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# STUDY THE TECHNOLOGICAL PARAMETERS INFLUENCE ON THE HARDNESS OF NI-W ALLOYS OBTAINED BY GALVANIC DEPOSITION

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***Abstract:*** *The paper presents the research on the characteristics, in terms of Vickers hardness for the alloy deposits obtained by nickel, tungsten and diamond powder co-depositions in a mixed galvanic bath. The series of Ni-W alloy with diamond power codepositions were obtained by electrodeposition in a Hull cell, changing the following working parameters: the secondary distribution of current (expressed by the anode - cathode distance), the stirring of the electrolitic bath and the diamond particle size. The micro-hardness of the metallic coating was measured using micro-hardness tester. In all the cases the microhardness and deposit is found to be affected by technological parameters.*
***Key words:*** *nickel, tungsten, alloy, composite, microhardness*

## 1. INTRODUCTION

The interest in electrodeposition of nickel-tungsten alloy with diamond particles has increased in recent years due to their unique combination of tribological, magnetic, electrical and electro-erosion properties (Eliaz et. al. 2005). To improve Ni based coatings, it is possible to incorporate pure metal particles such as W, Ti, Al, Mo or some oxide particle (Jugovic et. al. 2004, Guo et. al. 2000). Such procedures lead to better catalytic activities, enhanced corrosion resistance, and increased hardness and thermal resistivity. According to the specialty literature (Danielewski et. al. 2005) the Ni based composite coatings were first deposited from slurry, containing more than 10 mass% of insoluble particles.

## 2. EXPERIMENTAL

At present it extends the applications on the inclusion of electrically conductive particles in the metal matrices. The type matrix can be formed both from a single metal, and an alloy obtained by codeposition of two or more metals. A special application in this regard is the inclusion of the diamond particles in metal layer. Also, this layer is used in tribological applications of abrasion to achieve the surfaces with high coefficient of friction. The electroplating bath must be stirred to obtain the inclusion of even greater quantities of particles and much more uniform in the metal matrices. In the research, the stirring is conducted with a magnetic stirrer whose magnetic disk has variable speed.

Three different plating baths were investigated and the compositions are given in Table 1, (Eliaz et. al. 2005).

The pH electrolyte was adjusted to a value of 8.0 through additions of 0.1 M $H_2SO_4$ solution.

| No. crt. | Component | Concentration [g·L$^{-1}$] | | |
|---|---|---|---|---|
| | | Bath I | Bath II | Bath III |
| 1. | $NiSO_4 \cdot 6H_2O$ | 26.29 | 26.29 | 26.29 |
| 2. | $Na_2WO_4 \cdot 2H_2O$ | 131.94 | 131.94 | 131.94 |
| 3. | $C_6H_5Na_3O_7 \cdot 2H_2O$ | 147 | 147 | 147 |
| 4. | diamond particles size | 0.25 µm | 1.0 µm | 6 µm |

Tab. 1. The galvanic bath compositions

In this work, a Hull cell was used with a 250 ml capacity. A sheet of copper with an exposed area of 0.43 dm$^2$ was used as the cathode. A graphite counter electrode with an exposed area of 0.12 dm$^2$ was used as the anode. The cathode-to-anode surface area ratio was approximately 3.6.

The current density was calculated with the Hull - Mac Intyre equation:

$$i = I(5.1019 - 5.240 \log l) \quad (1)$$

where: $i$ - current density, [A·dm$^{-2}$]; $I$ - current intensity in cell circuit, [A]; $l$ – distance along the cathode from the point of maximum current densities, [cm]. Before electrodeposition, the electrode surface was polished with emery paper (320–1000 grain size), then was washed with distilled water, thoroughly degreased with acetone, activated with 20% $H_2SO_4$, washed once more with distilled water and immerse in the bath solution. The above described electrodes were connected in galvanostatic regime to the GWINSTEK GPR-1810HD power supply, having a digital control of current and voltage. The electrolysis time was fixed in order to be used in 1800 C of electricity. The temperature of electrolyte solution was kept constant at the value of 23 °C. The electrodeposition was carried by stirring the bath solution with a Heidolph magnetic stirrer at the rotating rate: 200, 300, 400, 500 and 600 rpm.

