Synthesis of Carbon Nanotubes over Electroless-Plating Ni Films and Their Applications as the Electrode Materials of Ele

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ABSTRACT

In this study, multi-walled carbon nanotubes were synthesis by thermal chemical vapor deposition over electroless plating nickel films with silicon substrate as the sbustrate. For the application of the electrochemical capacitors, carbon nanotubes were directly grown on the glassy carbon electrode with/without the electrodeposited ruthenium oxides onto the surface of the as-deposited carbon nanotubes films. The electrochemical behaviors of the as-prepared carbon electrodes were investigated by cyclic voltammetry. The results showed that: (a). Before electroless nickel plating, a process to sensitize and activated the substrate is necessary to achieve uniform and highly dispersive Ni films in a shorter duration, (b). The thinner and uniformly coated Ni-P particles, the smaller the diameters of the multi-walled carbon nanotubes are grown with more denser nanotubes distribution, (c). Hydrogen is necessary for CNT growth to prevent other amorphous carbonaceous carbon depoited. (d). NH3 ambient is helpful for better control of the nanotubes structure and growth density both in pretreatment and growth stage. (e). Cyclic voltammograms shows that the pseudocapacitive behavior of as-grown multiwalled carbon nanotubes functionctionalized with electrodeposited Ruthenium oxides. The specific capacitance of the CNTs and Ruthenium oxides functionalized CNTs is apparently greater than that of pristine GCE in the same medium.

Keywords : Electroless Plating ; Thermal CVD ; Multi-walled Carbon nanotube (MWNT) ; glassy carbon electrode(GCE) ; ruthenium oxide ; pseudocapacitive

