ITM-32: INVESTIGATION OF ELECTRODEPOSITED Ni-TiAlN COMPOSITE FILM

Esmar Budi[1,*)], Iwan Sugihartono[1], Agus Setyo Budi[1], Setia Budi[2], Alief Restu[1], Adhyatma Alamsyah[1], Ade Lina Permata[1], Muarief[1]

[1]Department of Physics, [2]Department of Chemistry
Faculty of Science and Mathematics, Universitas Negeri Jakarta
Jl. Pemuda No. 10 Rawamangun Jakarta Timur 13220

*) Email: esmarbudi@unj.ac.id

Abstrak

Pembentukan lapisan tipis komposit elektrodeposisi berbasiskan matriks nikel (Ni) pada bahan logam ditujukan untuk meningkatkan sifat ketahanan aus dan korosi bahan tersebut. Partikel senyawa keras nitrida umum ditambahkan pada matriks Ni guna meningkatkan sifat-sifat lapisan tipis komposit tersebut. Senyawa nitrida memiliki sifat-sifat unggul khususnya pada ketahanan aus dan korosi yang baik. Telah dilakukan kajian pembentukan lapisan tipis komposit elektrodeposisi Ni-TiAlN pada batang tungsten karbida. Sejumlah 2 gr/liter masing-masing serbuk TiN dan AlN ditambahkan kedalam larutan elektrolit yang terdiri dari 0.38 M $Ni_2SO_4.6H_2O$, 0.17 M $NiCl_2.6H_2O$ dan 0.49 M H_3BO_3. Percobaan dilakukan pada arus elektrodeposisi sebesar 3.5 dan 40 mA selama masing-masing 10 menit. Hasil percobaan menunjukan bahwa lapisan komposit memiliki morfologi yang semakin halus seiring dengan peningkatan arus elektrodeposisi.

Abstract

Electrodeposition of Ni-based composite films on metal is subjected to improve its wear and corrosion resistances. Hard nitride compound particles commonly are added into Ni matrix to enhance the composite film properties. The compound has excelent properties especally in mechanical and corrosion resistances. Electrodeposited Ni-TiAlN composite film on tungsten carbide rod as substrate has been investigated. Amount of 2 gr/liter of TiN and AlN powders were added into the electrolyte solution that consists of 0.38 M $Ni_2SO_4.6H_2O$, 0.17 M $NiCl_2.6H_2O$ and 0.49 M H_3BO_3. The experiment was performed at electrodeposition current of 3.5 and 40 mA for about 10 minutes. The results show that the composite film morphology is refined as increasing of electrodeposition current.

Keywords: *Ni-TiAlN composite film, electrodeposition, tungsten carbide, electrolyte solution.*

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1. Introduction

The development of electrodeposited Nickel-Nitride composite coatings or films have being investigated to protect the materials from friction and corrosion. Combination of Nickel (Ni) as metal matrix in composite film and hard particles such as TiN, TiC and SiC is subjected to improve the hardness, wear and corrosion resistance of the films [1-4].

Titanium Nitride (TiN) and Titanium Alumunium Nitride (TiAlN) has excellent mechanical and corrosion resistence especially in high temperature operation [5-7] and one of the promising material since its ability to form superhard and ultrahard coating with retained hardness at elevated temperature [8]. However, the development of electrodeposited Ni-TiAlN composite film is still lack of reports.

In the present study, the development of Ni-TiAlN composite film was conducted by using electrodeposition. The analysis on film composition and morphology are performed by using Scanning Electron Microscopy (SEM) and Energy Dispersive Spectroscopy (EDS) are discussed.

2. Researh Method

Tungsten carbide drill rod with dia. 1 mm was used as the substrate (cathode or working electrode) with the exposure area of substrate was aproximately 0.017 dm^2. The experimental equipment is set as Figure 1. Platinum (Pt) and $AgCl_2$ electrodes were used as counter and reference, respectively. Before electrodeposition proses, the substrate was rinsed in aquades and cleaned in alcohol 70% by using ultrasonic cleaner for 10 minutes. The electrolyte solution consists of 0.38 M $Ni_2SO_4.6H_2O$, 0.17 M $NiCl_2.6H_2O$ and 0.49 M H_3BO_3. A certain concentration of 2 gr/liter of TiN and AlN powders were added into the solution and were stirred using magnetic stirer for about 24 hours in order to achieve good dispersion. The experiment was performed at current 3.5 and 40 mA for about 10 minutes. The composition and morphology of the composite film were analyzed by using SEM/EDAX analysis.

