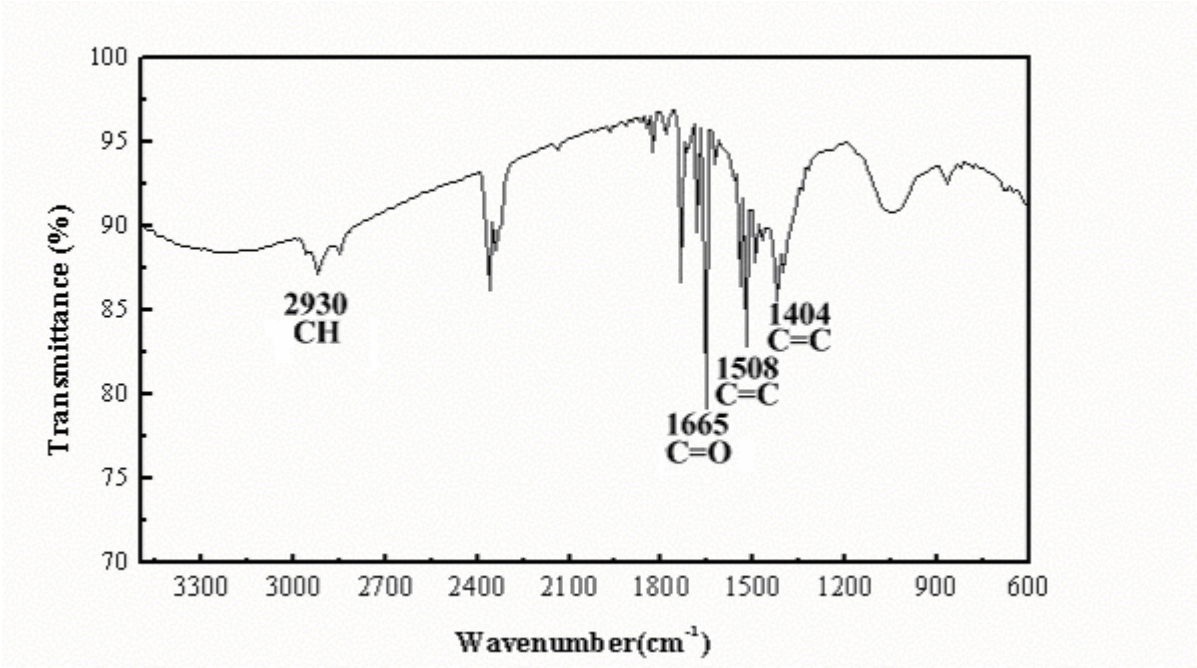

圖4-25 電泳沉積之CNTs 鍍層FTIR分析圖

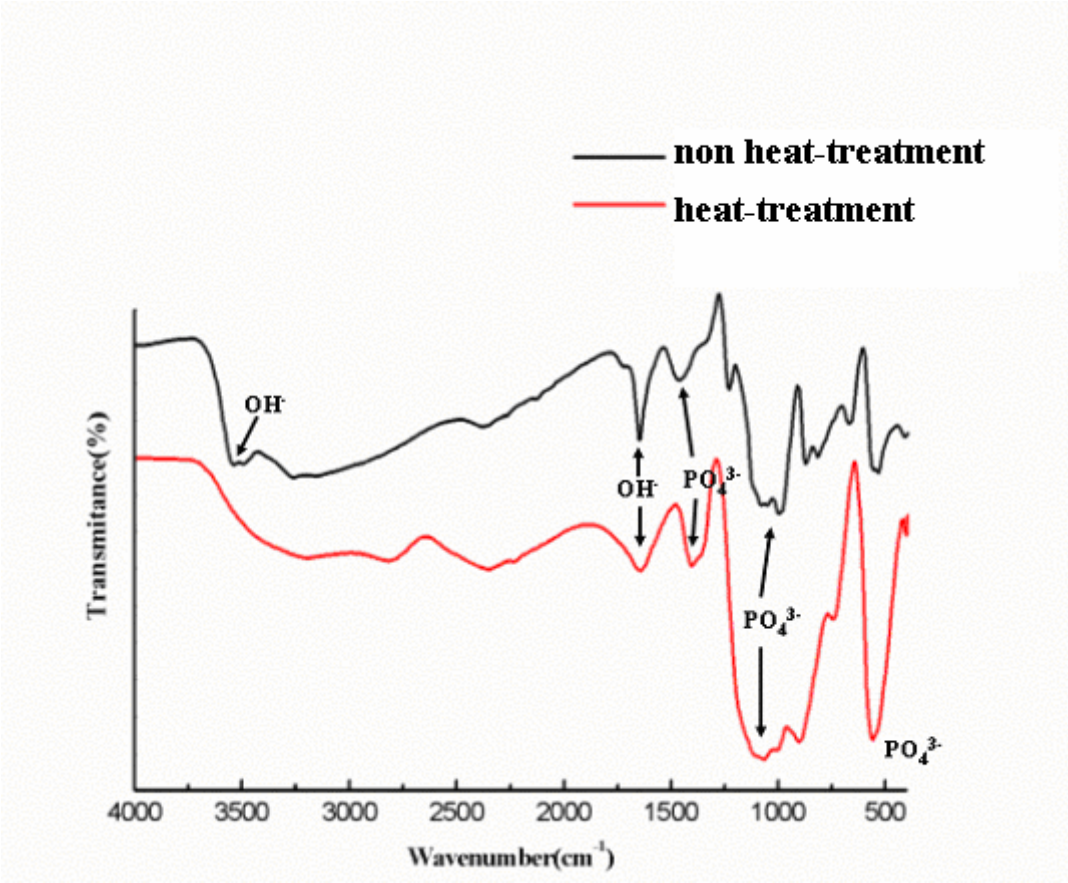

圖4-26 3mA/cm^{2}電流密度之沉積條件之HAp/CNTs 鍍層FTIR分析圖

