THE INFLUENCE OF POLARIZATION TENSION OF THE GRADING OVER THIN LAYER PROPERTIES OF TiN DEPOSED THROUGH PDV METHOD

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ABSTRACT

The deposits of tough thin layers on pieces and tools through PDV method knew a permanent and constant spreading owing to the great applicability of the resulting coatings which make that the thin layer deposit from the vapour stage to become a strategically industrial technology with great development possibilities, regarding both the materials and the optimization applications of the deposits processes.

In the present paper the PDV coatings studied (TiN obtained through the technology with cathodic arc) has a high hardness, a low friction coefficient and a good corrosion resistance, these properties making them excellent anti wear coatings, they are already used on a large scale in the mechanical industries, aero spatial, optics and biomedicine.

KEYWORDS: PDV method, thin layer, hardness, friction coefficient

1. Introduction

As a result of a rising coating and industrialization of the PDV technology, this one receives a great importance regarding the production costs connected with the optimization of the deposits parameters and the possibility of on-the-spot modification of the process variables according to the properties that the coating has to possess. The present paper has the aim of analyzing the way the mechanical and morphological properties of the TiN monolayer deposit tend to vary depending on the deposit parameters modifying the polarization tension of the grating.

2. Experiments

TiN coating were achieved by using the PDV represented in the figure 1. Two deposits on 10TiNiC180 stainless steel plates were achieved using the cathodic arc technology.

These TiN coatings called TiN-U_o and TiN-U_1 were achieved by modifying the polarization tension of the grating (U_o and U_1 being the two 140 V and 155 V tensions).

Fig. 1*. The PDV installation (Valahia University of Targoviste).*

Table 1. *The deposit parameters of the coatings*

Sample	Pressure N_2 [10^{-2} mbarr]	T_{max} substratum [^{0}C]	Polarization tension [V]	Deposit time [h]
TiN-U_0	1.6	400	140	5.5
TiN-U_1	1.6	400	155	5.5

The coatings obtained were examined and characterized by using the optics and electronic microscopy, the laser profilometry and with inductive sensor, Vickers microhardness meter, block on ring and scratch test tribometer.

3. Obtained results

In the following figures the coatings thickness is presented. They were made by means of the optic microscope in clear field; 120 measurements were made in different zones of the sample in order to obtain a medium significant statistic value.

Fig. 2. *Section from sample TiN-U$_o$ layer thickness 3.03 µm.*

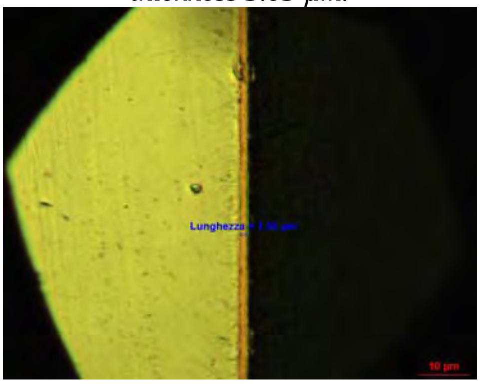

Fig. 3. *Section from sample TiN-U$_1$ layer thickness 1.55 µm.*

In table 2 the medium values and the standard deviations of the measured thickness are presented.

Table 2*. Measured values of the thickness.*

Sample	Medium measured value	Standard deviation
	[µm]	
TiN-U$_0$	2.74	0.33
TiN-U$_1$	1.46	0.16

After these first results were can emphasize the fact that the increase of the polarization tension of the grating led to a decrease of the coating thickness at about half of it.

Profilometries were made on the samples surfaces in order to evaluate the roughness (table 3) and to analyze the defects size. For the quantification of the defects size we resorted to determining some special parameters such as the medium height of the defects (P_c parameter) and the number of defects (of major height of the slated threshold) for the surface unit (SP_c parameter as shown in tables 4 and 5)

Table 3. *Roughness parameters*

Parameter	TiN-U$_0$	TiN-U$_1$
	[µm]	
R$_a$	0.0811 ±/-0.020	0.0582 +/-0.0064
R$_q$	0.17 +/-0.048	0.105 +/-0.0209