Green: Working electrode (Carbide drill)

Figure 1. *Experimental equipment setting*

3. Results and Discussion

The surface morphology and composition of tungsten carbide tool rod as the substrate are shown in Figure 2 and Figure 3, respectively. It shows that the substrate has a rough textured morphology. EDS analysis show that the carbide substrate composition consists of mainly tungsten (W) element (78,76 %wt).

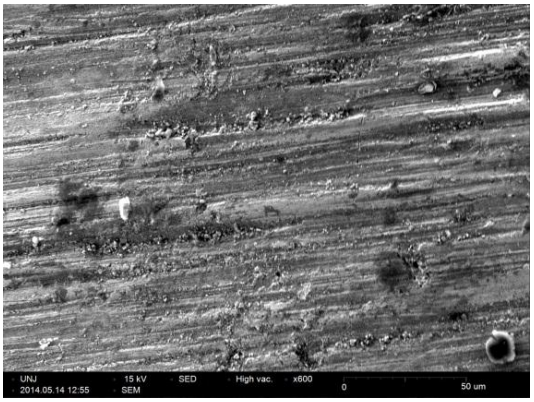

Figure 2. *SEM image of carbide tool rod morphology as substrate.*

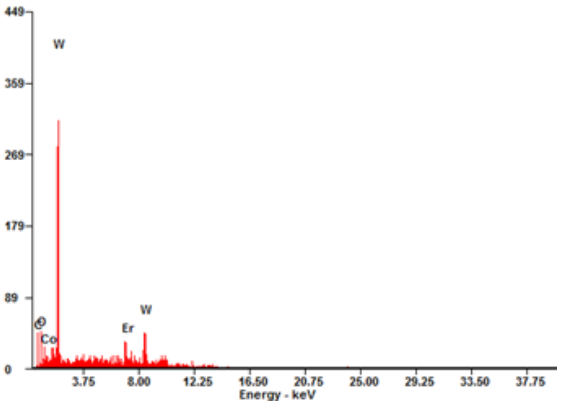

Figure 3*. EDS analysis of carbide tool rod*

The composite film morphology deposited at 3.5 mA and its composition are shown in Figure 4 and Figure 5. The composite film morphology shows a rough grain and it is refined with increasing current up to 40 mA (Figure 6).

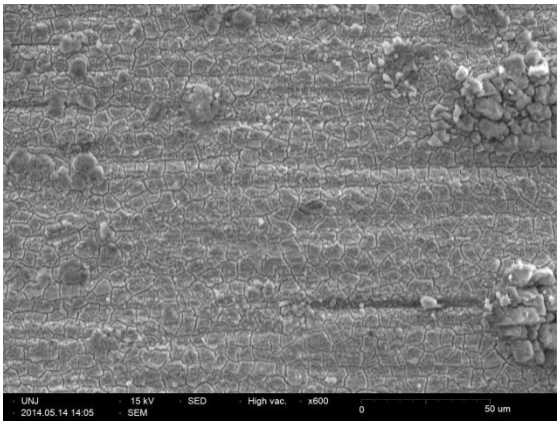

Figure 4. *Ni-TiAlN composite film electrodeposited at I = 3,5 mA.*

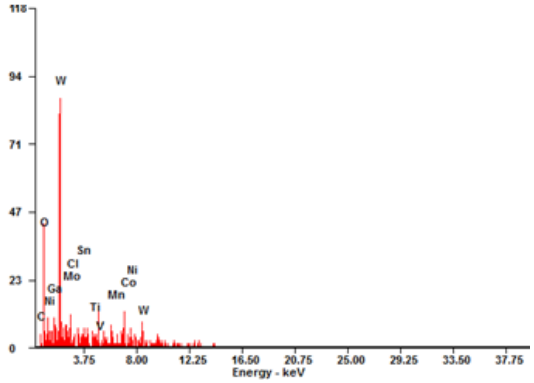

Figure 5*. EDS analysis of Ni-TiAlN composite film on carbide tool rod electrodeposited at I = 3.5 mA.*