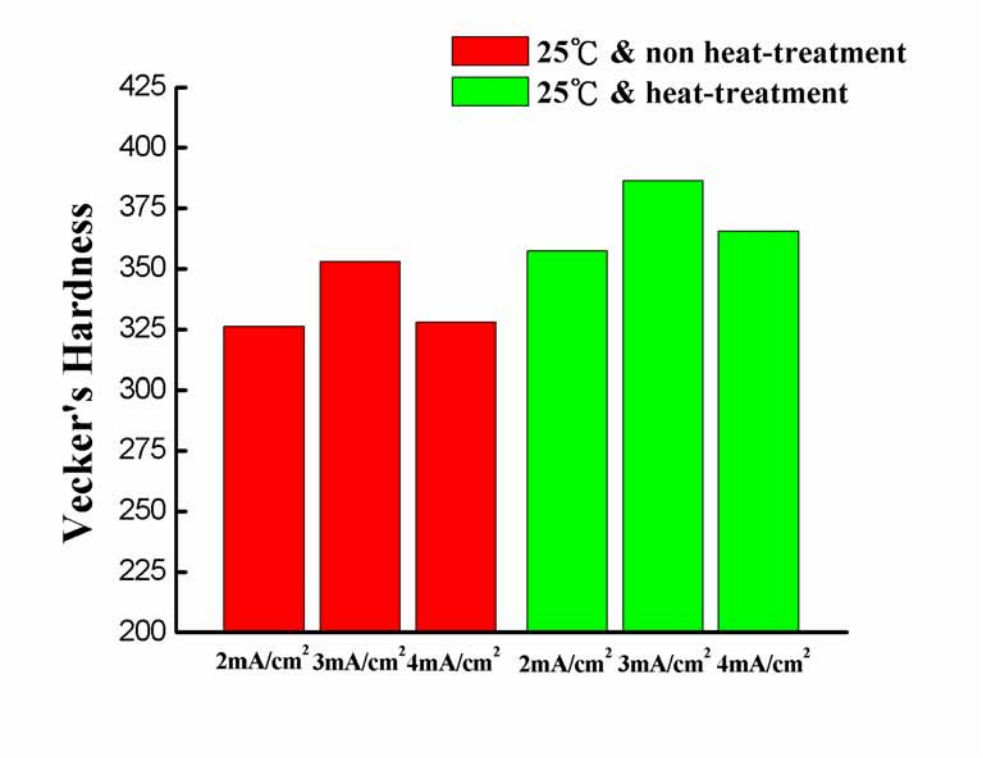

圖4-27　電解液25℃及各電流密度之沉積條件之單層HAp 鍍層硬度試驗

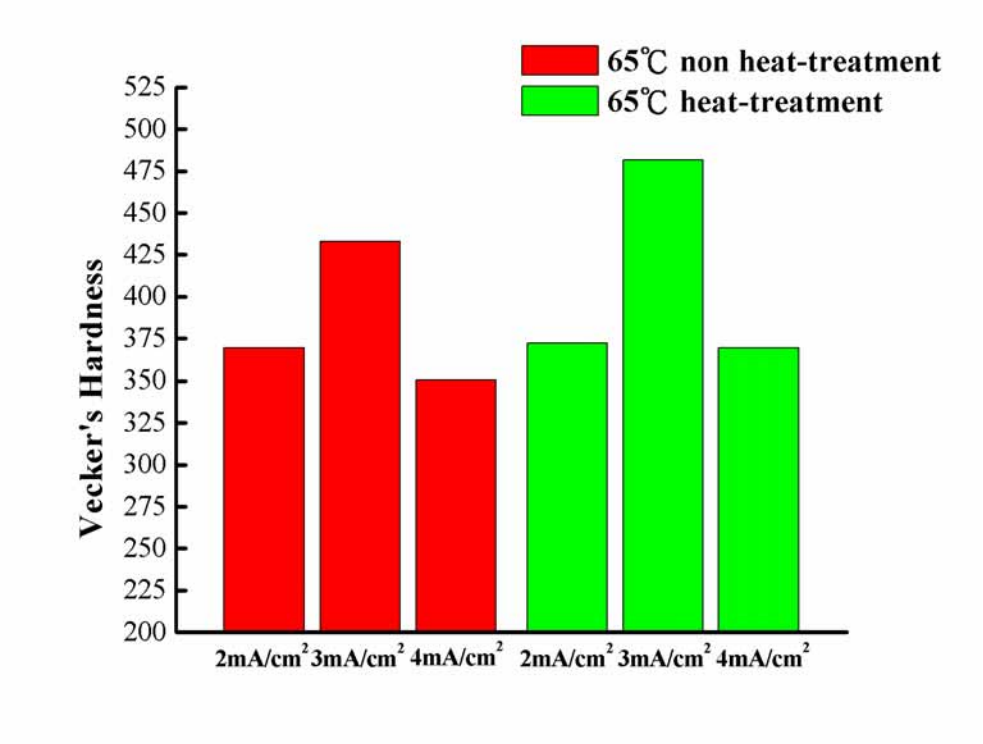

圖4-28　電解液65℃及各電流密度之沉積條件之單層HAp 鍍層硬度試驗