Table 4. *Medium height of the defects*

Parameter	TiN-U$_0$	TiN-U$_1$
	[µm]	
P$_c$	0.314 +/-0.234	0.296 -/-0.137

Table 5. *The defects density*

Parameter	TiN-U$_0$	TiN-U$_1$
SP$_c$ (pk$_s$/mm^2) ≥ 0.5 µm	768	386
SP$_c$ (pk$_s$/mm^2) ≥ 1 µm	319	64
SP$_c$ (pk$_s$/mm^2) ≥ 2 µm	48	6

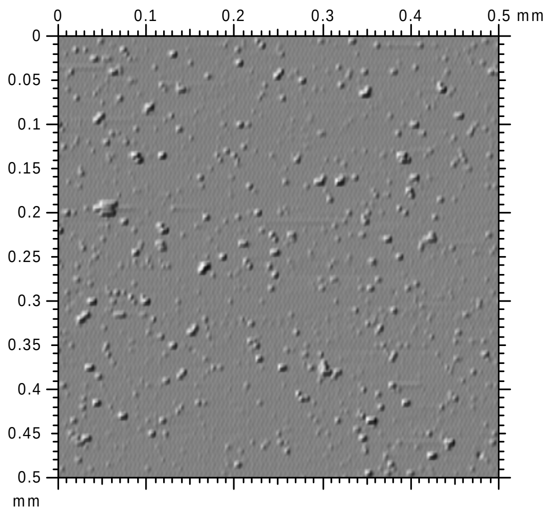

Fig. 4. *The profilometry of TiN-U$_o$ sample.*

We can notice that for the TiN coatings, at the rise of the grating polarization tension, the defects density decreases. In the figures 4 and 5 the superficial defects of the samples are presented. Measurements of microhardness were made on the coating substratum system in order to measure the coating hardness, emphasizing the substratum contribution; for this aim, 4 pre-established models were used (Burnett-Rickerby, Chicot-Lesage, Korsunsky, Puchi-Cabrera).

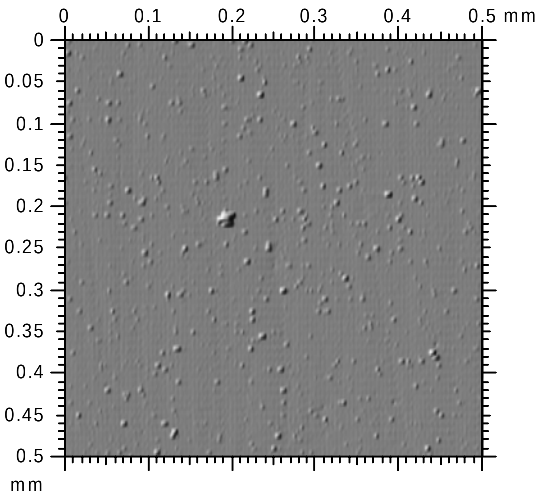

Fig. 5. *The profilometry of TiN-U_1 sample.*

In table 6 (Burnett-Rickerby B-R, Chicot-Lesage C-L models) the hardness values are presented according to drive loading.

Table 6. *Hardness according to the drive loading, calculated after Burnett-Rickerby (B-R), Chicot-Lesage (C-L) models.*

Loading	**HV TiN-U_0**		**HV TiN-U_1**	
[daN]	[daN/mm^2]			
	B-R	C-L	B-R	C-L
0.01	2477.42	2691.59	2565.36	3726.70
0,015	2506.94	2844.46	2116.75	3429.10
0,025	2682.78	3096.64	3240.08	3839.19
0,05	2788.12	3288.06	3175.85	3810.77
0,1	2366.80	2714.06	2833.48	-

Table 7. *Absolute coating hardness through Korsunsky method; k is the value of best fit of the model parameter; r^2 is the correlation coefficient*

	TiN-U_0	**TiN-U_1**
HV [daN/mm^2]	2872	1414.47
K	14.14	1.42
r^2	0.98	0.95

Table 8. *Absolute coating hardness after the Puchi-Cabrera model; n is the exponent that appears in Meyer law which connects the applied load to the imprint diagonal*

	TiN-U_0	**TiN-U_1**
HV[daN/mm^2]	2893.66	1433.86
n	1.30	1.54
r	0.96	0.96

In figure 6 one of the imprints measured for determining hardness is shown.

