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CORROSION OF COMPOSITE FERRO-NIOBIUM LAYERS IN COBALT MATRIX

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ABSTRACT

The ferro-niobium composite layers in cobalt matrix were obtained by cathode depositing from electrolyte solutions on steel base. The electrolyte included in its composition cobalt sulphate and cobalt chloride, boric acid was also added for pH stabilization. The ferro-niobium, powder with granulation smaller than 5µm, niobium content of 98% and 2% iron, were introduced into the electrolyte with 20g/L concentration. Electrodepositing was performed at different current densities: 615A/m^2, 570A/m^2, 458A/m^2 and the result was layers of cobalt and composite from ferro-niobium particles in cobalt matrix, with thickness varying between 50 – 90µm. Corrosion resistance was assessed by linear voltammetry test watching the corrosion behavior depending on composition and structure of deposited layers. The potentiodynamic polarization curve was analysed for composite layers compared with cobalt layers. From Tafel curves was determinated the corrosion rate for each type of coatings.

KEYWORDS: electrodeposition, corrosion resistance, ferro-niobium, cobalt

1. Introduction

Improved characteristics of cobalt layers can be made by the deposition of nickel or tungsten cobalt alloy [1] or cobalt matrix composite coatings [2].

This paper propose to obtain corrosion-resistant materials, consisting of a sheet steel support with low carbon content, covered by electrochemical method with a layer of cobalt where ferro-niobium particles were introduced.

The aim of this work was to determine the influence of current density on the kinetics of the cathodic reaction as well as composition, layers thickness and corrosion resistance of Co/ferro-niobium composite coatings. The paper describes the possibilities of electrocodeposition of ferro-niobium particles with cobalt matrix. Also, in this work, a comparative study is made of the corrosion electrodeposited cobalt and cobalt-ferro-niobium coatings.

The amount of embedded phase in the composite depends on the type bath-metal-particle combination and is governed mainly by the powder concentration in the plating bath, current density and agitation rate [2].

2. Experimental procedure

Composite coatings in cobalt matrix were electrodeposited from solution containing: 300 g/L $CoSO_4 \cdot 7H_2O$, 50 g/L $CoCl_2 \cdot 6H_2O$, and 30 g/L H_3BO_3 [3]. Suspensions contained ferro-niobium technical particles (98%Nb) at concentrations of 20 g/L. Size of the particles was smaller than 5 µm. To wet and distributed uniformly the particles in the electrolyte, the suspension was agitated with a magnetic stirrer with a rotation rate of 1500 rpm. Cobalt and composite ferro-niobium in cobalt matrix layers was made on steel support with chemical composition shown in Table 1.

Table 1. *Chemical composition of steel support, in %*

C	S	Mn	P	S	Al	Ti	V	Ni	Cr	Mo
0.025	0.015	0.210	0.013	0.010	0.046	0.002	0.001	0.008	0.025	0.001

Prior to the electrodeposition, the steel surfaces were polished, degreased in 100g/L NaOH, 50g/L Na_2CO_3 and 10g/L Na_2SiO_3 solution at 90^{0}C, washed in distilled water, pickling in 15% HCl solution, finally rinsed again with distilled water [4]. The steel support samples as substrates and two graphite anodes were used. All electrodes were in a vertical position in the cell. The conditions for the electrochemical process was: time 60 min; pH 5; concentration of FeNb particles in bath solution was 20g/L and current density of 615A/m^2 (code samples S1, S4), 570 A/m^2 (code samples S2, S3) and 458 A/m^2 (code samples S5).

Composite coated samples were heat treated at 1150 ^{0}C for one hour to remove hydrogen and stimulate diffusion processes between particles and matrix [5].

The chemical composition of the layers, determined by X ray diffraction is presented in Table 2.

***Table 2**. Chemical composition of the layers*

Code	Chemical composition in gravimetric percentage			
	Co	**Nb**	**Fe**	**other**
S1	99,01	0	0.70	bal
S2	98,87	0	0.64	bal
S3	80,2	0.17	19.64	bal
S4	77.37	0.35	22.28	bal
S5	51.81	0.97	46.32	bal

The aspect of the different areas of the two types of coatings, cobalt and cobalt-ferro-niobium, shows that niobium particles in the composite material determined finishing texture, increase compactness, uniformity, reduce ridges dendrites and inter-dendrites space (Figure 1 and 2).