Table of Contents

REFERENCES

[1] A. Brenner, G.E. Riddell, J. Res. NBS 37 (1) (1946) 31.
[2] G..O. Mallory, J.B. Hajdu, “ Electroless Plating: Fundamentals and Applications ”, AESF, Orlando, Florida, USA, 1990.
[3] M.D. Feldstein, Plat. Surf. Fin. 85 (1998) 248.
[4] X. Haowen, Z. Bangwei, J. Mater. Pro. Techno. 124 (2002) 8.
[5] H. Iwasa, M. Yokozawa, I. Teramoto, J. Electrochem. Soc. 115 (1968) 485.
[6] H. Cachet, M. Froment, E. Souteyrand, J. Electrochem. Soc. 139 (1992) 2920.
[7] M.V. Sullivan, J.H. Eigler, J. Electrochem. Soc. 104 (1957) 226.
[8] C.H. Ting, M. Paunovic, P.L. Pai, G. Chiu, J. Electrochem. Soc. 136 (1989) 462.
[9] R.M. Kennedy, K. Minten, X. Yang, D.F. Evans, J. Vac. Sci. Technol. B 9 (1991) 735.
[10] K.Wong, K. Chi, A. Rangappan, Plat. Surf. Fin. July (1988) 70.
[11] J. Lohau, S. Friedrichowski, G. Dumpich, E.F. Wassermann,J. Vac. Sci. Technol. B 16 (1998) 77.
[12] H. Sugimura, N. Nakagiri, Thin Solid Films 281-282 (1996) 572.
[13] T. Tada, T. Kanayama, J. Vac. Sci. Technol. B 16 (1998) 3934.
[14] Y. Shacham-Diamad, Y. Sverdlov, Microelectron Eng. 50(2000)525.
[15] H. W.Kroto, J. R. Heath, S. C. O ’ Brien, R. F. Curl and R. E. Smalley, Nature 318, (1985) 162.
[16] T. W. Ebbesen, Carbon Nanotube-Preparation and Properties, CRC Press, New York,(1997), p.37.
[17] S. Iijima, “ Helical microtubules of graphitic carbon, ” Nature, 354 (1991) 56.
[18] D. S. Bethune, C. H. Kiang, M. S. de Vries, G. Gorman, R. Saroy, J. Vazquez, and R. Beyers. “ Cobalt-catalysed growth of carbon nanotubes with single-atomic-layer walls, ” Nature, 363 (1993) 605.
[19] M. J. Yacaman, M. M. Yoshida, L. Rendon, and J. G. Santiesteban, “ Catalytic growth of carbon microtubules with fullerene structure, ” Appl. Phys. Lett., 62 (1993)202.
[20] M. Endo, K. Takeuchi, K. Takahashi, H. W. Kroto, and A. Sarkar, “ Pyrolytic carbon nanotubes from vapor-grown carbon fibers, ” Appl. Phys. Lett. 33[7] (1995) 873.
[21] F. Hoshi, K. Tsugwa, A. Goto, T. Ishikura, S. Yamashita, M. Yumura, T. Hirao, K. Oura,Y. Koga, Diamond Relat. Mater. 10 (2001) 254.
[22] M. A. Guillorn, A. V. Melechko, V. I. Merkulov, E. D. Ellis, C. L. Britton, M. L. Simpson, D. H. Lowndes, L. R. Baylor, Appl. Phys. Lett. 79 (2001) 3506.
[23] V. I. Merkulov, D. H. Lowndes, L. R. Baylor, Appl. Phys. Lett. 89 (2001) 1933.
[24] M. A. Guillorn, A. V. Melechko, V. I. Merkulov, D. K. Hensley, M. L. Simpson, D. H. Lowndes, Appl. Phys. Lett. 81 (2001) 3660.
[25] F. Marken, M. K. Gerrard, I. M. Mellor, R. J. Mortimer, C. E. Madden, S. Fletcher, Electrochem. Commun, 3 (2001) 177.
[26] P. V. Adhyapak, T. Maddanimath, S. Pethkrar, A. J. Chandwadkar, Y. S. Negi, K. Vijayamohanan, J. Power Sources 109 (2002) 105.
[27] H. S. Youn, H. Ryu, T. H. Cho, W. K. Choi. International Journal of Hydrogen Energy 27 (2002) 937.
[28] H. Zhu, X. Li, L. Ci, C. Xu, D. Wu, Z. Mao, Materals Chemisty and Physics 78 (2003) 670.
[29] X. Yan, X. Gao, Y. Li, Z. Liu, F. Wu, Y. Shen, D. Song, Chem. Phys. Lett. 372 (2003) 336.
[30] S. J. Tans, M. H. Devoret, H. J. Dai, A. Thess, R. E. Smalley, and C. Dekker, “ Room-temperature transistor based on a single carbon nanotube, ” Nature, 386(1997) 474.
[31] C. Liu, Y.C. Chen, Y. Tzeng, Effects of carbon content in iron catalyst coatings on the growth of vertically aligned carbon nanotubes on smooth silicon surfaces by thermal chemical vapor deposition, Diamond and Related Materials, 13 (2004) 1274 – 1280.
[32] T. de los Arcos et al., Influence of iron – silicon interaction on the growth of carbon nanotubes produced by chemical vapor deposition, Appl.

