Effect of Polarization on Plasma-Deposited Titanium Nitride W-TiN Layers on Cutting Tools

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***Abstract*—** Nowadays, materials science has become a very competitive field that takes part in technological development at the service of humanity. In other words, the emergence of new technologies requires the development of new materials that meet the needs of different sectors.

The objective of our work was to deposit hard thin layers of W-TiN under a reactive atmosphere (Ar + N2) by the magnetron sputtering method, using a W / Ti target. The deposition was carried out on different substrates, namely a wafer of a cutting tool K10, 316L stainless steel, glass and silicon. It should be noted that each deposition operation is preceded by a preparation of the substrates. All the experimental steps will be briefly detailed in the following.

***Keywords*—** Coating, Plasma, Tempering, Spray, Wear.

I. Introduction

Nitride thin films such as TiN, W-TIN have been widely used in industry for their chemical stability, hardness, corrosion resistance and decorative appearance. Nevertheless, despite their excellent properties, these binary films show a lack of efficiency for some applications. For example, in the case of high speed machining, generating high temperatures (above 700 ° C), the mechanical properties are degraded by the formation of oxide layers. In addition, the grain structure of the films and TiN in column form, suggests many structural defects, which promote the diffusion of oxygen.

In order to overcome these problems, research has focused on ternary coatings, such as and W-TiN, which make it possible to combine and reinforce the properties of the various compounds. W-TiN, in particular, is one of the most interesting alloys for the protection of cutting tools.

This study therefore aims to develop W-TiN coatings by the magnetron sputtering technique and to optimize this process by applying a negative bias to the substrates. By focusing on substrates in a K10 grade wafer, we are trying to improve their different properties. Procedure for Paper Submission [1] [2]

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II. Preparation Of Coating And Their Tests

In order to achieve a good deposition, the substrates must have a smooth and well polished surface, which is why it is necessary to carry out polishing and chemical cleaning before each production process. Of course, mechanical polishing is especially for steel substrates. In our case, two types of steel are studied, 316L and K10.

III. Realization Of Coating On Cutting Tools

For the deposition of coatings on cutting tools we used the RF sprayer, designed and produced locally at the laboratory of ionized media on the CDTA advanced technology development center, during this study the coatings of W-TIN were developed in the Sprayer enclosure after different preparation of cutting tools.

IV. Deposition And Procedures

After the operations of preparation of the cutting tools and the stripping of the target by a bombardment flux, which lasts a few minutes, the protective screen is actuated and the coating operation is triggered under the favorable conditions and deposition parameters.

TABLE I
DEPOSITION PARAMETERS

Parametres	Detail
Partial pressure of the first gas:	4 .10-5 mbar;
Partial pressure of the second gas:	8.7 .10-4 mbar;
Working pressure Inter-target distance - substrate	30 mtor 3 cm;
Power	200 watt
Intensity applied	0.3 - 0.5 amperes;
Time of deposit.	50 minutes

For the realization of this operation of coating of the cutting tools, which will be subjected thereafter to the various mechanical tests (hardness tests, corrosion tests), and later one will compare the mechanical characteristics without and with deposit, the Operation of this study involves two steps are:

A. The First Step :

In this step, the guarded control tools were selected as reference samples for the subsequent comparison of the initial mechanical properties.

B. The second step :

In this step the cutting tools on their active part have undergone a layer of coating W-TIN.

V. THE TESTES CARRIED OUT

After completion of the coating operation and obtaining the layers, we proceeded to the determination of certain properties by the submission of these cutting tools to the various tests, which are conditioned beforehand by the properties and the quality of the coatings.

VI. PROPERTIES OF THE COATINGS OBTAINED:

Before subjecting the coated cutting tools to corrosion tests, we present the methods used to characterize the coatings obtained on the cutting tools.

Among the main mechanical characteristics favoring the performance of the cutting tools and their service life, we are interested in the value of the thickness of the deposited layer, its adhesion as well as its hardness and corrosion resistence.

