STUDY OF MECHANICAL PROPERTIES OF NANOCOMPOSITE MULTILAYER COATINGS UNDER DYNAMICAL LOAD

Ing. Tomáš FOŘT, Doctoral Degree Programme (1)
Dept. of Microelectronics, FEEC, BUT
E-mail: xfortt00@stud.feec.vutbr.cz

Supervised by: Dr. Jaroslav Sobota

ABSTRACT

In the paper there are presented latest results of testing of the nanocomposite hard coatings in dynamical load. For the hard coatings testing and evaluation of their properties a new method - Dynamic Impact Wear Test (DIWT) was implemented. The impact force and the repetition frequency of strokes are adjustable in the range from 50 N up to 500 N and from 5 Hz up to 10 Hz respectively. The experiments indicate that this method is very proper for hard coating testing. It is possible to quantify the number of the load cycles which a coated component can withstand and define a critical fatigue force and by investigating the erosion area there is the possibility to obtain information about the film adhesion, elasticity, etc.

1 INTRODUCTION

For the evaluation of the properties of the hard nanocomposite coatings, well known methods (as for example the scratch test, microhardness tests and pin-on-disk tests) used to characterise thin films failure when taking into account the real load applied to a film under operating conditions. These tests also fail when considering the dynamic forces caused by impact load during milling or discontinuous cutting operations. In 1992 a new method – Dynamic Impact Wear Test (DIWT) was published [1]. Here the successive impacts of the cemented carbide ball onto a film coated sample induce high contact loads, which can vary in amplitude depending on the probe mass and the velocity of the probe immediately before the stroke. The force transformed to the substrate this way ranges from 50 N up to 500 N - enough to cause plastic deformation in the sample substrate.

2 DESIGN OF THE DYNAMIC IMPACT WEAR TEST DEVICE

The equipment is in principle an electromagnetic driven hammer. A probe, tungsten carbide ball of 5 mm in diameter, is mounted by means of a holder, and thus after each test it is possible to change its position to prevent the material adhering to the ball [2].

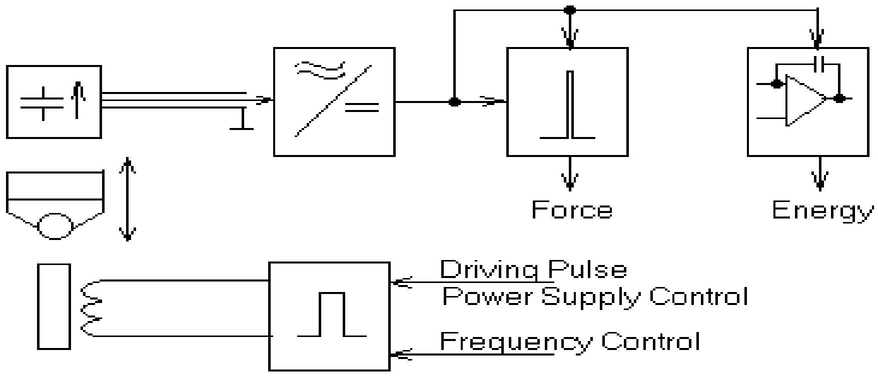

Fig. 1: *The principle of the Dynamic Impact Wear Test*

The DIWT device permits the variation of the impact force, the impact frequency and the number of the impacts [3,4]. Thus it is possible to quantify the number of the load cycles which a coated component can withstand and define a critical fatigue force. Moreover, by investigating the erosion area there is the possibility to obtain information about the film adhesion, elasticity, etc.