***Fig. 1**. Cobalt layer; current density: 570A/m^2; 50X*

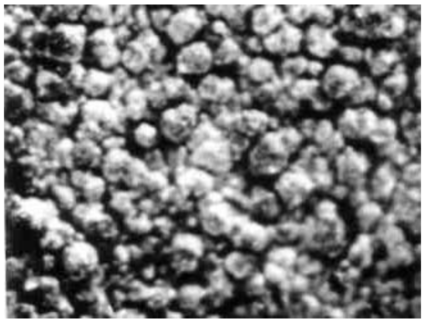

***Fig. 2**. Co/ferro-niobium composite layers; current density: 570A/m^2; 50X*

Layer thickness of cobalt layers and composite coatings layers was measured by optical microscopy. It was established that the thickness increases when current density increases, as shown in Figure 3.

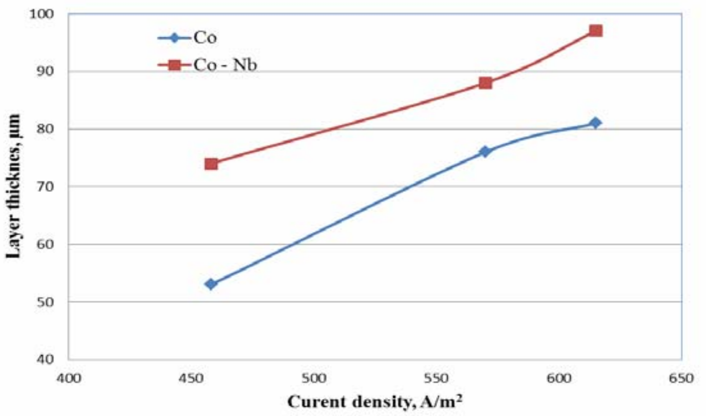

***Fig. 3**. Layer thickness variation with current density*

The corrosion behaviour was carried out with potentiostat type VOLTAMASTER 4 (PGP 201). A three electrode system with an electrochemical cell volume of 100mL was used to perform the experiments. The auxiliary electrode was a platinum sheet and the reference electrode was saturated electrode calomel (SCE).

The working electrode was the experimental samples which has an electro active area of 1cm^2. Before the experiments, the samples was degreased in acetone and alcohol, rinsed with distilled water and then, dried in air. Linear voltammetry curves of the codeposited layers were measured from -1000 mV toward the anodic direction of 500mV, with scan rate of 50mV/min. The corrosion behaviour of codeposited films has been observed by introducing them in corrosive environments: 0.1N HCl solution.

The Tafel curves were used as a method to study corrosion behaviour.

From the anodic and cathodic polarization curves the main electrochemical parameters of the corrosion process were obtained: corrosion potential E_{corr}, corrosion current density i_{corr}, polarization resistance R_p and corrosion rate V_{corr}, automatically calculated by specialized computer software – Table 3.

Table 3. *Electrochemical parameters of the corrosion process*

Code	i_{cor}	Rp	E	v_{cor}
	[μA/cm^2]	[Ωcm2]	[mV]	[μm/y]
S1	16.1084	709.62	-446,3	0.357
S2	13.6000	613.04	-408,4	0.301
S3	15.0000	597.91	-431.1	0.331
S4	9.7476	1170	-447.5	0.216
S5	4.1946	3000	-328.9	0.093

The polarization curves for cobalt coatings and Co/ferro-niobium composite coatings obtained at 570A/m^2 current density, are shown in Figure 4. In Figure 5 are shown the polarization curves of cobalt coating and Co/ferro-niobium composite layers obtained at 615A/m^2 current density. The polarization curves of Co/ferro-niobium composite layers obtained at different current density are shown in Figure 6.

