Journal of Engineering and Development, Vol. 18, No.6, November 2014, ISSN 1813- 7822

Studying the Effect of Ni Electroplating on Corrosion Behavior in Presence Ultra Fine Al_2O_3 and Sic

Asst. prof. Nirvana Abbas AbdAlameer
Chemical engineering , Technical college/Baghdad

Lecturer. Shayma Hameed Mohammad
Materials engineering techniques , Technical college/Baghdad

Asst. lecturer. Thaer Abdalwahab Shihab
Dies and Tools engineering techniques, Technical college/Baghdad

Abstract:

This work focuses on the effect of electro-deposition of nickel on corrosion behavior of mild steel substrate with ultra fine Al_2O_3 and SiC using the electroplating technology. The experimental results exhibited the substrate microstructure was sensitive to both current density and temperature. Grain growth were increased with increasing each of current density and temperature and thereafter decreased. Optimal values were $0.2A/cm^2$ and 45C°, respectively. Concentration of each Al_2O_3 and SiC were essential to electro-deposition, it was found 4gm/l after traditional weight loss technique was performed, it was found that corrosion rate of Ni and Ni- Al_2O_3 was deceased with exposure time in 3.5% NaCl solution whereas Ni-SiC exhibited higher corrosion rate. the addition Al_2O_3 was inhibited corrosion in acid solution.

Key word: electroplating nickel, Al_2O_3 and SiC

دراسة تأثير الطلاء الكهربائي بالنيكل مع مسحوق الالومينا وكاربيد السليكون فائقة النعومة على سلوك التآكل

ا.م. نيرفانا عباس عبد الامير
قسم الهندسة الكيماوية

م. شيماء حميد محمد
قسم هندسة المواد

م.م ثائر عبد الوهاب شهاب
تقنيات هندسة القوالب والعدد

الكلية التقنية – بغداد

الخلاصة :

ركز هذا البحث على تأثير الطلاء الكهربائي بالنيكل على سلوك التأكل لفولاذ متوسط الكاربون مع مسحوق كلا من الالومينا وكاربيد السليكون فائقة النعومة. أظهرت النتائج ان البنية المجهرية للمادة الأساس تتأثر بكل من كثافة التيار ودرجة الحرارة. نمو الحبيبات تزداد بزيادة كلا من التيار ودرجة الحرارة وبعد ذلك تقل. أفضل النتائج كانت هي عند 0.2 امبير\ سم^2 و 45 م$^\circ$. ان تركيز كلا من الالومينا وكاربيد السليكون أساسي في عملية الطلاء الكهربائي حيث وجد ان افضل تركيز هو 4 غم\ لتر. بعد انجاز تقنية فقدان الوزن التقليدية، وجد ان معدل التأكل عند الطلاء بالنيكل و نيكل- الومينا يقل مع زمن الغمر بمحلول كلوريد الصوديوم في حين اظهر معدلات عالية عند وجود كاربيد السليكون في المحلول. اما في المحاليل الحامضية فان الالومينا عملت كمانع للتأكل حيث قللت من قيمته مقارنة بالنيكل- كاربيد السليكون.

Introduction

Metal – matrix composites are materials in which the properties of metallic host material are modified with the addition of a second phase (ceramic). Electro-deposition of composite coating, based on second phase hard particles dispersed in a metallic matrix. The second phase can be hard oxide (Al_2O_3, TiO_2& SiO_2) or carbide particles (SiC & WC) [1].

Electroplating is an electro deposition process for producing a dense, uniform, and adherent coating, usually of metal or alloys, upon a surface by the act of electric current. The coating produced is usually for decorative and\or protective purposes, or enhancing specific properties of the surface. The surface can be conductors, such as metal, or non-conductors, such as plastics. Electroplating products are widely used for many industries, such as automobile, ship, air space, machinery, electronics, jewellery, defence, and toy industries. The core part of the electroplating process is the electrolytic cell (electroplating unit). In the electrolytic cell (electroplating unit) a current is passed through a bath containing electrolyte, the anode, and the cathode. Multilayered coatings are produced by plating different metals from the same solution at different potentials. A pulse train-shaped potential is enforced, resulting in the multilayer deposition. For example, multilayered coatings based on copper, nickel, chromium, in that order, can be applied to either metal or plastic components for visual appearance, corrosion and wear resistance, and weight saving **[2]**.

