COMPARISON OF PROPERTIES AND BEHAVIOUR OF SELECTED SYSTEMS OF THIN FILM - SUBSTRATE WITH TiSiN, AlCrN AND AlTiN ON SAMPLES AND SELECTED CUTTING TOOLS

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Abstract

The paper is devoted by evaluation of comparison of selected systems of thin film - basic material, which are optimized in the range of solution of the project with goal application of thin films on selected real cutting tools. There are evaluated thin films prepared by low voltage reactive arc evaporation in vacuum with different composition of ternary nitride. The evaluation of properties and behaviour is oriented on systems with thin films TiSiN, AlCrN and AlTiN. The surfaces of these systems of thin film - basic material are evaluated from point of view of verification homogeneity of thin films through of area of samples and through of geometry of selected real tools too. The distribution of thickness is evaluated by x-ray fluorescence analysis on samples and real selected places of geometry of tools too. The other comparison is realised from point of view of differences of mechanical properties and behaviour by using of indentation methods namely of nanoindentation and scratch indentation for evaluation of differences in hardness and adhesive cohesive behaviour of systems thin films - basic material.

Keywords: Thin films, arc evaporation, nanoindentation, scratch test

1. INTRODUCTION

The very much different technology process for deposition thin films are offered and very much different kind of thin films with different composition chemical and structural is offered, too [1,2]. The each of technology process has some advantages and disadvantadges, too [3,4]. The concrete thin films has influenced by deposition process - type of deposition process and optimization of deposition process parameters. Deposition process is influence by wide range different macro and micro parameters. Some of this parameters is possible control and some of this parameters is not possible to control, but influence properties and behaviour of thin films. The basic material is one of the most important of deposition parameters - its properties and behaviour - structure composition, chemical composition, mechanical and chemical resistivity and the other. The better prediction of behaviour in real stress conditions is possible to give by evaluation not only basic properties but by analysis behaviour during measurement method namely by indentation measurement during indentation process. The main influence have the geometry of the samples and real products and the homogenity of the deposition process on large area and difficult geometry, too.

2. X-RAY FLUORESCENT METHOD

The x-ray fluorescent method was used for evaluation of homogeneity of thin films across diameter of samples and across cutting edge of tools after the deposition process with similar deposition parameters. This method has advantages by nondestructive evaluation of chemical composition and thickness and possibility to evaluate thickness on real surfaces and real geometry. The other advantages is in the possibility evaluate thickness in very small area of surface. The measurement by x-ray fluorescent method was used for evaluation of profile of thickness across all sample. The samples has diameter 30 mm and measurement was realised from one

edge across the centre to the second edge of samples. The similar evoluation was realised across cutting edge of tools.

2.1. X-ray fluorescent analysis on samples

There are analysed the profiles of the thickness across the surface of systems thin film - substrate. The comparison of the x-ray fluorescent spectrums for different substrate is on the **Figure 1** and comparison for different system thin film - substrate is on the **Figure 2**. There is possible to view differences between substrates namely in intensity of spectral line Fe, W and Mo and Ti (samples with thin films). The profile of x-ray fluorescent spectrums is shown on **Figure 3** and detail of this profile in spectral line Fe is on **Figure 4**. There is possible to view what across of the diameter of sample the spectrum changed namely intensity of spectral line of Fe, which show, what thin film is not homogeneity across diameter and on the edge is different then in the centre of samples.