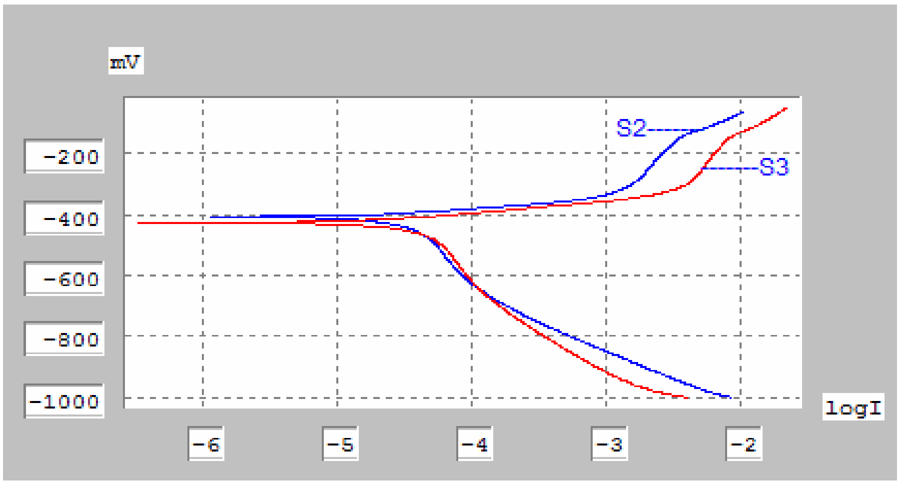

Fig. 4. *Polarization curves of cobalt coatings and Co/ferro-niobium composite coatings, obtained at 570A/m^2 current density*

Polarization measurements in 0.1N HCl indicate similar results of corrosion resistance for cobalt and ferro-niobium particles in cobalt matrix obtained in some conditions for electrodeposition.

As show in Figure 6, the corrosion resistance of Co/ferro-niobium composite layers increases with niobium content from the layers.

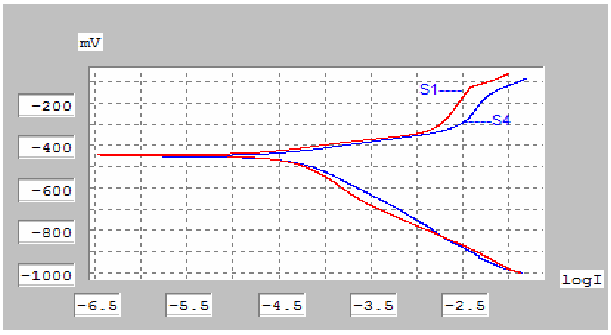

***Fig. 5.** Polarization curves of cobalt coating and Co/ferro-niobium composite coatings obtained at 615A/m^2 current density*

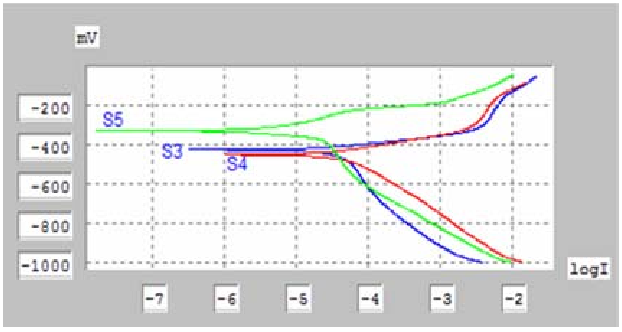

***Fig. 6.** Polarization curves of Co/ferro-niobium composite layers obtained at different current density*

3. Conclusion

- Composite thin films which consist of ferro-niobium particles in a cobalt matrix were deposited on a steel substrate using the electrocodeposition method.
- The surface morphology of the cobalt-ferro-niobium coatings is different from the pure cobalt coatings. The presence of niobium particles in composite layers determined the finish texture, uniform ridges dendrites and diminishing interdendrites space.
- The thickness of the layer increases non-linearly with increasing current density. The best value of thickness corresponds to composite coatings obtained at 615A/m^2.
- Polarization measurements in 0.1N HCl indicate a similar results of corrosion resistance for cobalt and ferro-niobium particles in cobalt matrix obtained in some conditions for electrodeposition.
- Generally, the corrosion resistance of cobalt-ferro-niobium composite layers increased with niobium content from composite layers.

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