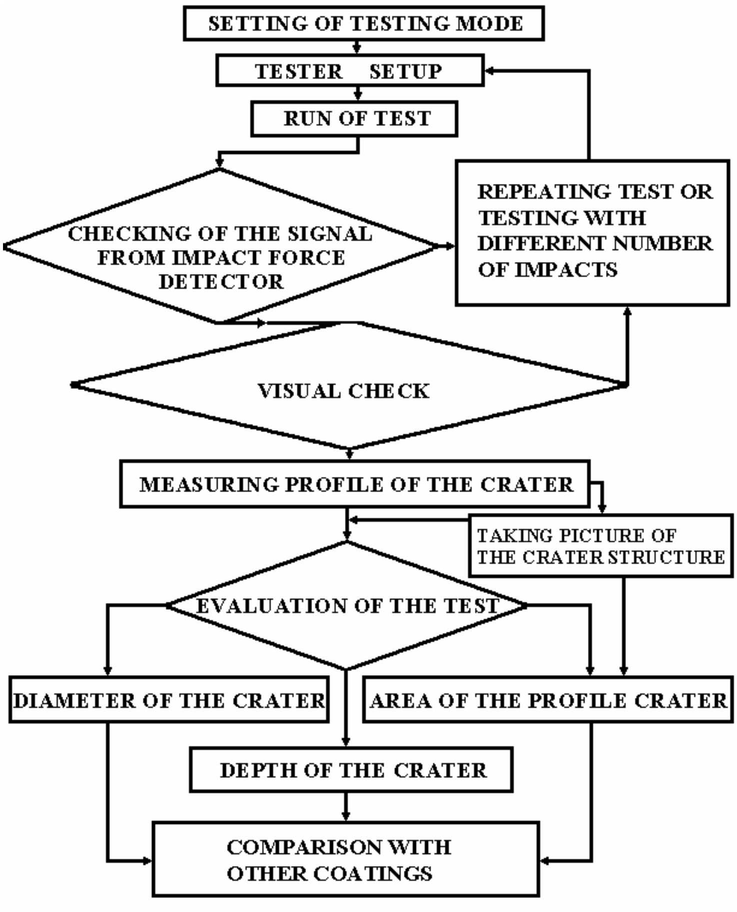

Fig. 2: *Block chart of the measurement.*

The impact force is adjustable in the range from about 50 N up to 500 N and is controlled by solenoid driving power voltage. The repetition frequency of strokes can be set in the range from 5 Hz up to 10 Hz. Thus in the time period of one minute about 500 strokes can be done. The impact force and frequency is controlled by PC computer, or can be both adjust locally.

To achieve good reproducibility of measurements, the impact force is measured by means of a piezoelectric sensor. The piezoelectric sensor signal is stored by the PC-computer with the internal AD/DA PC-card. The variation of the measurement parameters (impact force, number of impacts, but also the first impact events, memory effects, etc.) and their optimum setting for different layer types could be then easily investigated.

Two DIWT devices were designed and hard nanostructured coatings DIWT experiments were performed.

3 TESTING

In the Fig.3 there is an example of the erosion area. The erosion spot selected for evaluation is marked with an arrow. After visual control of the sample the erosion area, the diameter, and the depth of the erosion area is measured on the Talystep profilometer (Taylor - Hobson). Example of the measured profile is in the fig. 4. [5] The area of the erosion spot is important parameter which gives mutual comparison of the samples under investigation.

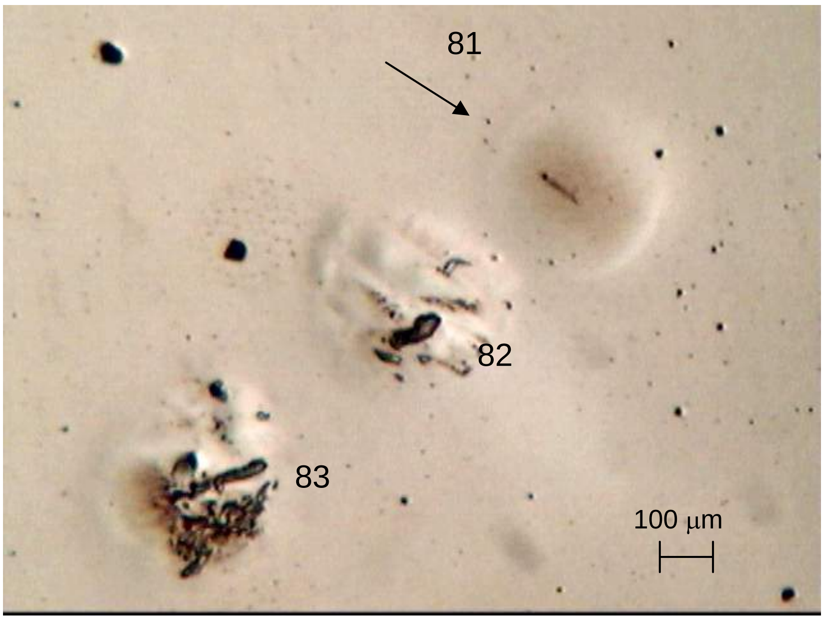

Fig. 3: *Example of the erosion area*

Erosion spot is measured in two directions perpendicularly. The information about the erosion spot symmetry is obtained this way and more reliable information about erosion spot dimension is thus obtained.