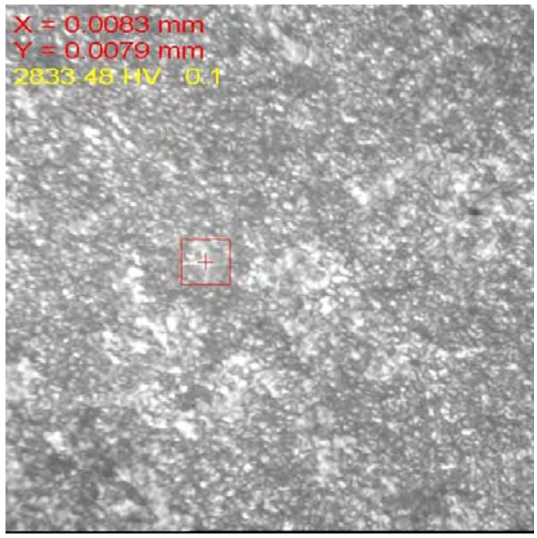

Fig. 6. *The imprint measured for determining the hardness with 0.1 daN load.*

At this point the following appreciations are necessary: no doubt that B-R and C-L models are very dependent on the values of Young model of substratum and coating (which were taken from the specialized references). These limits could be surpassed by determining the elasticity model of the examined coating. On the contrary, Korsunski and Puchi-Cabrera models had the advantage of being totally independent of Young model.

The tribologic samples were made using both a tribometer with block on ring configuration with and without lubrication.

All samples were made by using the following parameters:

- the rotation speed of the hasp: 36 rpm;
- the applied loading: 47 N;
- testing time of the sample: 300s.

The non-lubricated samples emphasized an unexpected crack of the coating.

In table 9, the resulting medium value of the dynamic friction coefficient is presented.

Table 9. *The medium value of the dynamic coefficient (without lubrificant).*

	TiN-U_0	**TiN-U_1**
Dynamic friction coefficient	0.31	0.29

Lubrication tribologic samples were also made (Hydraunyoil FH 51 lubricant). In the figure 7 we can notice the evolution of the dynamic friction coefficient, and in table 10 their medium values.

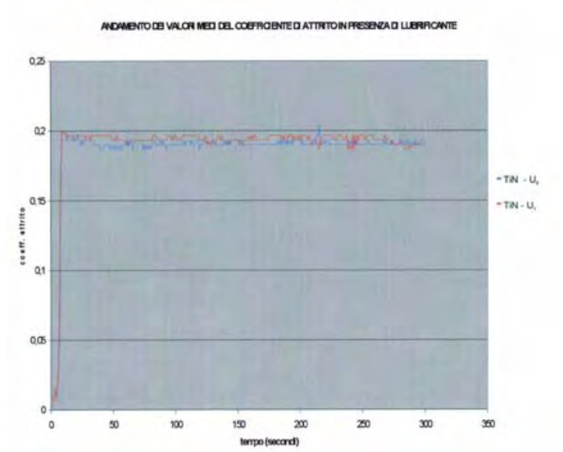

Fig. 7. *The evaluation of the dynamic friction coefficients according with lubrication.*

Table 10. *The medium values of the friction coefficient with lubrication.*

	TiN-U$_0$	**TiN-U$_1$**
Dynamic friction coefficient	0.19	0.19

For the scratch test samples, four destruction successive conditions were individualized (contraction, aliquation easy, aliquation moderate, aliquation heavy) each of them being reached at the applied critical loading.

Two tests were made for each material; the medium values of the critical loading at different degrees of destruction are presented for each material in table 11.

Table 11. *Medium critical (in Newton) corresponding to the scratch tests*

	TiN-U$_0$	**TiN-U$_1$**
Contraction	1.584	1.428
Easy aliquation	10.985	8.970
Moderate aliquation	10.985	8.970
Heavy aliquation	12.570	11.803

From the executed samples confrontation we can draw the conclusion that the TiN coating obtained with polarization tension of the inferior grating behaves better.

4. Conclusions

The obtained results emphases the influence of the deposing parameters, especially the polarization tension of the grating over the mechanic behaviour of the coating. For the TiN coating, a rise of the polarization tension of the grating determines besides a decrease of the final thickness, a substantial decrease of the defects number too, together with good values of the wear hardness and resistance under lubrication conditions.

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