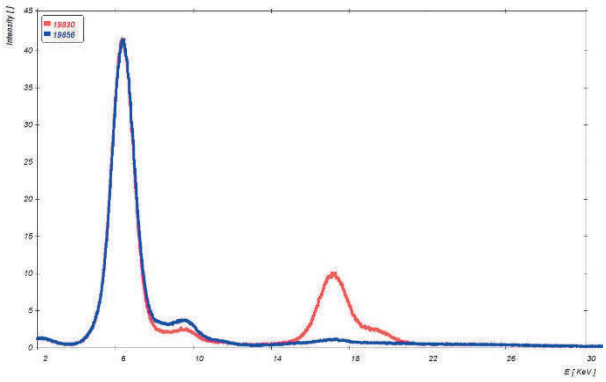

Figure 1 Different substrate

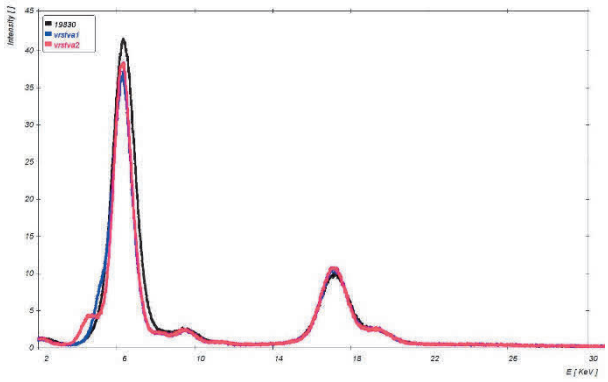

Figure 2 Different thin films

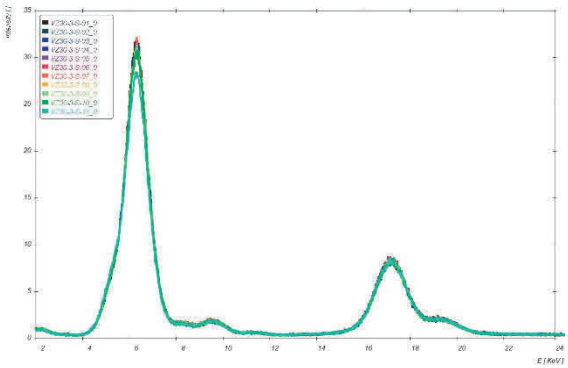

Figure 3 The profile across of the diameter

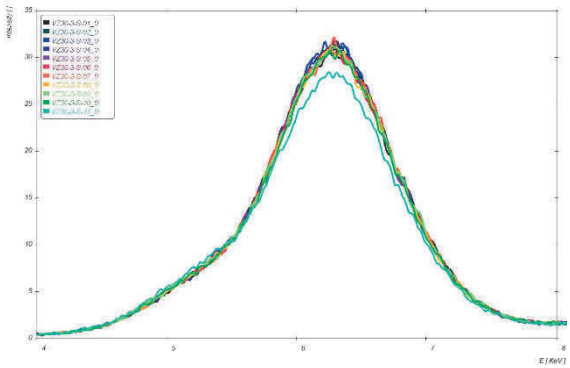

Figure 4 The detail of the profile across the sample

X-ray fluorescent analysis on cutting edges of tools

There was analysed the possibilities to evaluate of the profile of x-ray spectrums on real products namely cutting tools. In the second step there are analysed the profile across cutting edges of tools. We must used the possibilities for evaluation in small area and with multifocus setting. We prepared special holder for the better posibilities to setting the place of measurement. The profiles of the x-ray spectrums across cutting edge of tools are on **Figure 5**, **Figure 6**, **Figure 7** and **Figure 8**. The **Figure 5** show the detail of spectrums in the spectral line Mo analysed across the edge of tool and similar **Figure 6** show the detail of profile of the spektrum in spectral line Fe.

