lectrodeposited Process and Mechanical Properties of Ni /Ni -P Bi-layered Coating

黃文杰、李弘彬、李得勝

E-mail: 374651@mail.dyu.edu.tw

ABSTRACT

Both pulse and direct current (DC) electroplating methods were employed in this thesis to prepare the Ni-P and Ni coatings, respectively. The former coating had low internal stress and high hardness while the latter possessed high toughness and better ductility. With these different characteristics, the internal stress of a Ni/Ni-P composite coating was tuned to a smaller magnitude by changing the thickness ratio between Ni and Ni-P layers. The microstructure examined by using transmission electron microscope (TEM) showed the Ni-P coating had a P-content of 10.7 wt% and a structure of equiaxed grains accompanying with scattered nanograins. The crystal defects, such as twins and dislocations, were observed in the microstructure. Furthermore, the electroplated Ni coating was with coarse columnar grains. Although the Young ’ s modulus of the homogeneous coating was able to be determined by load-indentation curve of the nano-indentation testing, the apparent Young ’ s modulus of the Ni/Ni-P composite coating was difficult to be measured directly. Therefore, a simple bending testing on a cantilevered specimen was designed in this study. The bending testing provided a tool for measuring the mechanical properties of multi-layered specimen. The good ductility of the electrodeposited Ni coating indicated its higher impact resistance while the high hardness of Ni-P coating revealed its low tolerance in deformation.

Keywords : Electroplating、multi-layer coating、nano-indentation、bending testing

Table of Contents

REFERENCES

[1]H. Yang, C. T. Pan, M.C. Chou, Ultra-fine machining tool/molds by LIGA technology, Journal of Micromechanics and Microengineering, Vol.11, pp.94-99, 2001.

[2]C. S. Lin, C. Y. Lee, F. J. Chen, C. T. Chien, P. L. Lin,W. C. Chung,Electrodeposition of Nickel-Phosphorus Alloy from Sulfamate Baths with Improved Current Efficiency, Journal of the Electrochemical Society, Vol.153, pp.387-392, 2006.

[3]M. Crobu, A. Scorciapino, B. Elsener, A. Rossi, The Corrosion Resistance of Electroless Deposited Nano-Crystalline Ni-P Alloys, ElectrochimicaActa, Vol.53, pp.3364-3370, 2008.

[4]K. H. Hou, M. C. Jeng, Y. K. Shen, M. D. Ger, The Wear Behavior of Pulse Current Electroforming Ni-P-SiC Composite Coatings, Key Engineering Materials, Vol.364-366, pp.358-363, 2008.

[5]S. T. Ke, J. L. Lee, Y. M. Yeh,S. J. Lee, M. D. Ger, A Study of the Microstructure and Properties of Electroformed Ni-PMode Insert, Key Engineering Materials, Vol.364-366, pp.232-236, 2008.

[6]行政院國家科學委員會，微機電系統技術與應用，行政院國家科學委員會精密儀器發展中心，2003。

[7]LIGA製程, http://www.imm-mainz.de/, 1990.