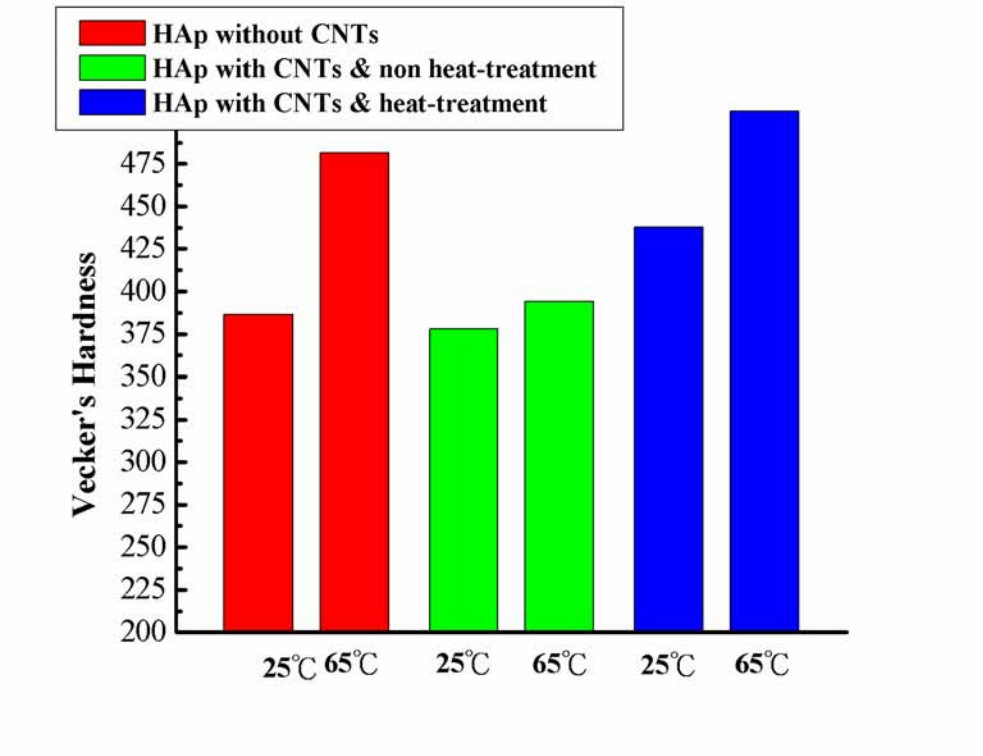

圖4-29　3mA/cm^{2}電流密度之沉積條件HAp/CNTs 鍍層硬度試驗

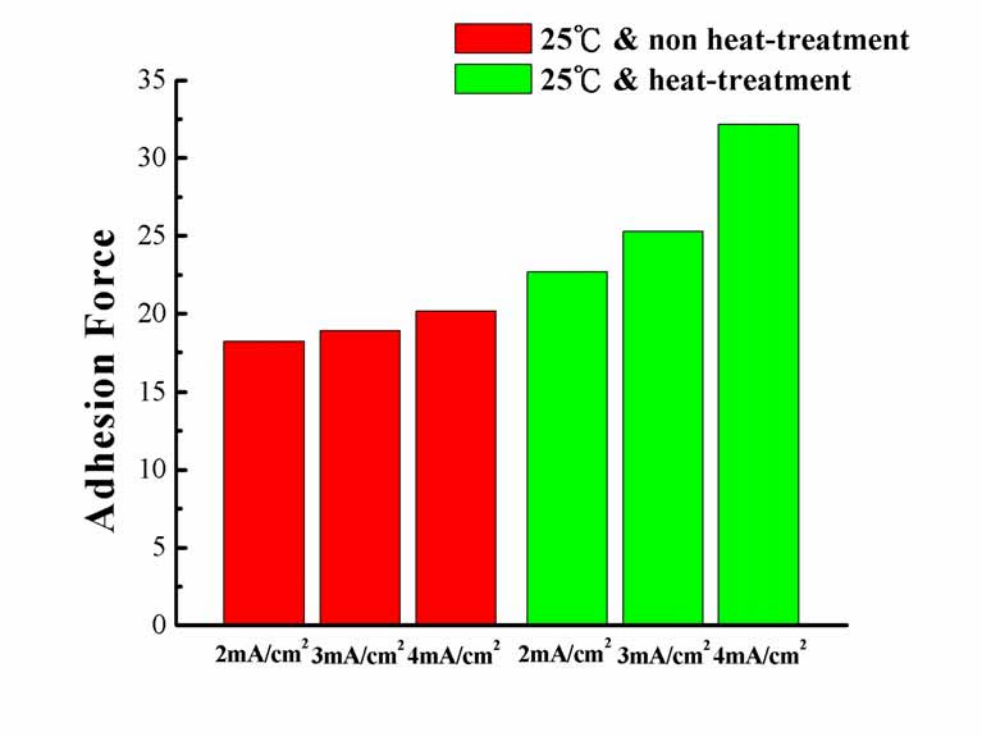

圖4-30　電解液25℃及各電流密度之沉積條件之單層HAp 鍍層附著力試驗