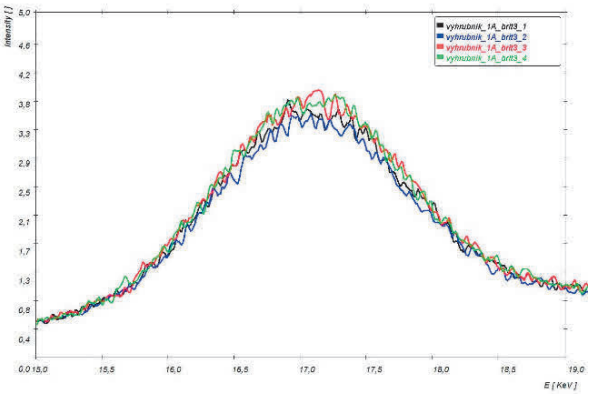

Figure 5 The detail of profile of spectrums in Mo

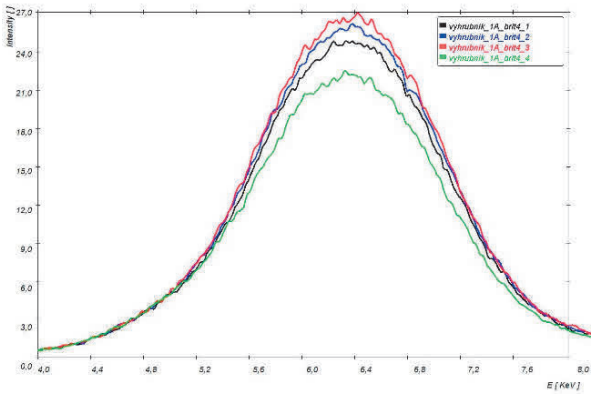

Figure 6 The detail of profile of spectrums in Fe

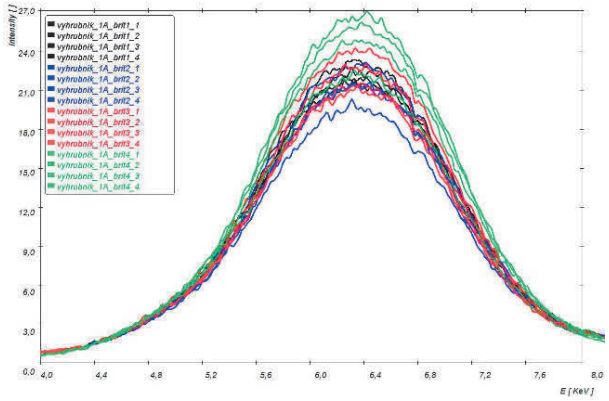

Figure 7 The detail of profile of spectrums in Fe

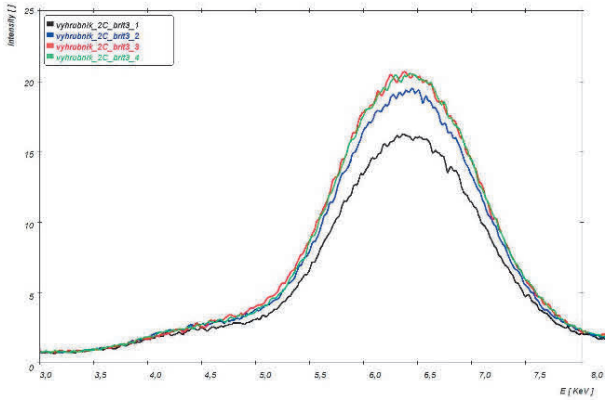

Figure 8 The detail of profile of spectrums in Fe

The results of measurement of profile thickness across cutting edges in **Figure 5** - **Figure 8**. From this figures is possible view what thickness is different in different places on cutting edges of tools. This is very important for different application. The inhomogeneity of thickness can influence behaviour of systems thin film - substrate on tools and here is very important to prepare thickness optimal for the places, which are the large stressed during application operation.

3. NANOINDENTATION MEASUREMENT

The systems of thin film - substrate on samples and cutting tools above mentioned was evaluated by nanoindentation, too. The measurement was realised by maximal normal load 200 g, 25 g and 2g. There is used for evaluation of modification of surface of substrate under thin films by deposition process and hardening of surface of substrate by thin films (200 g), for evaluation of properties and behaviour on interface between thin films and substrate (25 g) and for evaluation of properties and behaviour of thin films (2 g). The **Figure 9** show indentation curves measured with maximal load 200 g on samples with different thin films. The **Figure 10** show indentation curves measured with the same parameters of measurement (loading rate, time delay in maximal load). The indentation curves measured by mode 2 - loading, time delay 10 s, unloading with constant rate of loading. The measurement on real geometry and real surfaces on cutting tools was optimized by seting parameters for measurement and by special holder for gripping cutting tools and preparing measurement on cutting edges.