The use of mild steel in engineering material for pipelines, transportation, construction, hardware, electrical components and metal-processing is widespread. Many different types of coating are applied commercially to provide protection from corrosive environments and thus extend the life span of mild steel based infrastructure. The coating is designed to retain the mechanical properties of the mild steel while protecting against wear and corrosion **[3]**

Mykolas studied the corrosion of nickel metal matrix composites (Ni-MMC) B_4C, Al_2O_3 and SiC practical. The results exhibit an accelerating effect of B_4C has been observed in both neutral and acid salt fog environments. Al_2O_3 inhibited corrosion in the acid environment and did not affect it in the neutral one **[4]**.

Salam. studied the effect of current density and heat treatment on the electrodeposited Nickel coated bulk graphite. Based on experimental results in this work, the variations of deposition conditions such as current density result in obtaining a high quality electrodeposited layer **[5]**

Experimental work

1. Mild steel substrate was studied with dimensions (1*1 *0.2)cm.
2. Ni as anodic electrode with purity (99.9%) in the electro- deposition experiments.
3. Electrolyte was watts solution containing nickel sulphate: $NiSO_4.6H_2O$, nickel chloride: $NiCl_2$. $6H_2O$ and boric acid: H_3BO_3 listed in **Table 1.**
4. The electroplating was carried out in a glass container with capacity (5 L).
5. The pH of solution was (3-4) and different temperatures of 25, 35, 45 &50C°.
6. The current density was varied between 0.1 and 0.3 A \ cm^2 and the blending time was 1 hr.

7. The Al_2O_3 and SiC powder were added to the bath at concentrations from 2 to4 gm /l, after the bath reached a uniform temperature of 50 C° and blended for 1 hr using magnetic stirrer.
8. The distance between the electrodes was (5 cm) .
9. The plating solution was maintained at homogenous conditions using magnetic stirrer (350 rpm) during electro deposition.
10. The plating time was 15 min.
11. The corrosion rate was determined by weight loss and calculated using following correlation[6].

$$\text{CORROSION RATE (mpy)} = \frac{534\ W}{A.D.t} \qquad \text{----------} (1)$$

Where:

W: weight loss (mg)

D: density of specimen material (g/cm^3)

A: area ($inch^2$)

t: time of exposure (hr)

Results and Discussions

Good quality nickel deposits can be produced within the ranges of solution pH, temperature, current density and (Al_2O_3&SiC) additives given in **Table (1).** When current density passes through electrolyte solution at optimal parameters this crease high potential difference at the substrate surface and an increase in mobility of hydrogen and nickel ions.

Table .(1) chemical composition of mild steel

C	S	Ni	Si	P	Sn	Al	Cr
0.43	0.34	0.09	0.036	0.035	0.001	0.01	0.96
W	**Co**	**Fe**	**V**	**Mn**	**Cu**	**Mo**	
0.04	0.01	-	0.21	0.9	0.151	0.032	

At low current density the thickness of the deposit is not uniform over the substrate surface due to difference in the ohmic resistance of the path through the electrolyte to an anode. The distribution of deposition current due to this factor is the primary current density distribution where the current density is high so that the deposit is more uniform than would be predicted from the primary current density distribution. The results show that the Optimum coating at 0.2 A/cm^2 for different concentrations of Al_2O_3.

The grain size of the electrodeposited nickel is found to be increased with increasing temperatures. High temperature helps to increase grain growth thus it reduces coating time. Coating was carried out at different temperatures (25, 35, 45&55C°). When temperature was increased the coating increases and thereafter decreased. Improvement in coating at 45C° is due to the fact that temperature accelerates grains growth on metal surface thus coating time is reduced.