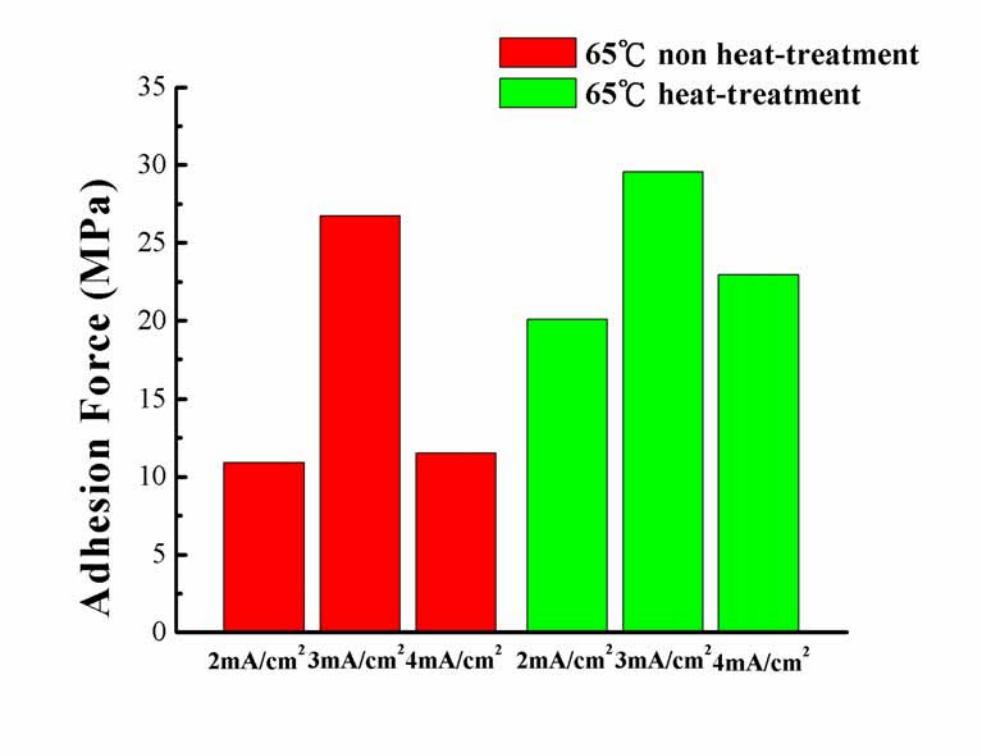

圖4-31　電解液65℃及各電流密度之沉積條件之單層HAp 鍍層附著力試驗

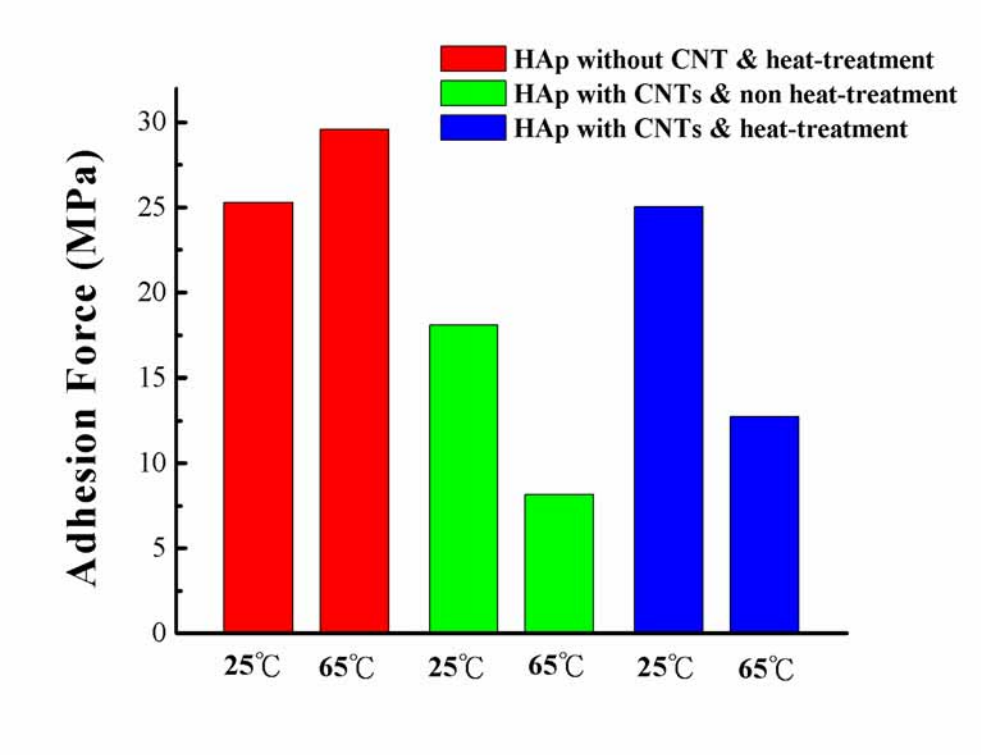

圖4-32　3mA/cm^{2}電流密度之沉積條件HAp、HAp/CNTs 鍍層附著力試驗