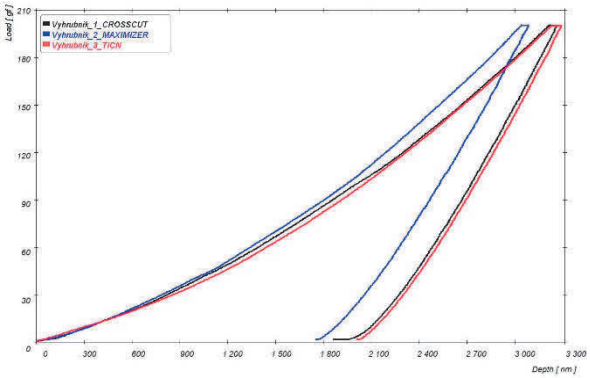

Figure 9 Indentation curves - maximal load 200 g

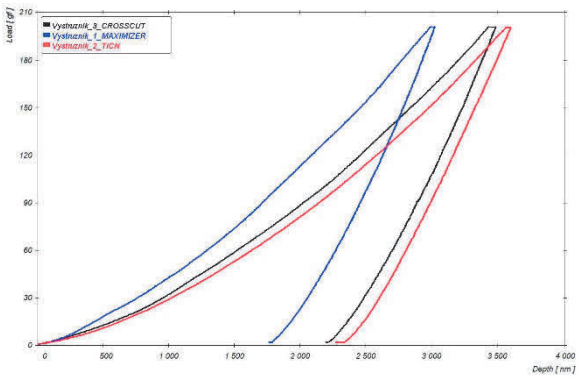

Figure 10 Indentation curves - maximal load 200 g

There is possible to view from comparison measurement on samples, what thin film TiSiN has the largest hardness then TiAlN and TiCrN. The similar results is for measurement on cutting edge of tools, where is large differences between different systems of thin film - substrate on tools (**Figure 9**, **Figure 10** and **Figure 11**). **Figure 11** show result from measurement with maximal load 25 g. Results are similar as from measurement with 200 g maximal load.

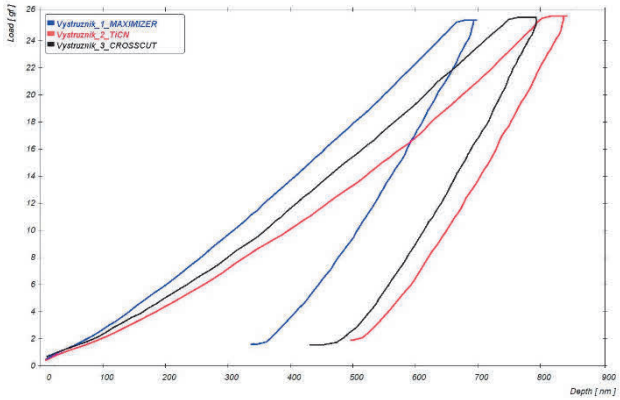

Figure 11 Indentation curves with maximal load 25 g

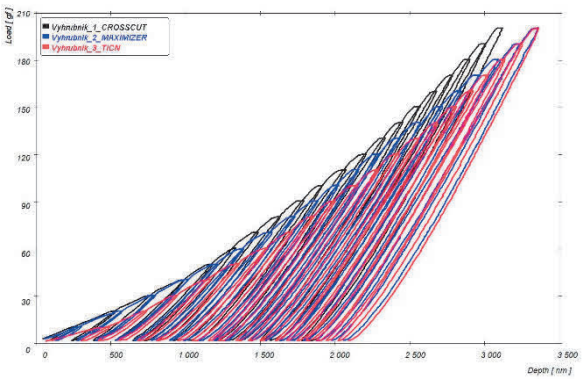

Figure 12 Cyclic indentation curves - 200 g

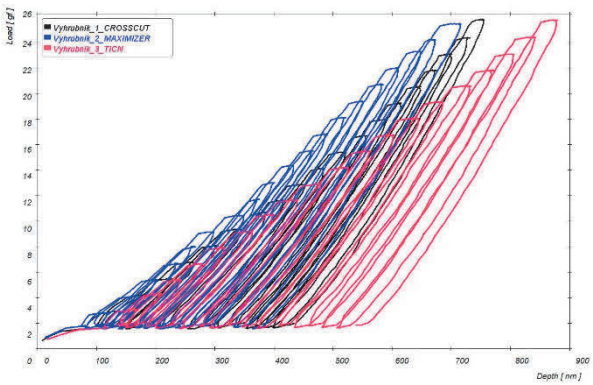

Figure 13 Cyclic indentation curves - 25 g

Cyclic indentation curves (**Figure 12**, **Figure 13**) show what simple measurement of indentation curves give some results about differences in hardness of thin films and hardening of surfaces, but cyclic indentation curves give much more information about resistivity to the repeated loading and expansion of failures and

cracks. From this point of view the larger resistivity have the system thin film TiCrN - substrate for large maximal load (**Figure 12**, **Figure 13**), because the systems with TiSiN have the high brittleness. The measurement with higher load show information about behaviour of all systems thin film - substrate, but with lower load show behaviour namely of thin films on surfaces.