The micro-hardness, [VH], of the metallic cover was measured using micro-hardness tester Shimadzu, HMV –2T. The loading weight was of 490.3 mN and the load duration of 15 s.

Hardness measurements involve making an impress on the surface deposit (or cross sections for thin coatings). Impress has a well defined geometry and is applied with a specific task, figure 1.

Vickers hardness (VH) is the ratio of force pressure and impress allowed by indenter on sample, S. Impress area can be determined depending on the angle and indent diagonal d. For this purpose the two diagonals $d_1$ and $d_2$ of which one is the arithmetic mean of diagonal in mm, shall be determined. Vickers hardness is obtained from the next equation (Gutt et. al. 2000).

$$VH = \frac{F}{S} = \frac{F}{\dfrac{d^2}{2\sin\dfrac{136}{2}}} = 1{,}854\frac{F}{d^2} \quad (2)$$

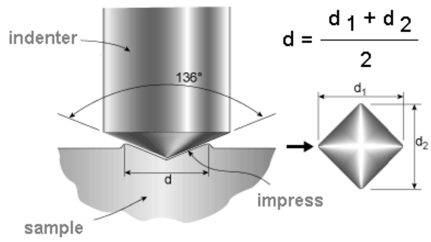



Fig. 1. Vickers hardness test principle

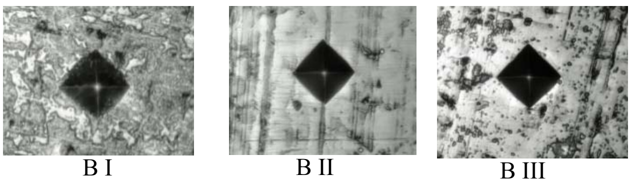
All experiments and testes were carried out at the Faculty of Food Engineering from “Stefan cel Mare” University of Suceava, Romania.

## 3. RESULTS AND DISCUSSION

The electrochemically deposited Ni - W alloy with diamond particles using experimental logistics presented above have been tested in terms of hardness. Figure 2 presents the hardness indentation in Ni - W alloy with diamond particles of different electrodeposited size on sublayers at: $i$ = 1.43 A/dm$^2$, t = 30 min, T = 23°C, pH = 8, 300 rpm. From the images of hardness indentation in deposition where they are automatically recorded by the opto-electronic system one can see that the structure of the deposit had been modified, fact which implies the modification of the hardness.

The revealing of experimental results on the evolution of micro-hardness depending on the current density and the rotating rate of magnetic disc in electrolyte of galvanic bath was obtained. To study the influence of the secondary current distribution at different levels of electrolyte stirring on Vickers micro-hardness, Hull cell was used. The distribution of secondary current is given by the anode - cathode distance, Figure 3.

The results of determinations for three baths with different size of diamond particles are shown in figure 4 (diamond particles size of 0.25 μm), figure 5 (diamond particles size of 1.0 μm) and figure 6 (diamond particles size of 6.0 μm) respectively.



B I B II B III

Fig. 2. The hardness indentation in Ni-W alloy with diamond particles electrodeposited on layers at: $i$ = 1.43 A/dm$^2$, t = 30 min, T = 23°C, pH = 8, 300rpm

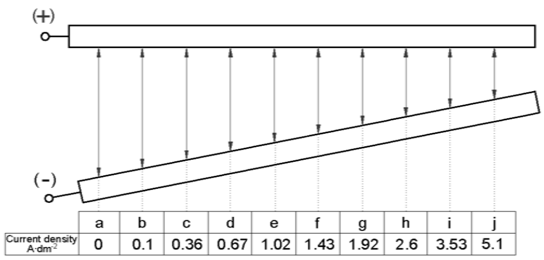



Fig. 3. Scheme of Hull galvanic cell used to Ni-W alloy with electrodeposited diamond particles