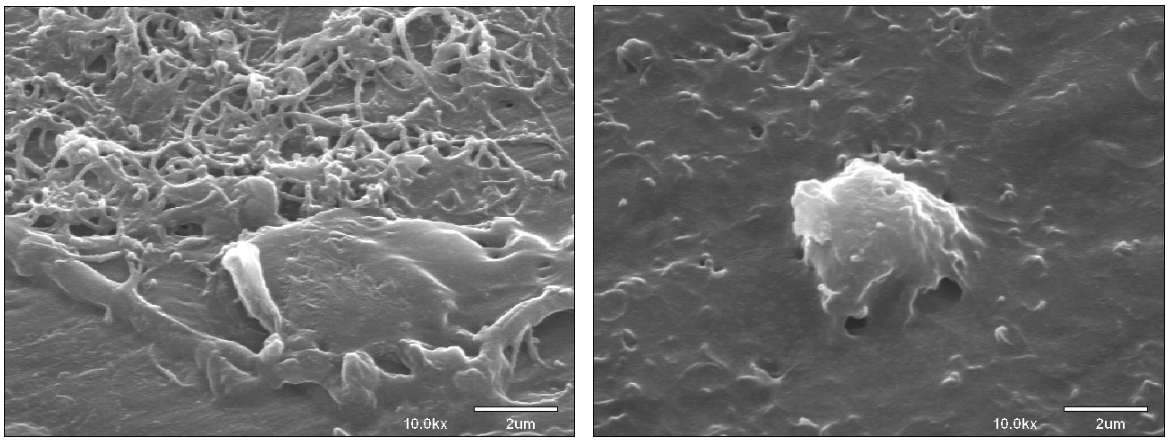

圖 4-33 電泳沉積 CNT 鍍層細胞培養 24 小時之 SEM 照片

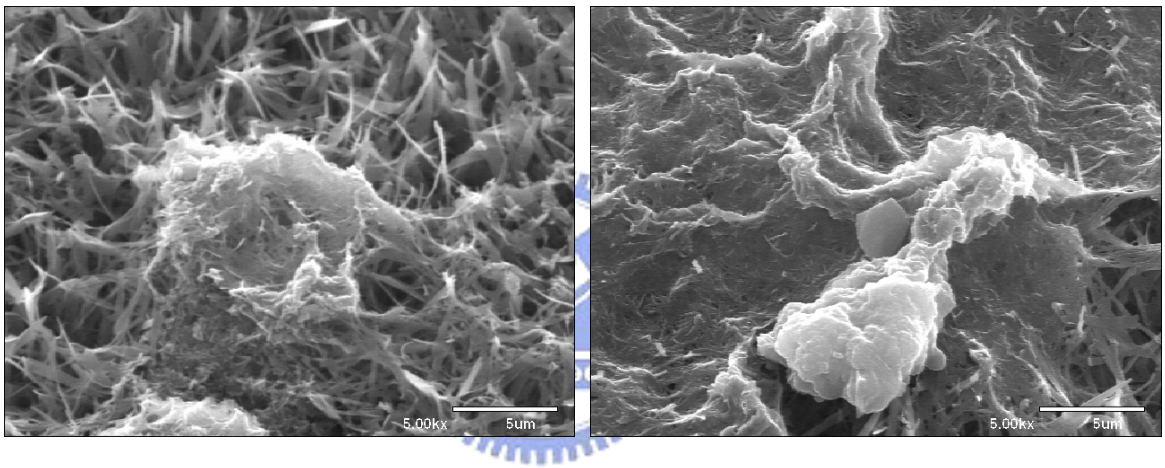

圖4-34 電泳沉積HAp/CNT鍍層細胞培養24小時之SEM照片

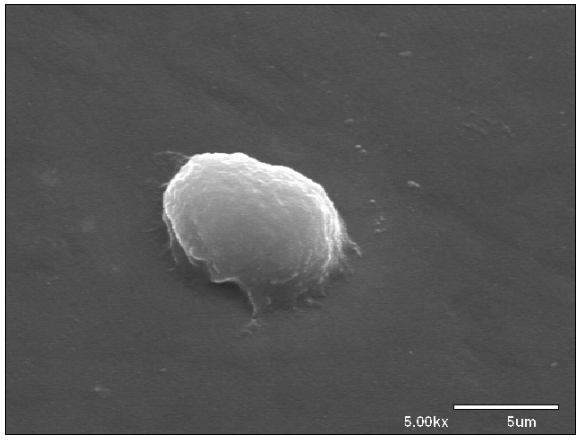

圖4-35 鈦片細胞培養24小時之SEM照片

第五章　結論與未來展望

5-1 結論

本研究以電解沉積法沉積 HAp/CNT 複合鍍層，對於 HAp/CNT 鍍層作物化性分析與生物相容性實驗之後，我們可得到以下幾個特性:

1. 由SEM照片中得之，電流密度3mA/cm^{2}可以較均勻之HAp鍍層；電解液25℃之鍍層表面型態為平板狀，電解液65℃之鍍層表面型態為針狀；CNT之管徑約50~70nm且可以電泳沉積法鍍於鈦片上，HAp/CNT複合鍍層較不均勻。
2. 由XRD圖可知，電解液未升溫，電流密度越高，DCPD結晶相繞射強度越弱，電解液升溫65℃，電流密度越高，HAp結晶相繞射強度越強；300℃燒結可使DCPD轉換為HAp結晶；CNT使鍍層經熱處理後不易轉換為HAp。
3. 由微硬度測試得之，CNT鍍層可有效提升HAp之硬度。
4. 由附著力測試得之，CNT鍍層會降低HAp鍍層之附著力。
5. 由細胞培養之結果顯示，骨母細胞於CNT鍍層上之生物適應性較鈦金屬佳，生長速度較快，故可知CNT不具生物毒性，可以應用於生物醫學材料。

5-2 未來展望

以電泳沉積法沉積之奈米碳管鍍層對於 HAp 之附著力並無幫助，但因

其不具生物毒性且具有非常優異的機械特性，仍然適用於生物醫學材料，惟期待往後可以尋找出適合的沉積方式。

參考文獻

[1] 王盈錦， “生物醫學材料”，合記出版社，(2002).

[2] M. S. Block, J. N. Kent, J. F. Kay, “Evaluation of hydroxylapatite-coated titanium dental implants in dogs”, J. Oral Maxillofac Surg., Vol.:45, pp. 601, (1987).

[3] Mitsuo Niinomi, “Mechanical properties of biomedical titanium”, Material Science & Engineering A, A243, pp.231, (1998).

[4] 台北市牙科植體學會，”臨床口腔植體學”，日益企業有限公司出版部，pp. 19, (1999).

[5] http://www.cheng.es.osaka-u.ac.jp/kanedalabo/HAP.htm

[6] Jae Man Choi, Hyoun Ee Kim, In Seop Lee, “Ion beam assisted deposition (IBAD) of hydroxyapatite coating layer on Ti-based metal substrate”, Biomaterials, Vol.:21, pp. 469, (2000)

[7] I. Zhitomirsky, “Electrophoretic hydroxyapatite coatings and fibers”, Mater. Lett., Vol.:42, pp. 262, (2000).

[8] M. Manso, S. Ogueta, P. Herrero-Fernández, L. Vázquez, M. Langlet, J. P. García-Ruiz, “Biological evaluation of aerosol-gel-derived hydroxyapatite coatings with human mesenchymal stem cells”, Biomaterials, Vol.:23, pp. 3985, (2002).

[9] C. F. Feng, K. A. Khor, E. J. Liu, P. Cheang, “Phase transformations in plasma sprayed hydroxyapatite coatings”, Scripta Material, Vol.:42, pp. 103, (2000).

[10] I. Zhitomirsky, “Cathodic electrosynthesis of titania films and powders”, Nanostructure Materials, Vol.:3, pp. 521, (1997).

[11] Kay Teraoka, Atsuo Ito, Kazuo Onuma, Tetsuya Tateishi, and Sadao Tsutsumi, “Bending strength of synthetic OH-carbonated hydroxyapatite single crystals” Journal of Biomedical Materials Research, Vol.:34, pp. 269, (1997).

[12] Yifei Hu, Xigeng Miao., “Comparison of hydroxyapatite ceramics and hydroxyapatite/ borosilicate glass composites prepared by slip casting”, Ceramic international, Vol: 30, pp. 1788, (2004).

[13] Wie H., Hero H., and Solheim T., “Hot isolation pressing processed hydroxyapatite coated titanium implants: light microscopic and scanning electron microscopy investigations”, Int. J. Oral Maxillofac Implants, Vol.:13, 837, 1998.

[14] Biing Yow Wu and A. S. T. Chiang, “Sol gel coating and its applications”, Chinese J. of Materials Science, Vol.: 28, 169, (1996).

[15] S.K. Yen., C.M. Lin, “Cathodic reactions of electrolytic hydroxyapatite coating on pure titanium”, Material chemistry and phys, Vol.:77, pp 70, (2002).

[16] K. Hayashi, T. Mashima, K. Uenoyama, “The effect of hydroxyapatite coating on bony ingrowth into grooved titanium implant”, Biomaterials, Vol.:20, pp 111, (1999).