4. SCRATCH INDENTATION TEST

The measurements was realised in the mode with increased acted normal force during measurement from 0 to 120 N. The indentor was standard Rockwell diamond indentor with radius of curve of tip 0.2 mm. The results are morphology of surface after scratch test (**Figure 14**, **Figure 15**). There is possible to discusse what thin films TiSiN have larger hardness but this thin films have higher failuring during scratch indentation because thin films are brittle. The best results is for thin films with higher toughness.

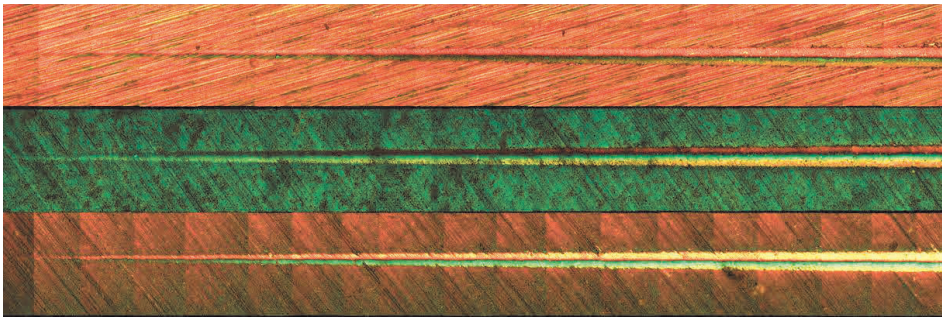

Figure 14 Morphology of failures across and in the scratches on systems with different thin films TiSiN, TiAlN and TiCrN - range of maximal normal force is from 0 N to the 60 N.

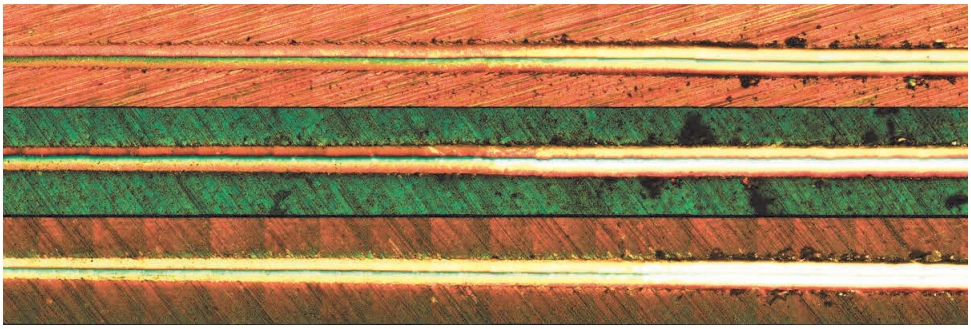

Figure 15 Morphology of failures across and in the scratches on systems with different thin films TiSiN, TiAlN and TiCrN - range of maximal normal force is from 60 N to the 120 N.

5. CONCLUSION

There was optimized analysis of homogeneity by x-ray fluorescent method on real parts of products namely cutting edge of selected tools. The result show, what inhomogeneity of thin films across the sample is very big problem for application on real products. The large inhomogeneity is measured on cutting edges of selected tools, too. Different spectrums namely intensity of spectral lines was measured on different cutting edges and across one cutting edge, too. From this point of view is very important for testing quality of thin films realise the measurement on real surfaces and real geometry. In the next step there was testing the possibilities for measurement of mechanical properties and behaiour on the real parts and concrete cutting edges, too. Differences from measurement by indentation with different modes of measturement. Show, what much more important is not only basic measurement but cyclic measurement, too, becasuse by this is tested resistivity to the repeated stress by indentation.

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