[8]許倍誠，電鍍鎳組織與機械性質之研究，碩士論文，大葉大學，彰化，2000。

[9]陳黼澤，鎳磷與鈷磷合金電鍍，碩士論文，台灣大學，台北，2005。

[10]蘇葵陽、張良謙，實用電鍍理論與實際，復文書局，1986。
[11]楊文呈，壓花輪模具鎳磷合金電鍍製程，碩士論文，大葉大學，彰化，2006。
[12]張允誠、胡如南、向榮，電鍍手冊(上冊)，第二版，國防工業出版社，北京，1997。
[13]E. Toth-Kadar, I. Bakonyi, A. Solyom, J. Hering, G. Konczos,Preparation and Characterization of Electrodeposited Amorphous Ni-P Alloys, Surface and Coating Technology, Vol.31, pp.31-43, 1987.
[14]R. Rajnarayan, M. N. Mungole, Electrodeposition of Ni-P Alloy Coatings, Surface Technology, Vol.24, pp.233-239, 1985.
[15]J. Crousier, Z. Hanane, J-P. Crousier, Electrodeposition of NiP Amorphous Alloys A Multilayer Structure, Thin Solid Films, Vol.248, pp.51-56, 1994.
[16]M. Ratzker, D. S. Lashmore, K. W. Pratt, Electrodeposition and Corrosion Performance of Nickel Phosphorus Alloys, Plating and Surface Finishing, Vol.76, pp.74-82, 1986.
[17]R. L. Zeller, III and U. Landau, Electrodeposition of NiP Amorphous Alloys, Journal of Electrochemical Society, Vol.139, pp.3464-3469, 1992.
[18]M. M. V. Parente, O. R. Mattos, S. L. Diaz, P. Lima Neto, F. J. Fabbi Miranda, Electrochemical Characterization of Ni-P and Ni-Co-P Amorphous Alloy Deposits Obtained by Electrodeposition, Journal of Applied Electrochemistry, Vol.31, pp.677-683, 2001.
[19]G. McMahon,U. Erb, Structural Transitions in Electroplated Ni-P Alloys, Journal of Materials Science Letters, Vol.8, pp.865-868, 1989.
[20]I. Ogno, H. Ohfuruton, S. Haruyama, Electrodeposition of Ni-P Alloys with Pulsating Current, 日本金屬學會誌， Vol.50, pp.1075-1080, 1986.
[21]T. Morikawa, T. Nakade, M. Yoloi, Y. Fukumto, C. Iwakura, Electrodeposition of Ni-P Alloys from Ni-Citrate Bath, Electrochimica Acta, Vol.42, pp.115-118, 1997.
[22]J. Crousier, Z. Hanane, J-P. Crousier, Electrodeposition of NiP AmorphousAlloys. A Multilayer.Structure, Thin Solid Films, Vol.248, pp.51-56, 1994.
[23]T. M. Harris, Q. D. Dang, The Mechanism of Phosphorus Incorporation during the Electrodeposition of Nickel-Phosphorus Alloys, Journal of The Electrochemical Society, Vol.140, pp.81-83, 1993.
[24]Kawashima, Y. P. Lu, H. Habazaki, K. Asama, K. Hashimoto, Structure and Corrosion Behavior of Electro-Deposited Ni-P Alloys, Corrosion Engineering, Vol.38, pp.643-653, 1989.
[25]K. P. Larsen, A. A. Rasmussen, J. T. Ramkilde, M. Ginnerup, O. Hansen, MEMS Device for Bending test : measurements of fatigue and creep of electroplated nickel, Sensors and Actuators A: Physical, Vol.103, pp.156-164, 2003.
[26]M. Haj-Taieb, A. S. M. A. Haseeb, J. Caulfield, K. Bade, J. Aktaa, K. J. Hemker, Thermal stability of electrodeposited LIGA Ni-W alloys for high temperature MEMS applications, Microsystem Technologies, Vol.14, pp.1531-1536, 2008.
[27]A. S. M. A. Haseeb, K. Bade, LIGA fabrication of namocrystalline Ni-W alloy micro specimens from ammonia-citrate bath, Microsystem Technologies, Vol.14, pp.379-388, 2008.
[28]R. Saha, W. D. Nix, Effects of the substrate on the determination of thin film mechanical properties by nanoidentation, Acta Materialia, Vol.50, pp.23-38, 2002.
[29]S. Johansson, J- A Schweitz, L. Tenerz, J.Tire ’ n, Facture Testing of Silicon Microelements in Situ in a Scanning Electron Microscope, Journal of Applied Physics, Vol.63, pp.799-803, 1988.
[30]C. J. Wilson, A. Ormeggi, M. Narbutovskih, Fracture Testing of SiliconnMicrocantilever Beam, Journal of Applied Physics, Vol.79, pp.2386-2393, 1995.
[31]W. D. Nix, Mechanical Properties of Thin Films, Metallurgical Transactions A, Vol.20, pp.2217-2245, 1989.
[32]T. P. Weihs, S. Hong, J. C. Bravman, W. D. Nix, Mechanical deflection of cantilever microbeams: A new technique for testing the mechanical properties of thin films, Journal of Materials Research, Vol.3, pp.931-942, 1988.
[33]T. P. Weihs, S. Hong, J. C. Bravman, W. D. Nix, Measuring the strength and stiffness of thin film materials by mechanically deflecting cantilever microbeams, Thin Films: Stresses and Mechanical Properties, Symposium Process, Pittsburgh, PA, pp.87-92, 1989.
[34]R. Weil, The Origins of Stress in Electrodeposits, Review of the Literature Dealing with Stress in Electrodeposited Metal, Plating, Vol.58, pp.137-146, 1971.
[35]C. S. Lin, C. Y. Lee, F. J. Chen, and W. C. Li, Structural Evolution and Internal Stress of Nickel-Phosphorus Electrodeposits, Journal of The Electrochemical Society, Vol.152, No.6, pp.370-375, 2005.
[36]V. C.Nguyen, C. Y. Lee, L. Chang, F. J. Chen, and C. S. Lin, The Relationship between Nano Crystallite Structure and Internal Stress in Ni Coatings Electrodeposited by Watts Bath Electrolyte Mixed Wihth Supercritical CO2, Journal of The Electrochemical Society, Vol.159, pp.D393-D399, 2012.