The character of the deposit is sensitive to the pH of plating solution. The pH is controlled at close to pH_4. Boric acid is used in nickel plating solutions for buffering purposes; its concentration may affect the appearance of the deposits as shown in **Table (2)**.

Table .(2) conditions of electro plating

Materials	**Concentration, gm/l**
$NiSO_4.6H2O$	250
$NiCl_2.6H2O$	35
HBO_3	30

The effect of concentration of Al_2O_3 (2, 3&4 gm/l) was studied at constant current density 0.2A/cm^2 and temperature 45C°. It was found coating increased with increasing in concentration of Al_2O_3.The SiC particles were added to the solutions at the same conditions and it has same results.

The brightness of electro-less nickel varies significantly, depending on the specific formulation. Thus a very bright electro less deposit appear dull if the substrate is rough.

One of the most common reasons for selection of electro- deposition nickel coating in functional applications is its excellent corrosion resistance. Electro-deposition nickel has shown its ability to withstand the combination of corrosive chemicals and hardness.

The corrosion rates of specimens were calculated by the weight losses equation (1) and expressed in mils per year (mpy). The results split into three factors: Ni coating, Ni-Al_2O_3 & Ni-SiC in each 3.5% NaCl as shown in **Figure (4) & Table (2),** and 10% HCl solutions as shown in **Figures (5) & Table (3)**

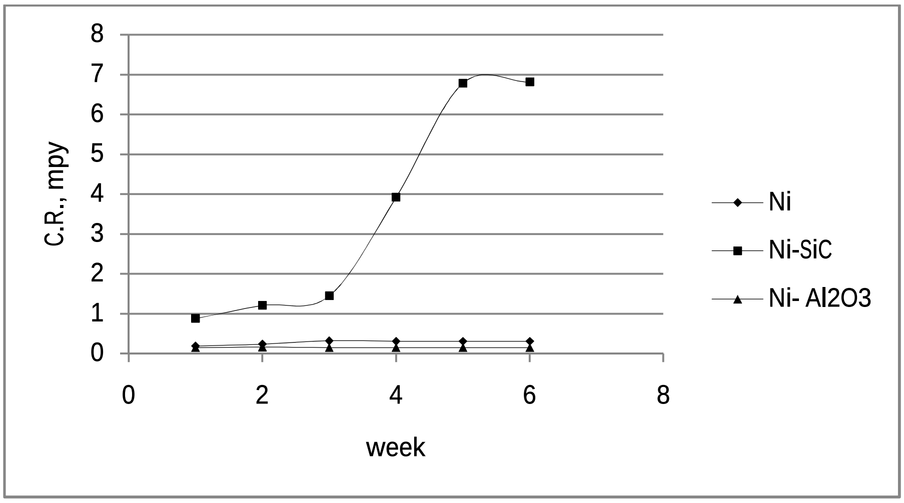

Fig .(4) corrosion rate of the specimens in 3.5% NaCl.

Table .(3) corrosion rate of the specimens in 3.5% NaCl.

	C.R.,mpy					
Samples	**1 Week**	**2 Week**	**3 Week**	**4 Week**	**5 Week**	**6 Week**
Ni	0.19	0.24	0.32	0.31	0.31	0.31
Ni-SiC	0.88	1.21	1.45	3.92	6.78	6.81
Ni- Al_2O_3	0.15	0.16	0.15	0.15	0.15	0.15