A. Thickness Of The Deposited Layer :

Two methods of measurement can be distinguished:
Direct measurement of thickness: it has two methods:
Mechanical methods use a stylus that moves over the surface of the layer.

Profile meter (with laser emission) (ALTISURF 500) This method requires the creation of a part of the substrate by the deposition or by elimination of the deposit (HNO 3 solution at 10 %). This measurement can be obtained by a mechanical Diamond tip that moves at a constant speed along the line of the workpiece or with a profilometer.

The probe, all remaining permanent contact, whose amplitude is recorded electronically. [4]

B. Adhesion of the deposit:

These tests can be performed using a scratch-test, or a stylus whose diamond tip is applied normally to the surface of the sample while gradually increasing the load and ending with a probe Mechanical (Perthometer-S10 D) mahr, with 5 µm scale and a 5mm stroke will plot the graphs (spectrum) of the surface and the depth of the step. The results can be given as a curve or adhesion diagram. [5]

C. Hardness:

For the case of the measurement of the micro-hardness of the coatings, the most used methods are the Knoop hardness or the Vickers hardness. In this case, the Vickers hardness measurement was carried out on a micro durometer (mechanical laboratory). The TIN coatings were subjected to these tests, under loads ranging from (200 to 1000) gf, it is expressed by the ratio of the maximum load applied to the surface of the contact footprint. [3]

D. Electrochemical Study

In this context, electrochemical measurements have proven to be very useful in predicting the performance of materials and mitigating the risks of their damage. They provide access to information related to surface reactions, thus estimating the resistance and rate of corrosion.

VII. EXPERIMENTAL APPARATUS:

The electrochemical measurements are carried out by means of a cell which uses a conventional three-electrode system, connected to a computer-controlled potentiostat: [8]

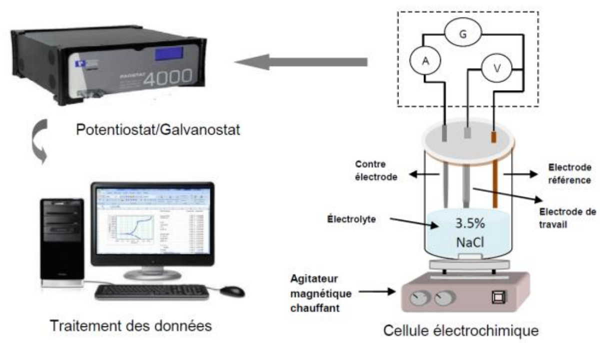


Fig. 1 Corrosion test tools.

VIII. THE RESULTS OF THE VARIOUS TESTS:

A. Thickness Of The Deposited Layer :

In this work we are able to obtain exact results. We measured the thickness of the two methods with an electronic probe (Sth-perthometer-S10), with a scale of 5 µm and a stroke of 5 mm. . we obtained the thickness around 2.50 µm, then to confirm that we use a profilometer with laser, the specter below shows the final thickness value around 2.25 µm.

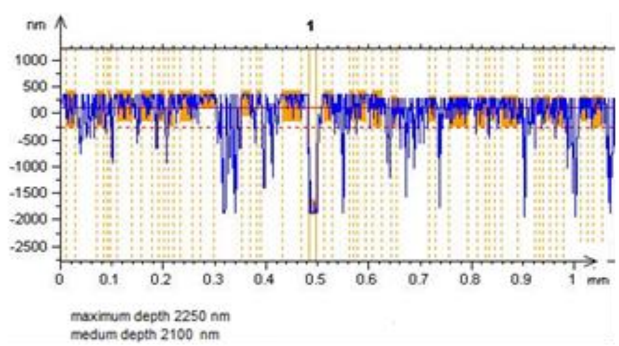


Fig. 2 Thikness of diposited layer.