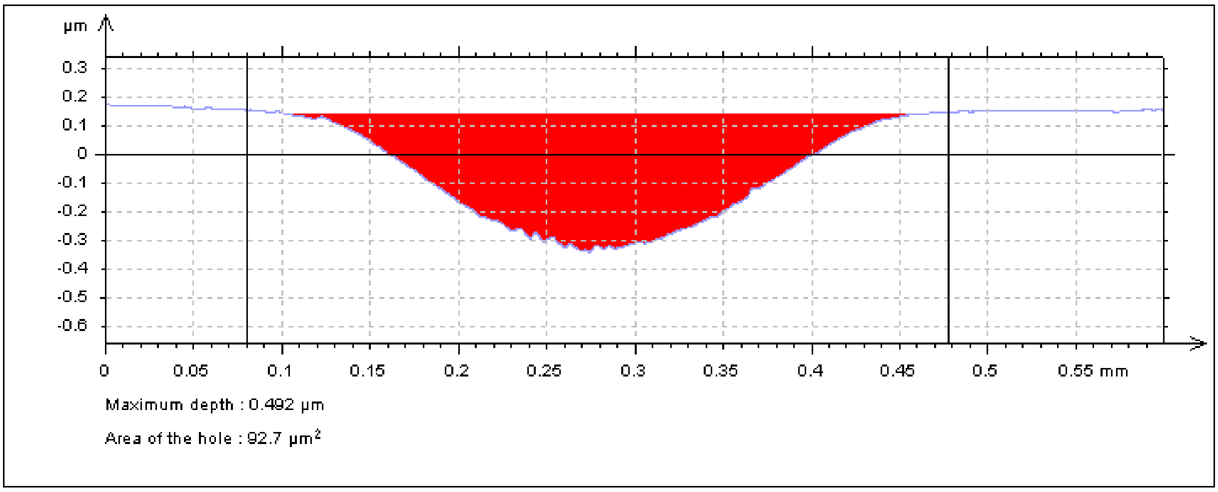

Fig. 4: *The profile of the erosion spot measured by Talystep profilometer*

The variation of the measurement parameters (impact force, number of impacts, but also the first impact events, memory effects, etc.) and their optimum setting for different layer types could be thus easily investigated.

