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CONTRIBUTIONS TO THE DETERMINATION IN-SITU OF LAYER THICKNESS AND GLOSSINESS OF GALVANIC DEPOSITS

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Abstract: *The papers presents the achievements of a collective research on promoting new methods and equipments to determine in situ, continuously and automatically the glossiness and thickness layer of galvanic deposits. The determined sizes are used in an advanced qualitative and quantitative characterization of the galvanic process.*
Key words: *measurement, thickness, gloss, automatically*

1. INTRODUCTION

Layer thickness and galvanic deposit glossiness are two important sizes in electrodeposition. Layer thickness is the extensive size that allows the correlation of technological parameters of galvanic deposition with all quantitative aspects of the process. Thus, from its value it determines current and energy efficiency, material and energy balance and also calculate the productivity (Ivascan, 1973, Gutt, 2008a) offering important conclusions that can be drawn on uniformity cathode deposition.

The gloss of galvanic deposition is a qualitative parameter that expresses the uniformity of secondary current distribution in galvanic bath and efficiency of gloss agents in close correlation with operating technological parameters.

Currently, (Bohnet, 2010, Lohrengel, 2004) both parameters are determined at the end of the process, therefore there are no possibilities to study online the process and to correct inconsistent values during deposition (Gutt, 1985, Gutt, 2008b, Gutt, 1993, Gutt, 1998).

2. EXPERIMENTAL

Below there is a laboratory galvanic cell for the continuously study of these two sizes without interrupting the galvanic process and without removing the cathode from galvanic bath, figure 1. In this respect, we will use an electro dynamic system for the alternative continuous movement of the optical probe and a differential inductive sensor to measure the value of movement, the achievements belonging to the collective of the University Suceava (Gutt, 2008 b,c,d,e).

The working procedure with this cell is very simple: after mounting the cathode, the miniature silver mirror is folded away on it and the whole ensemble is dipped into galvanizing bath. Using the micrometric screw the distance between micro lens and mirror is adjusted, until photocurrent intensity value, which is a measure of intensity I_1 of the reflected radiation intensity I_0 of incident radiation has a maximum value. In these conditions gloss value L is considered as:

$$[L]=I_{1=}100\% \qquad (1)$$

After that, the silver mirror is folded, the new distance is adjusted so that the cathode surface should be in the focal point of microlens (measured photocurrent is maximum) and it measures the value of photocurrent intensity light given by reflected radiation intensity I_2.

Report $I_2/I_0 \cdot 100$ gives gloss value L_2 of the cathode without galvanic coating.

After these measurements the two electrodes of the galvanic cell are put under voltage and the process of metallic or alloy deposition on the cathode begins. The glossiness of galvanic deposit and its thickness will evolve over time, depending on process parameters

At preset and well established times, automatically measurements of light intensity will be made I_3. ....*which through* reports $I_3/I_0.100$ .... $In/I_0.100$ will give values of gloss L_3. ...... L_n , according to different parameters of process in that time in galvanic bath. By the recommended working procedure, respectively by measuring the gloss area using a silver mirror, followed by successive measurements of galvanic deposit reflection, the expression of gloss as l_n/I_0 reports lead to elimination of the influence of radiation absorption by the galvanic electrolyte, because the value of this absorption is found both at numerator and denominator of fraction, and by simplification gives 1 value which does not affect the outcome measurements.

Taking into consideration that thickness of layer increases in time, the galvanic deposit area approaches closely to the lens coming out of its focal point of lens; a vertical displacement of probe is necessary to put deposition back into the focal point of optical lens, in this purpose an actuator of electro dynamic linear motor type is used. The actuator is part of an electronic adjustment chain aimed at automatic maintaining of the deposit layer in the focal point of the optical system for gloss measuring, needed to achieve precision measurements of gloss. In this purpose, at preset time intervals, the actuator, of the electro dynamic type, receives an amplified control signal that causes progressive distancing of galvanic probe until the zero first derivative value of intensity I of reflected radiation from the galvanic deposition depending on the distance x between the optical head and the deposition, orders to stop this displacement:

$$dI/dx = 0 \qquad (2)$$

(at maximum size value the first derivative size is always zero). When in the deposition galvanic process derivative the first value is different from zero:

$$dI/dx \neq 0 \qquad (3)$$

Sample surface was moved from the focal point due to thickening of the galvanic deposit and by the differential electromagnetic sensor and by the adjustment chain it automatically commanded the actuator to remove slowly the optical probe deposition At one time, this displacement is equal to the new thickness of the layer and is characterized by maximum intensity value I of reflected radiation from sample which means that galvanic surface deposit is found in the focal point and it initiated automatically measurement of gloss which takes place in optimal conditions and the value of the derivative is again zero.

The optical displacement of probe is continued to screen the galvanic deposition until it reaches a predetermined limit value, value at which the probe stops and changes the sense of movement approaching the deposit back until it reaches again the focal point leading to a further gloss measurement.

The electronic system performed automatically arithmetic average between the first reading value of gloss and its second read value, this average is stored and displayed as a representative value of gloss at that time. By lowering the value of vertical repositioning movement of probe, measured at a time with the differential inductive sensor of displacement during galvanic deposition, from the value of displacement of probe at the first measurement of gloss without deposition, the layer thickness of galvanic deposit is automatically obtained at that time, its value is still used to calculate the sizes and important characteristics of process.