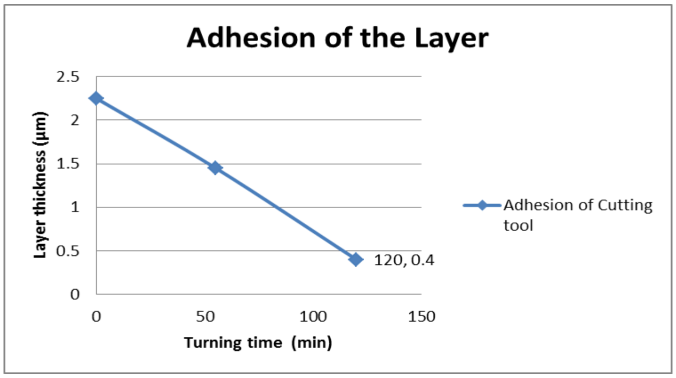
This figure shows that the value of the thickness of the deposited layer is 2.25 microns.

B. Adhesion of the deposit:

Techniques for determining the adhesion of materials and

layers of deposited coatings include the scratch test method and the method of tearing the layer by polishing. [3]
For this study, the second method was carried out on a polisher (KNUTHROTOR.2 strueers). Thus starting from an initial thickness of 2.5 µm, polishing carried out at a speed of 3000 rpm with abrasive paper of 1000, gave a reduction of the thickness of 1.45 µm during a severe exposure of 55 minutes.

This material consumption expressed by the variation of the thickness is represented by the following spectrum Measurement of the depth of the deposited layer after 120 minutes, 0.40 microns.



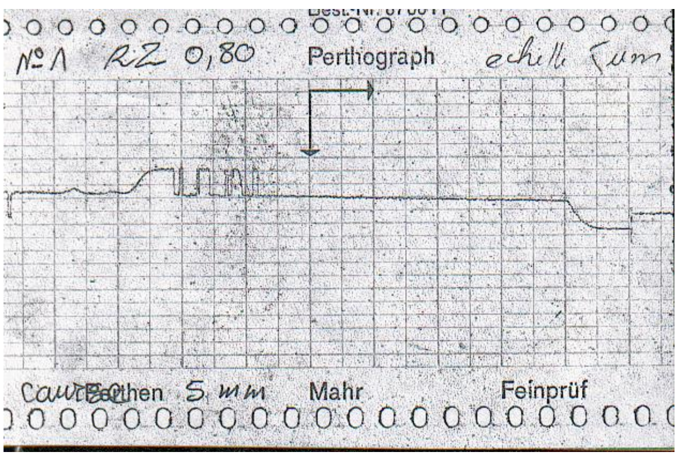


Fig. 3 Measurement of the depth of the layer deposited after 120 Minutes of polishing , 0.40 µm

C. Hardness:

Compared to the hardness value of a non-coated cutting tool, the comparative curves obtained show a clear increase in hardness. The evolution of this hardness is due to the TIN coating layer there is a significant difference in hardness. This hardness gradually improves the initial state of a tool with a traditional surface treatment in the TIN coating state.

The presentation of the variation of the hardness of these high-speed steel cutting tools is expressed on the following graphs:

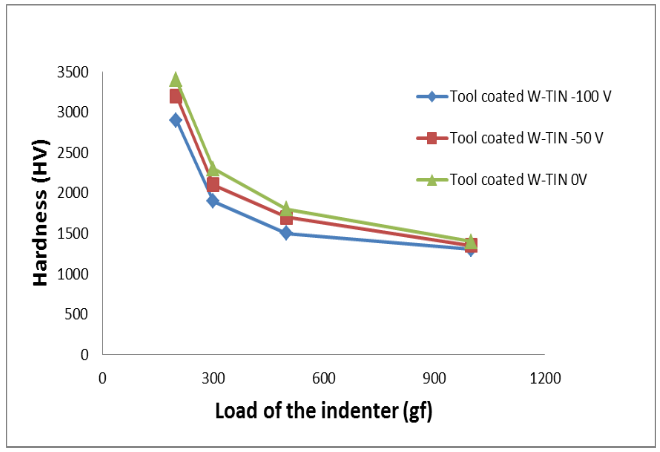


Fig. 4 Hardness curves depends on polarization.