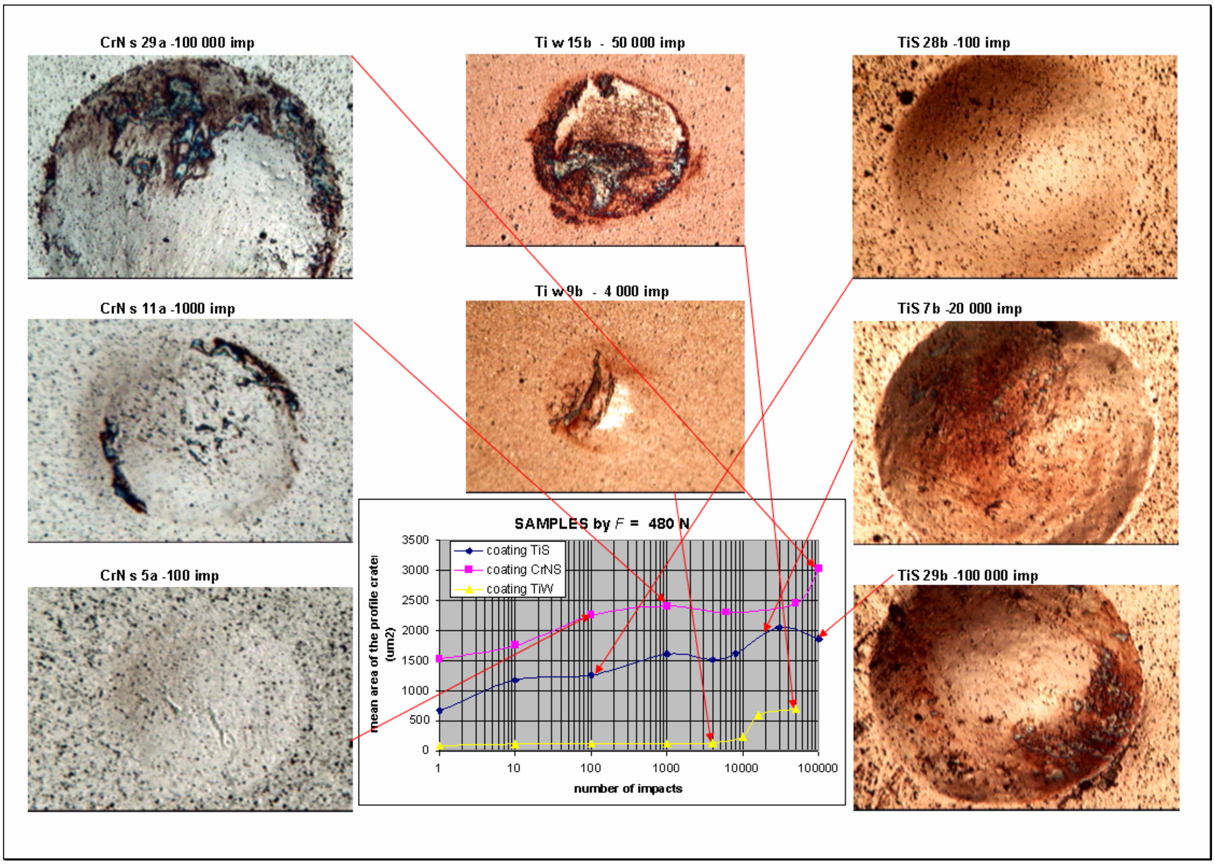

Fig. 5: *Result of comparison two coating*

On the fig. 5 there is an example of the comparison of three coatings. Different behavior is obvious when we compare the same coatings on different substrates. On the left side there is CrN coating on steel and erosion evolution by increasing numbers of impacts. On the right side of the picture there is TiN coating on steel and in the middle there is TiN coating on wolfram-carbide substrate.

For the sufficient device stability and reproducibility of the test procedure the same test force must be guaranteed – it means the kinetic energy of the probe immediately before the stroke must be set precisely. This is effectuated by means of careful current and time control.

4 DISCUSSION AND CONCLUSION

Coated tools show their effectiveness not only in wear reduction, but more often in a better workpiece surface finish, in a higher productivity and reduced use of lubricants. For hard coatings characterization two identical DIWT probes were designed and the DIWT experiments were performed. The results indicate that the measurements are reproducible and that this method is very proper for the application given. It is possible to quantify the number of the load cycles which a coated component can withstand and define a critical fatigue force. By investigating the erosion area more information about the film under dynamic loads can be acquainted.

REFERENCES

[1] Knotek, O. at al.: Surface and Coatings Technology, A new technique for testing the impact load of thin films: the coating impact test, 54/55 (1992) 102-107

[2] Boušek, J., Sobota, J.: Electronic Devices and Systems 1999 - Proceedings, "Dynamic impact wear testing of nanostructured coatings", Editor: Musil Vladislav, December 1999, Brno ISBN 80-214-1466-9

[3] Fořt, T., Fibich, M.: Proceedings of the 10th Conference and Competition STUDENT EEICT 2004 Volume 1, The Impact Tester for Thin Hard Coatings, BRNO University of Technology, ISBN-80-214-2634-9

[4] Boušek, J., Fibich, M., Fořt, T., Grossman, J., Sobota, J.: In Nano 04 Nenamat mobilization workshop, “Dynamic impact wear tester”. Brno: Auda, Bezručova 17a, Brno university of technology, 2004, s. 56 - 56, ISBN 80-214-2672-1

[5] Boušek, J., Fibich, M., Fořt, T., Grossman, J., Sobota, J.: Vrstvy a povlaky 2004, “Dynamic impact wear test exploitation” Trenčín: Digital Graphic, Trenčín, 2004, s. 47 - 94, ISBN 80-968337-8-2