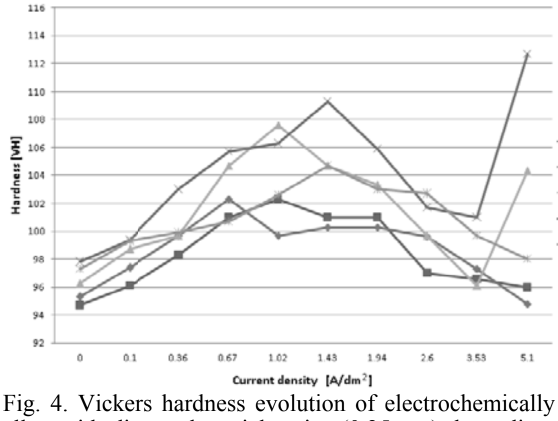



Fig. 4. Vickers hardness evolution of electrochemically Ni-W alloy with diamond particles size (0.25 μm) depending on the current density and the rotating rate of magnetic disc in electrolyte

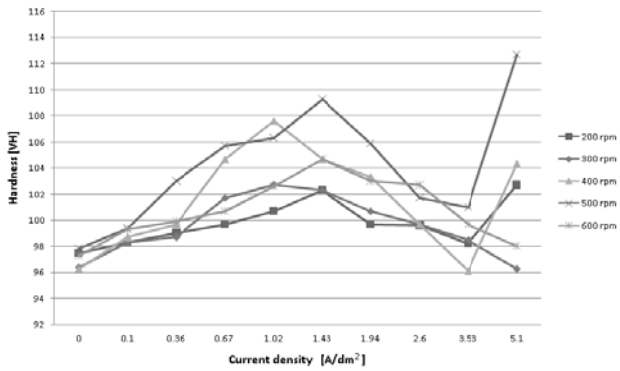



Fig. 5. Vickers hardness evolution of electrochemically Ni-W alloy with diamond particles size (1 μm) depending on the current density and the rotating rate of magnetic disc in electrolyte

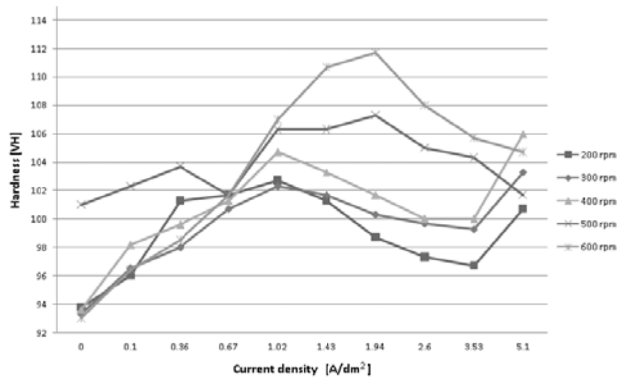



Fig. 6. Vickers hardness evolution of electrochemically Ni-W alloy with diamond particles size (6.0 μm) depending on the current density and the rotating rate of magnetic disc in electrolyte

## 4. CONCLUSIONS

It is possible to co-deposit nickel and tungsten metals with the diamond particles included using the Hull cell with magnetic stirring. The study of hardness for metal matrix with a Vickers micro-hardness and with the optoelectronic analysis of images provides the information on the strength of diamond particles fixation on the cathode surface in the deposit. The optimal parameter value for the current density, the agitation level of the bath electrolyte, the particle diamond size to obtain a maximum of Vickers hardness at chemical composition is specified in the following: $i$ = 1.5 A/dm$^2$, corresponding the anode cathode distance to *f* area, 500 rpm for size particles of 0.25 μm, and 1.0 μm, but 600 rpm for size particles of 6 μm. The influence of diamond particle size is negligible.

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