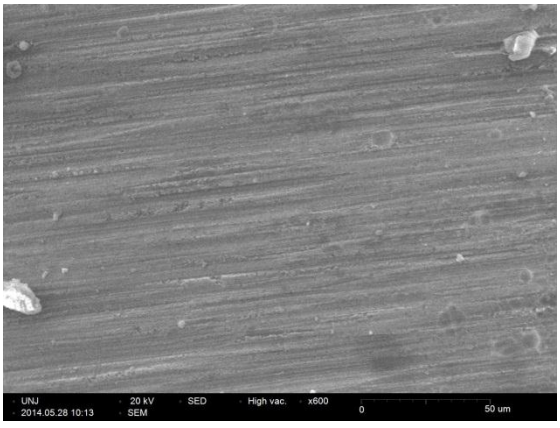

Figure 6. *Ni-TiAlN composite film electrodeposited at I = 40 mA.*

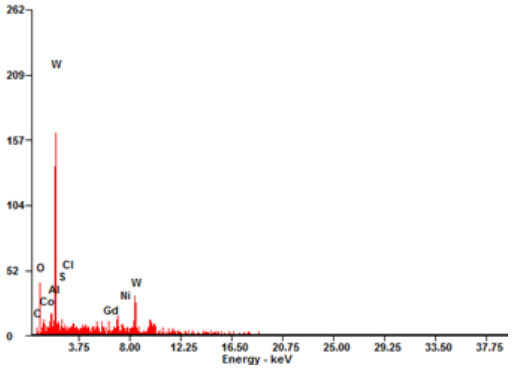

Figure 7. *EDS analysis of Ni-TiAlN composit deposited at I = 40 mA*

The refinement of film morphology at high current is due to reduction process and crystal growth of nickel [1]. At high current, the nitride particles content decrease cause the nickel crystal growth is pavorable. The formation of electrodeposited film is a competition between nucleation and crystal growth. The particles absorbed on the substrate inhibit the crystal growth of nickel and activate the nucleation [9].

The EDS analysis indicates the presence of a few amount of Ni, Ti and Al in the film while there is no N elements detected in the film (Figure 5 and 7). The amount of film composition is controlled by the particles flux to the substrate (cathode) surface and it is controlled by current density [10].

4. Conclusion

Ni-TiAlN composite film has been investigated by using electrodeposition process. The film morphology is governed by current density and it is refined as increasing current density.

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References

[1] ZHU Xu-bei, CAI Chao, ZHENG Guo-qu, ZHANG Zhao, LI Jin-feng. Electrodeposition and corrosion behavior of nanostructured Ni-TiN composite films. Trans. Nonferous Met. Soc. China, Vol. 21, (2011), p. 2216-2224.

[2] M. Karbasi, N. Yazdian, A. Vahidian. Development of electro-co-deposited Ni–TiC nano-particle reinforced nanocomposite

coatings. Surface & Coatings Technology, Vol. 207 (2012), p. 587–593.

[3] M.R. Vaezi, S.K. Sadrnezhaad, L. Nikzad. Electrodeposition of Ni–SiC nano-composite coatings and evaluation of wear and corrosion resistance and electroplating characteristics. Colloids and Surfaces A: Physicochem. Eng. Aspects, Vol. 315, (2008), p. 176–182.

[4] Yang Xiu-ying, Li Kang-ju, Peng Xiao, Wang Fu-hui. Beneficial effects of Co2+ on co-electrodeposited Ni-SiC nanocomposite coating. Trans. Nonferrous Met. Soc. China, Vol. 19 (2009), p. 119 – 124.

[5] Yoon, S.Y., Lee, K.O., Kang, S.S., Kim, K.H. Comparison for Mechanical Properties Between TiN and TiAlN Coating Layers by AIP Technique. Journal of Material Processing and Technology, Vol.130-131, (2002), p. 260-265.

[6] Sergiy Korablov, M.A.M. Ibrahim, Masahiro Yoshimura Hydrothermal corrosion of TiAlN and CrN PVD films on stainless steel Corrosion Science 47 (2005) 1839–1854.

[7] R.M. Soutoa, H. Alanyali. Electrochemical characteristics of steel coated with TiN and TiAlN coatings Corrosion Science 42 (2000) 2201-2211.

[8] Veprek, S., Haussmann, M., Reiprich, S., Shizhi, Li., Dian, J. (1996). Novel Thermodynamically Stable and Oxidation Resistant Superhard Coating Materials. Surface and Coating Technology, Vol. 86-87, pp. 394-401.

[9] Singh, D.K., Tripathi, M. K., Singh, V. B. Electrodeposition and characterization of Ni-WC composite coating from non-aqueous bath. International Journal of Materials Science and Applications 2(2) (2013): 68-73.

[10] Zhao-xia, N., Fa-he, C., Wei, W., Zhao, Z., Jian-qig, Z., Chu-nan, C. Electrodeposition of Ni-SiC nanocomposite film. Trans. Nonferrous Met. Soc. China 17 (2007) 9-15.