (2000) 583.
- [35] C. T. Lin, Y. K. Su, S. J. Chang, H. T. Huang, S. M. Chang and T. P. Sun: *IEEE Photo. Technol. Lett.* 9 (1997) 232.
- [36] J. D. Hwang, G. H. Yang, W. T. Chang, C. C. Lin, R.W. Chuang and S.J. Chang: *Microelectronic Engineering*, 77 (2005) 71.
- [37] C. J. Huang, Jiann-Ruey Chen and S.P. Huang: *Mater. Chem. & Phys.* 70 (2001) 78.
- [38] J. S. Chou and S. C. Lee: *Appl. Phys. Lett.* 64 (1994) 1971.
- [39] M. P. Houg, C. J. Huang, Y. H. Wang, N. F. Wang and W. J. Chang: *J. Appl. Phys.* 82 (1997) 5788.
- [40] H. R. Wu, K. W. Lee, T. B. Nian, D. W. Chou, J. J. Huang, Y. H. Wang, M. P. Houg, P. W. Sze, Y. K. Su, S. J. Chang, C. H. Ho, C. I. Chiang, Y. T. Chern, F. S. Juang, T. C. Wen, W. I. Lee and J. I. Chyi: *Mater. Chem. & Phys.* 80 (2003) 329.
- [41] D. W. Chou, K. W. Lee, J. J. Huang, H. R. Wu, Y. H. Wang, M. P. Houg, S. J. Chang and Y. K. Su: *Jpn. J. Appl. Phys.* 41 (2002) L748.
- [42] K. W. Lee, D. W. Chou, H. R. Wu, J. J. Huang, Y. H. Wang, M. P. Houg, S. J. Chang and Y. K. Su: *Electron. Lett.* 38 (2002) 830.
- [43] J. D. Hwang, Z. Y. Lai, C. Y. Wu and S. J. Chang: *Jpn. J. Appl. Phys.* 44 (2005) 1726.
- [44] C. T. Lee, H. Y. Lee and H. W. Chen: *IEEE Electron. Dev. Lett.* 24 (2003) 54.
- [45] X. A. Cao, H. Cho, S. J. Pearton, G. T. Dang, A. P. Zhang, F. Ren, R. J. Shul, L. Zhang, R. Hickman, and J. M. Van Hove: *Appl. Phys. Lett.* 75 (1998) 232.
- [46] D. J. Fu, Y. H. Kwon, T. W. Kang, C. J. Park, K. H. Baek, H. Y. Cho, D. H. Shim, C. H. Lee and K. S. Chung: *Appl. Phys. Lett.* 80 (2002) 446.
- [47] J. I. Pankove: *Mater. Res. Soc. Symp. Proc.* 162 (1990) 515.
- [48] G. Parish, S. Keller, P. Kozodoy, J. A. Ibbetson, H. Marchand, P. T. Fini, S. B. Fleischer, S. P. DenBaars and U. K. Mishra: *Appl. Phys. Lett.* 75 (1999) 247.
- [49] Q. Chen, J. W. Yang, A. Osinsky, S. Gangopadhyay, B. Lim, M. Z. Anwar, M. Asif Khan, D. Kuksenkov and H. Temkin: *Appl. Phys. Lett.* 70 (1997) 2277.
- [50] P. Kung, X. Zhang, D. Walker, A. Saxler, J. Piotrowski, A. Rogalski and M. Razeghi: *Appl. Phys. Lett.* 67 (1995) 3792.
- [51] H. C. Casey, Jr., G. G. Fountain, R. G. Alley, B. P. Keller and S. P. DenBaars: *Appl. Phys. Lett.* 68 (1996) 1850.
- [52] K. Matocha, R. J. Gutmann and T. P. Chow: *IEEE Trans. Electron Devices* 50 (2003) 1200.
- [53] S. J. Chang, Y. K. Su, F. S. Juang, C. T. Lin, C. D. Chiang and Y. T. Cherng: *IEEE J. Quantum Electron.* 36 (2000) 583.
- [54] C. T. Lin, Y. K. Su, S. J. Chang, H. T. Huang, S. M. Chang and T. P. Sun: *IEEE Photonics. Technol. Lett.* 9 (1997) 232.
- [55] J. D. Hwang, G. H. Yang, W. T. Chang, C. C. Lin, R. W. Chuang and S. J. Chang: *Microelectron. Eng.* 77 (2005) 71.
