Study on the Residual Stress and Wear of Ni－P Electrodeposited Coating

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ABSTRACT

The high strength, wear and corrosion resistance, and fine microscopic texture of the nickel-phosphorus alloy render it as a potential candidate for replacing the cadmium or hard chromium plating mostly employed in automotive, aerospace and printing industries. In this study, the pulse current was adopted to be the power source of the electroplating in the sulfamate bath. It can raise the phosphorus content in the deposition, improve the current efficiency of the process and reduce the deposition stress as well. The corrosion and wear characteristics of an electrodeposited Ni-P coating were studied using block-on-ring wear tester. The testing environments included dry wear and immersion wear in 5% NaCl water solution at 25 ° C and 50 ° C to simulate the corrosive atmosphere. The wear behaviors in friction coefficient, wear rate and surface roughness were discussed. Under the boundary lubrication circumstance, it is found that the wear mechanism originates from both adhesive and abrasive wear for dry contact to abrasive wear dominant situation for corrosion wear. The corrosion film formed at accelerated corrosion wear testing not only lowers the friction coefficient but also the wear rate.

Keywords : Ni-P coating ; residual stress ; corrosion wear ; boundary lubrication ; corrosion film

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REFERENCES

[1].D. S. Lashmore and J. F. Weinroth,“ Pulse Electrodeposition of Nickel-Phosphorus Metallic Glass Alloys, ” Plating Surface Finishing, 69(72-76), 1982.

[2].L. Wang, Y. Gao, T. Xu, Q. Xue,“ Corrosion Resistance and Lubricated Sliding Wear Behaviour of Novel Ni – P Graded Alloys as an