[17] Xuebin Zheng, Minhui Huang, Chuanxian Ding, “Bond strength of plasma-sprayed hydroxyapatite/Ti composite coatings”, Biomaterial, Vol.:21, pp 841, (2000).

[18] S. K. Yen, C. M. Lin, “Characterization of electrolytic Al_2O_3/CaP composite coating on pure titanium,” Journal of electrochemical Society, Vol.:149, pp 79, (2002).

[19] V. Nelea, H. Pelletier, P. Mille, D. Muller, ” High-energy ion beam implantation of hydroxyapatite thin films grown on TiN and ZrO_2 inter-layers by pulsed laser deposition ”, Thin solid films, Vol.: 453 –454, pp 208, (2004).

[20] Hae-Won Kim, Young-Hag Koh, Long-Hao Li, Sook Lee, Hyoun-Ee Kim, “Hydroxyapatite coating on titanium substrate with titania buffer layer processed by sol–gel method”, Biomaterial, Vol.: 25, pp 2533, (2004).

[21] M. L. Cohen, “Nanotubes, nanoscience, and nanotechnology”, Materials Science & Engineering C, Vol.:15, pp 1-11, (2001).

[22] S. Iijima, “Helical microtubules of graphitic carbon”, Nature, Vol.:354, pp. 56, (1991).

[23] M. J. Yacaman, M. M. Yoshida, L. Rendon, and J. G. Santiesteban, “Catalytic growth of carbon microtubules with fullerene structure”, Appl. Phys. Lett., Vol.:62, pp. 202, (1993).

[24] G. Overney, W. Zhong, D. Tománek, “Structural rigidity and low Frequency viberational mode of long carbon tubules”, Z. phys. D, Vol.:27, pp. 93, (1993).

[25] Eric W. Wong, Paul E. Sheehan, Charles M. Lieber, “Nanobeam Mechanics: Elasticity,

Strength, and Toughness of Nanorods and Nanotubes", Science Vol.: 277, pp. 1971, (1997).

[26] H. J. Dai, J. H. Halfner, A. G. Rinzler, D.T. Colbert, R. E. Smalley, "Nanotubes as nanoprobes in scanning probe microscopy ", Nature, Vol.:384, pp. 147, (1996).

[27] C. Journet, W. K. Maser, P. Bernier, A. Loiseau, M. Lamy de la Chapelle, S. Lefrant, P. Deniard, R. Lee, J. E. Fischer, "Large scale production of single-walled carbon nanotubes by the electic-arc technique", Nature, Vol.:388, pp. 756, (1997).

[28] A. Iiie, A.C. Ferrari, T. Yagi, J. Robertson, "Effect of sp^2-phase nanostructure on filed emission from amorphous carbon", Appl. Phys. Letter, Vol.:76, pp. 2627, (2000).

[29] L. Y. Wang, J. P. Tu, W. X. Chen, Y. C. Wang, Charls Olk, D. H. Cheng, X. B. Zhang, "Friction and behavior of electroless Ni-based CNT composite coating", WEAR, Vol:254, pp. 1289, (2003).

[30] R. Z. MA, J. WU, B. Q. WEI, J. LIANG, D. H. WU, "Processing and properties of carbon nanotubes–nano-SiC ceramic", Journal of Materials Science, Vol.:33, pp. 5243, (1998).

[31] Jinwei Ning, Junji Zhang, Yubai Pan, Jingkun Guo, "Fabrication and mechanical properties of SiO_2 matrix composites reinforced by carbon nanotube", Material Science & Engineering A, A357, pp. 392, (2003).

[32] Chunsheng Du, David Heldbrant, Ning Pan, "Preparation and preliminary property study of carbon nanotubes films by electrophoretic deposition", Mater. Lett., Vol.:57, pp. 434, (2002).

[33] K.L. Ou, H.C. Wen, W.N. Wang, K.H. Yang, and S.Y. Chiou, C.C. Hsu, "The Effect of Co/Si Phase Transformation on Carbon Nanotube Growth by PECVD",The International Conference on Electrical Engineering, Sapporo, Japan, July 4-8.

[34] Guohua Jiang, Li Wang, Chang Chen, Xiaochen Dong, Tao Chen, Haojie Yu, "Study on attachment of highly branched molecules onto multiwalled carbon nanotubes", Material letters, Vol.:59, pp. 2085, (2005).