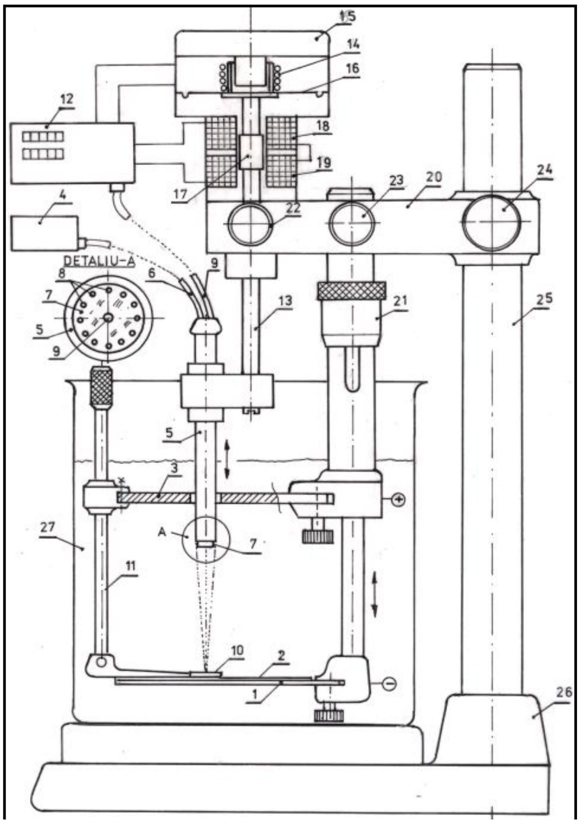

Fig.1. Schematic diagram of the galvanic cell with automatic measurement of layer thickness and glossiness during the galvanic deposition process. 1-cathode, 2-galvanic deposition, 3-anode, 4-laser source, 5-optical probe, 6-optical lighting fiber, 7-focus lens, 8-twelve optical fibers, 9-central optical fiber for acquisition and transmission of monochromatic radiation reflected from the sample, 10-miniatural circular folding mirror, 11-rod for mirrror folding, 12-electronic unit, 13-displacement rod, 14-coil, 15-continuous magnet, 16-elastic membrane, 17-mobile core, 18.19-colis, 20-transverse, 21-micrometric screw, 22.23, 24-special screws, 25-column, 26-cheek, 27-galvanic bath.

3. RESULTS AND DISCUSSION

Using a specific software, galvanic deposit thickness can be played automatically according to different parameters of the process or may be used, as appropriate, to adjust the parameters for optimizing the galvanic deposition process.

Thus, the current yield ($\eta_{current}$) can be continuously calculated and displayed versus time, as the ratio between the measured mass value (m_m) of deposit and theoretical mass value (m_{theor}) of deposition calculated from Faraday law taking into account intensity (I) of current, deposition time (t), atomic weight (A) of galvanic deposit, number of Faraday F (F = 96.500 Q) and valence (z). If we take into account that the mass of a deposited metal is related to layer thickness by the surface on which the deposit was made (axb) and the density (ρ) of galvanic deposition, the following expression of current efficiency is obtained:

$$\eta_{current} = \frac{m_m}{m_{teor}} = \frac{g_m \cdot a \cdot b \cdot \rho}{m_{teor}} \cdot 100 = \frac{g_m}{\frac{A}{z \cdot F} \cdot I \cdot t} = \frac{g_m \cdot z \cdot F}{A \cdot I \cdot t} [\%] \qquad (4)$$

In the same way, one can calculate the continuously displayed power yield η_{power} , as the product of current yield $\eta_{current}$ and voltage yield $\eta_{voltage}$,, yield expressing the effective use of power taking into account the voltage applied between two electrodes U_e which is higher than necessary, theoretical Nernst potential ε^o for discharge to the cathode of the metal corresponding to the galvanic deposition type:

$$\eta_{pover} = \eta_{current} \cdot \eta_{voltage} \qquad (5)$$

$$\eta_{voltage} = \frac{\varepsilon^0}{U_e} \qquad (6)$$

Automatic calculation of current and power efficiency allows further development of all automatic ways of material and power balances at any time of deposition and identifying the influence of different parameters on the galvanic process productivity allowing the automatic processing using a mathematical model of optimization.

4. CONCLUSIONS

Layer gloss and thickness of galvanic depositions automatically, continuously and in situ determined, allow both the perfect monitoring of optimal working conditions and their use as well as reaction sizes for automatic adjustment in circuit galvanic process to optimize it.

5. REFERENCES

Bohnet J., (2010) Zur Abscheidung von metallischen Cromschichten, Galvanotechnik nr.4, Saulgau, .p.746-749

Lohrengel M.,M., (2004) Untersuchungen der elektrochemischen Deckschichtkinetik mit Transientenmethoden , Shaker Verlag Aachen, p. 108-144

Gutt G., Gutt S., (2008a). Sonde zur Glanz-und Schichdickenbestimmung galvanischer Schichten, *Patentvorschlag, Offenlegungschrift*, A/00385, *Bukarest*

Gutt G., Gutt S., (2008b). Galvanische Zelle zur automatischen Glanz-und Schichdicken Messung galvanischer Schichten, *Patentvorschlag, Offenlegungschrift A/0362. Bukarest*

Gutt Gh., Gutt S, (1985). Über die Möglichkeit der Stofftransportverbesserung bei galvanischen Nickelniederschlägen (deutsch), *Revue Roumaine de Chimie, 30, nr. 6, S. 453-459*

Ivascan St (1973). Apparat zur Glanzmessung von Metallen, *Patent, RO. 72320/OSIM, Bukarest*

Gutt S., Gutt Gh., (1993). Beiträge zur Material- und Energiebilanz beim elektrochemischen Schleifen, (rumänisch) , *Revista de Chimie, vol. 44, nr. 11, S. 972-977*

Gutt S., Gutt Gh., (1998). Beiträge zur Messung und Bewertung der sekundären Stromverteilung bei galvanischen Prozessen, (rumänisch), *Revista de Chimie, nr. 1, S. 37-42*