Phys. Lett., 80 (2002) 2383.
[33] T. W. Ebbesen, P. M. Ajayan, H. Hiura, and K. Tanigaki, Nature, 367,519 (1994).
[35] T. W. Ebbesen and P. M. Ajayan, Nature, 358, 220 (1992). J. M. Lambert, P. M. Ajayan, P. Bernier, J. M. Planeix, V. Brotons, B. Coq, and J. Castaing, Chem. Phys. Lett., 226, 364 (1994).
[36] A. Thess, R. Lee, P. Nikolaev, H. Dai, P. Petit, J. Robert, C. Xu, Y. H. Lee, S. G. Kim, A. G. Rinzler, D. T. Colbert, G. E. Scuseria, D. Tomanek, J. E. Fischer, and R. E. Smalley, Science, 273, 483 (1996).
[37] Gorbunov A, Jost O, Pompe W, Graff A, Carbon 40(2002),113 [38] Oberlin A, Endo M, Koyama T, Carbon 14(1976),133 [39] Oberlin A, Endo M, Koyama T, J. Crys. Growth 32(1976),335 [40] Baird T, Fryer J.R, Giant B, Carbon 12(1974),591 [41] M. R. Falvo, G. J. Clary, R. MII. Taylor, V Chi, FP Brooks, SWashburn, R Superfine, 1997, Nature, 389, p. 582 [42] M. Treacy, T. W. Ebesen, J. M. Gibson, 1996, Nature, 381, p678 [43]鄭凱文，「利用鐵、鎳金屬片及次微米鐵點陣列成長具方向性奈米碳管」，國立東華大學材料科學與工程研究所碩士論文，第8頁，民國九十一年 [44] N. Krishnankutty, C. Park, N. M. Rodriguez, R. T. K. Baker, 1995,Carbon, 27, pp. 925-930 [45] M. Terrones, W. K. Hsu, H. W. Kroto, D. R. M. Walton, 1998, Nanotube : A Revolution in Materials Science, Topics in Current Chemistry 199 ,p. 1 [46] S. Bandow, 1997, Japanese Journal of Applied Physics, Part 2 36, pp.1403-1405 [47] B. Vigolo, A. Penicaud, C. Coulon, C. Sauder, R. Pailler, C. Journet,P. Bernier, and P. Poulin, 2000, Science, 290, p. 1331 [48] J. Kong, N. R. Franklin, C. Zhou, M. G. Chapline, S. Peng, K. Cho, H. Dai, 2000, Science, 287, p. 622 [49] J. H. Hafner, C. L. Cheung, C. M. Lieber, 1999, Journal AmericaChemical Society, 121, p. 9750 [50] A. J. Bard and L. R. Faulkner,“ Electrochemical Methods, Fundamentals and Applications ”,John Wiley & Sons, Singapore(1980).
[51] D. Pletcher,“ A First Course in Electrode Processes ”, The Electrochemical Consultancy, England (1991).
[52] D. R. Crow,“ Principles and Applications of Electrochemistry ”, 2nd Ed. Chapman and Hall Ltd. London (1979).
[53] 陳奕勳,“ 陽極沈積錳系水合氧化物於電化學超級電容器之應用 ”,國立中正大學化學工程研究所碩士論文, 2003.
[54] A. M. Couper, D. Pletcher, and F. C. Walsh, Chem. Rev., 90, 837 (1990).
[55] H. Wendt,“ Electrocatalysis in Organic Electrochemistry ”, Electrochim. Acta, 29, 1513 (1991).
[56] B. Marsan, N. Fradette, and G. Beaudoin, J. Electrochem. Soc. 139, 1889(1992).
[57] L. Nanni, S. Polizzi, A. Benedetti, and A.D. Battisti,“ Morphology, Microstructure, and Electrocatalytic Properties of RuO2-SnO2 Thin Films ” J. Electrochem. Soc., 146, 220-225 (1999).
[58] R. Kotz, M. Carlen, Principles and applications of electrochemical capacitors, Electrochim. Acta, 45 (2000) 2483.
[59] 黃耀煌,“ 循環伏安法置備之含水釕氧化物於電化學電容器之應用 ”,國立中正 大學化工研究所碩士論文, 1999.
[60] J. P. Zheng and T. R. jow,“ A New Charge Strage Mechanism for Electrochemical Capacitors, ” J. Electrochem. Soc., 142, L6-L8 (1995)
[61] Ting-Kan Tsai , Chia-Chih Chuang , Chuen-Guang Chao ,Wei-Long Liu,“ Growth and field emission of carbon nanofibers on electroless Ni – P alloy catalyst, ” Diamond and Related Materials 12 (2003) 1453 – 1459.
[62] Girish Arabale, Deepali Wagh, Mahesh Kulkarni, I.S. Mulla, S.P. Vernekar, K.Vijayamohanan, A.M. Rao,“ Enhanced supercapacitance of multiwalled carbon nanotubes functionalized with ruthenium oxide, ” Chemical Physics Letters 376 (2003) 207 – 213.
[63] 江鴻儒,“ 循環伏安法及電鍍法制備釕電極在電化學電容器之應用 ”,國立中正大學化學工程研究所碩士論文, 2001.
[64] Xu Zhang, et al.,“ Surface-enhanced Raman of Z-vibration mode in single-walled and multi-walled carbon nanotube, ” Chemical Physics Letters, 372(2004) 497.
[65] P. E. Nolan, M. J. Schabel, D. C. Lynch., Hydrogen control ofcarbon deposit morphology, Carbon, 33(1995) 79