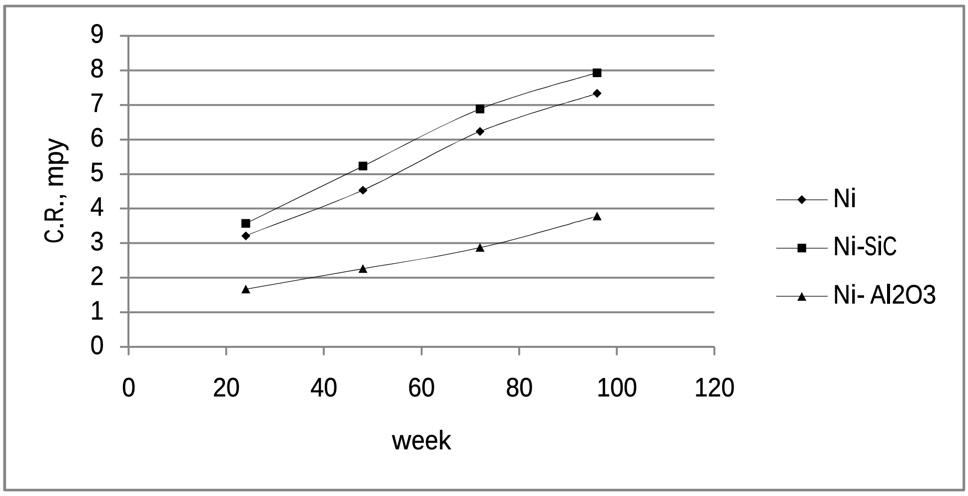

Fig .(5) corrosion rate of the specimens in 10%HCl.

Table .(4) corrosion rate of the specimens in 10%HCl.

	C.R.,mpy			
Samples	**24 hour**	**48 hour**	**72 hour**	**96 hour**
Ni	3.21	4.53	6.23	7.33
Ni-SiC	3.57	5.23	6.88	7.93
Ni- Al_2O_3	1.67	2.26	2.87	3.78

Ni coating, the results exhibit that nickel plating provides sufficient corrosion resistance due to corrosion resistance of electro less nickel is largely a function of its phosphorus content, which provides more passive and more resistant deposits. The superior corrosion resistance of electro-less nickel is due to its unique structure. In as deposited conditions, high phosphorus coatings are completely amorphous. It is the amorphous character of electro less nickel that improves its corrosion resistance[1].

In comparing of corrosion behavior between Ni- SiC and Ni- Al_2O_3 coating, the corrosion rate of Ni-SiC was more prone to corrosion than those incorporating insulators as Al_2O_3.

One reason for this tendency is the establishment of galvanic cell linking their two constituent phases. For this reason, corrosion can vary with semiconductors such as SiC can promote galvanic reaction. Galvanic corrosion is not usually a problem with insulating materials such as Al_2O_3.

Ni-Al_2O_3 coating: after the specimen was coated in nickel, The Al_2O_3 powder was added to the bath at concentration from 2 to 4 gm/l according the experimental work and the current density variation 0.1 -0.3 A/ cm^2. The corrosion rate of Ni-Al_2O_3 did not differ from corrosion rate of Ni coating in 3.5%NaCl solution.Al_2O_3 inhibited corrosion in acidic solution.

Conclusions

1. The deposition parameters such as concentration, current density and type of additives exhibit strong effect on coating.
2. Coating in Al_2O_3 inhibited corrosion in the acid.
3. The corrosion rate of Ni-SiC was more prone to corrosion than those incorporating insulators like Al_2O_3.
4. The corrosion rate of Ni-Al_2O_3 did not differ from corrosion rate of Ni coating in 3.5%NaCl solution.

References

1. **M. Surrender, “wear characterization of electrodeposited Ni-WC composite coating”, thesis, India, 2004.**
2. **Helen H. Lou, Yinlun Huang” Electroplating” Francis, 2006.**
3. **Lim C.Y., ”corrosion investigation of coating on mild steel substrate exposed to various corrosive environments”, Malaysian journal of chemistry, 2007.**
4. **Mykolas G., “corrosion study of electroplated nickel metal matrix composites with B_4C, Al_2O_3 and SiC “institute of chemistry, thesis, 2002.**
5. **Salam H., “effect of current density and heat treatment on electrodeposited nickel coated bulk graphite”, Eng. &Tech. Journal, 2010.**
6. **G. Fontana, “corrosion engineering”, 3th edition, New Dehi, 2006.**