- [56] C. J. Huang, J. R. Chen and S. P. Huang: *Mater. Chem. Phys.* 70 (2001) 78.
- [57] H. R. Wu, K. W. Lee, T. B. Nian, D. W. Chou, J. J. Huang, Y. H. Wang, M. P. Houg, P. W. Sze, Y. K. Su, S. J. Chang, C. H. Ho, C. I. Chiang, Y. T. Chern, F. S. Juang, T. C. Wen, W. I. Lee and J. I. Chyi: *Mater. Chem. Phys.* 80 (2003) 329.
- [58] D. W. Chou, K. W. Lee, J. J. Huang, H. R. Wu, Y. H. Wang, M. P. Houg, S. J. Chang and Y. K. Su: *Jn. J. Appl. Phys.* 41 (2002) L748.
- [59] M. L. Lee, J. K. Sheu, W. C. Lai, S. J. Chang, Y. K. Su, M. G. Chen, C. J. Kao, G. C. Chi and J. M. Tsai: *Appl. Phys. Lett.* 28 (2003) 2913.
- [60] B. C. Hsu, S. T. Chang, T. C. Chen, P. S. Kuo, P. S. Chen, Z. Pei and C. W. Liu: *IEEE Electron Device. Lett.* 24 (2003) 318.
- [61] Y. Z. Chiou, Y. K. Su, S. J. Chang, J. Gong, C. S. Chang, and S. H. Liu: *J. Electron. Mater.* 32 (2003) 395.
- [62] J. D. Hwang, and C. C. Lin: *Thin Silid Films*, 491 (2005) 276.
- [63] J. I. Pankove: *Mater. Res. Soc. Symp. Proc.* 162 (1990) 515.
- [64] S. Arulkumaran, T. Egawa, H. Ishikawa, T. Jimbo, and M. Umeno: *Appl. Phys. Lett.* 73 (1998) 809.
- [65] D. Fu, and T. W. Kang: *Jpn. J. Appl. Phys.* 41 (2002) L1437.
- [66] C. T. Lee, H. Y. Lee, and H. W. Chen: *IEEE Electron Device Lett.* 24 (2003) 54.

- [67] J. S. Chou and S. C. Lee, Appl. Phys. Lett. 64 (1994) 1971.
- [68] C. J. Huang, M. P. Hwang, Y. H. Wang, H. H. Wang, J. Appl. Phys. 86 (1999) 7151.
- [69] J. D. Hwang, Gwo Huei Yang, Yuan Yi Yang and Pin Cuan Yao: Jpn. J. Appl. Phys. 44 (2005) 7913.
- [70] S. Nakamura, M. Senoh, N. Iwasa, and S. Nagahama, Jpn. J. Appl. Phys. Part 2 Letter 34 (1995) L797-800 .
- [71] S. Nakamura, T. Morko, and M. Senoh, Appl. Phys. Lett. 64 (1994) 1689.
- [72] S. Nakamura, M. Senoh, S. Nagahama, N. Iwasa, T. Yamada, T. Matsushita, Y. Sugimoto, and H. Kiyodo, Appl. Phys. Lett. 70 (1996) 868.
- [73] D. W. Jenkins and J. D. Dow, Phys. Rev. B 39 (1989) 3317.
- [74] J. I. Pankove: Mater. Res. Soc. Symp. Proc. (1990) 160:515.
- [75] S. W. Kim, J. M. Lee, Chul Huh, N. M. Park, H. S. Kim, I. H. Lee, and S. J. Park, Appl. Phys. Lett. 70 (2000) 3079.
- [76] S. Nakamura, T. Mukai, M. Senoh, and N. Iwasa, Jpn. J. Appl. Phys. Part 2 Letter 31 (1992) L139-2.
- [77] C. H. Kuo, S. J. Chang, Y. K. Su, L. W. Wu, J. K. Sheu, C. H. Chen and G. C. Chi, Jpn. J. Appl. Phys. Part 2 Letter 41 (2002) L112-5.
- [78] H.C. Cheng, C.Y. Huang, F.S. Wang, K.H. Lin, F.G. Tarntair; Jpn. J. Appl. Phys. Part 2 Letter 39 (2000) L19-21.
- [79] James D. Plummer, Michal D. Deal, Peter B. Griffin, Silicon VLSI technology, Prentice Hall, Inc. U.S.A.