We noticed an improvement over the hardiness compared with uncoated cutting tools, On the other hand, the hardness of the W-TIN layers also corresponds to the polarization, higher polarization gives a high hardness, [3]
0 volt gives a hardness better than -50 volt and -100 volt

In this study, we found that the hardness tends to increase with polarization. This result is directly related to a high dens structure, reduced grain size and a small amount of structural defaults.

D. Electrochemical Study

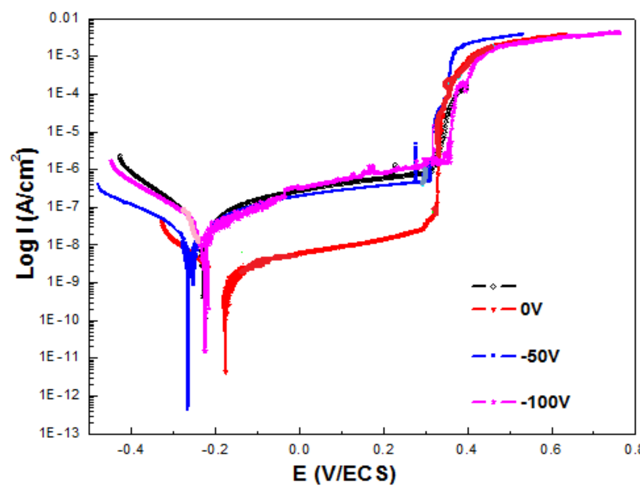


Fig. 5 Measurement Corrosion rate depending on polarization

The Tafel curves shown in Figure 5 show almost the same pace. The anodic domain indicates the presence of a passivation stage; where the intensity varies very little with the potential. It should be noted that the current density is a very important parameter, which makes it possible to evaluate the kinetics of the corrosion reactions.

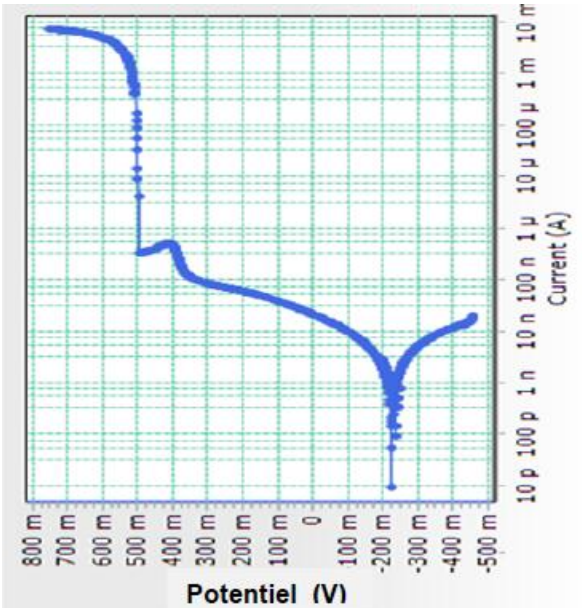


Fig. 6 Measurement Corrosion rate depending on polarization

Therefore, the drop in density means the appearance of passive films, while the abrupt increase of the latter indicates the rupture of this film and the development of pitting corrosion. This is characteristic of the behavior of stainless steel.

The potential Ecorr and the density Icorr are determined by the projection of the intersection of the tangents with the anodic and cathodic curves, on the axes of the abscissae and coordinates. Corrosion parameters including Tafel constants βa, βc, polarization resistance (Rp) and corrosion rate (Cr) are Confirme that the addition of W-TiN coatings can be advantageous, compared to bare stainless which not coated.

IX. CONCLUSION

W-TiN films have been successfully developed by the reactive magnetron sputtering technique. The different properties have been studied by highlighting the influence of the polarization of substrates. The results obtained demonstrated that the application of a polarization led to a decrease in the thickness of the layers on the one hand, and the increase in their roughness of another. This had a direct effect on the mechanical properties, and the electrochemical behavior of the coatings. The W-TiN films have made a considerable improvement in the properties of the steels, in particular on the hardness which has increased by three times the value of the uncoated steel, as well as a better resistance to corrosion.

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