Alternative to Hard Cr Deposits, ” Applied Surface Science 252 (7361 – 7372), 2006.
[3].A. Bai, P. Y. Chuang, C. C. Hu, “ The Corrosion Behavior of Ni-P Deposits with High Phosphorus Contents in Brine Media, ” Materials Chemistry and Physics 82 (93-100), 2003.
[4].許倍誠, “ 電鍍鎳組織與機械性質之研究 ”, 大葉大學機械工程研究所碩士論文, 2000年2月。
[5].鄧伊浚, “ 電鍍鎳鈷與鎳鐵合金組織與機械性質之研究 ”, 大葉大學機械工程研究所碩士論文, 2003年6月。
[6].陳黼澤, “ 鎳磷與鈷磷合金電鍍 ”, 國立台灣大學材料科學與工程學研究所碩士論文, 2005年7月。
[7].蘇葵陽、張良謙, “ 實用電鍍理論與實際 ”, 復文書局, 1986年。
[8].N. S. Qu, K. C. Chan and D. Zhu, “ Surface Roughening in Pulse Current and Pulse Reverse Current Electroforming of Nickel, ” Surface and Coatings Technology, Volume No.(220-224), 1997.
[9].曾元宏, “ 脈衝電流應用於微電鑄最適化之研究 ”, 國立清華大學化學工程學系, 碩士論文, 2001年。
[10].許仁哲, “ 內應力對無電鍍鎳銅磷析鍍於鋁基材上影響之研究 ”, 國立成功大學材料科學及工程學系, 博士論文, 2004年。
[11].J. L. Carbajal, R. E. White, ” Electrochemical Production and Corrosion Testing of Amorphous Ni-P, ” Journal of the Electrochemical Society, 135 (2952-2957), 1988.
[12].K. H. Hou, M. C. Jeng , M. D. Ger, “ A study on the Wear Resistance Characteristics of Pulse Electroforming Ni – P Alloy Coatings as Plated, ” Wear, 262 (833 – 844), 2007.
[13].I. Apachitei, F.D. Tichelaar, J. Duszczyk, L. Katgerman, “ The effect of heat treatment on the structure and abrasive wear resistance of autocatalytic NiP and NiP – SiC coatings, ” Surface and Coatings Technology 149 (263 – 278), 2002.
[14].A. P. Sannino, H.J. Rack, “ Dry Sliding Wear of Discontinuously Reinforced Aluminum Composites :Review and Discussion, ” Wear, 189, (1-19), 1995.
[15].K. Z. Gahr, “ Microstructure and Wear of Materials, ” Elsevier Science Publishing Company Inc, 1987.
[16].劉國雄, 林樹均, 李勝隆, 鄭晃忠, 葉均蔚編著, “ 工程材料科學 ”, 全華科技圖書, (834-837), 1995。
[17].陳豐彥, 何信威, “ 燒結摩擦材料 ”, 粉末冶金手冊, 中華民國粉末冶金協會, (445-457), 1994。
[18].莊東漢編著, “ 材料破損分析 ”, 五南圖書, (368-379), 2007。
[19].柯賢文編著, “ 腐蝕及其防治 ”, 全華科技圖, 1985。
[20].鮮祺振編著, “ 金屬腐蝕特性討論 ” 徐氏基金會 1998/01/10。
[21].D. A. Jones, “ Principles and Prevention of Corrosion, ” 2Ed, Prentice Hall International, Inc., (44-171),1997.
[22].D. H. Jeong, U. Erb, K. T. Aust, G. Palumbo, “ The Relationship Between Hardness and Abrasive Wear Resistance of Electrodeposited Nanocrystalline Ni-P Coatings, ” Scripta Materialia 48 (1067-1072) 2003.
[23].I. Apachiter, F. D. Tichelaar, J. Duszczyk, L. Katgerman, “ The Effect of Heat Treatment on the Structure and Abrasive Wear Resistance of Autocatalytic NiP and NiP – SiC Coatings ”, Surface and Coatings Technology 149 (2002) 263-278.
[24].S. Alirezaei, S. M. Monirvaghefi, M. Salehi, A. Saatchi, ” Wear Behavior of Ni-P and Ni-P-Al2O3 Electroless Coatings, ” Wear 262 (978-985) 2007.
[25].V. V. N. Reddy, B. Ramamoorthy, P. K. Nair, ” A Study on the Wear Resistance of Electroless Ni-P/Diamond Composite Coatings, ” Wear 239 (111-116) 2000.
[26].B. Bozzini, C. Martini, P. L. Cavallotti, E. Lanzoni, ” Relationships Among Crystallographic Structure, Mechanical Properties and Tribological Behaviour of Electroless Ni-P(9%)/B4C Films, ” Wear 225 – 229 (806-813) 1999.
[27].L. Wang, Y. Gao, T. Xu, Q. Xue, “ Corrosion Resistance and Lubricated Sliding Wear Behaviour of Novel Ni – P Graded Alloys as an Alternative to Hard Cr Deposits, ” Applied Surface Science 252 (7361 – 7372) 2006.
[28].C. S. Lin, C. Y. Lee, F. J. Chen and W. C. Li, J. “ Structural Evolution and Internal Stress of Nickel-Phosphorus Electrodeposits, ” Journal of the Electrochemical Society, 152 (C370)2005.
[29].K. H. Hou, M. C. Jeng, M. D. Ger, “ A Study on the Wear Resistance Characteristics of Pulse Electroforming Ni – P Alloy Coatings as Plated, ” Wear, 262 (833 – 844) 2007.
[30].D. H. Jeong, U. Erb, K. T. Aust, G. Palumbo, “ The Relationship Between Hardness and Abrasive Wear Resistance of Electrodeposited Nanocrystalline Ni-P Coatings, ” Scripta Materialia 48 (1067-1072) 2003.
[31].I. Apachiter, F. D. Tichelaar, J. Duszczyk, L. Katgerman, “ The Effect of Heat Treatment on the Structure and Abrasive Wear Resistance of Autocatalytic NiP and NiP – SiC Coatings, ” Surface and Coatings Technology 149 (263-278) 2002.
[32].S. Alirezaei, S. M. Monirvaghefi, M. Salehi, A. Saatchi, “ WearBehavior of Ni-P and Ni-P-Al2O3 Electroless Coatings, ” Wear 262 (978-985) 2007.
[33].L. Wang, Y. Gao, T. Xu, Q. Xue, “ Corrosion Resistance and Lubricated Sliding Wear Behaviour of Novel Ni – P Graded Alloys as an Alternative to Hard Cr Deposits, ” Applied Surface Science 252 (7361 – 7372) 2006.
[34].A. Bai, P. Y. Chuang, C. C. Hu, “ The Corrosion Behavior of Ni-P Deposits with High Phosphorus Contents in Brine Media, ” Materials Chemistry and Physics 82 (93-100) 2003.
[35].B. Bozzini, P. L. Cavallotti, G. Parisi, “ Corrosion and Erosion Corrosion of Electrodeposited Ni-P/ B4C Composotes, ” British Corrosion

Journal 36 (49-55) 2001.
[36].L. Benea, P. L. Bonora, A. Borello, S. Martelli, ”Effect of SiC Size Dimensions on the Corrosion Wear Resistance of the Electrodeposited Composite Coating, ” Materials and Corrosion 53 (23-29) 2002.
[37].張仁威，“矽晶圓輪磨表面粗糙度預測模型之研究”，大葉大學機械工程研究所碩士論文，2007年6月。