Wear-Improved PVD-Coatings by usage of a Pulsed DC-Arc-Process (PulsArc)

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1. Introduction

The goal of this presentation is to demonstrate a newly developed technology for DC-Arc processing and the resulting advantages for hard coating deposition in industrial application.
The vacuum-arc process generates highly ionized plasma. The ionization energy in the formed plasma will increase up to 50 eV by superposing of the DC-Arc with a sequence of short high-current pulses. An ionization rate of nearly 100 % will be obtained during this pulses. While the high current pulse the spot of the arc discharge is devided in many small spots moving with a high velocity (at about 30 m/sec for Titanium, Figure 1). Former studies showed the opportunity to reduce remarkably the emission of droplets at higher deposition rates [1, 2]. An important advantage of the PulsArc-process is the simple design for the additional power supply. The improvements with the PulsArc-technique for hardness and wear coefficients of Ti[Al]N- and Ti[Al]C-hardcoatings deposited thus have been analyzed by nanoindentation and scratch tests and for explanation supported by GDOES and REM.

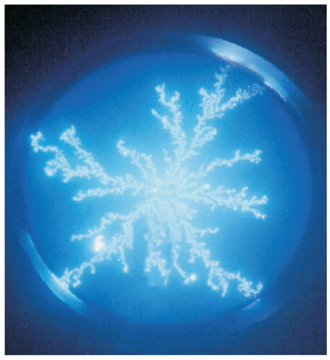

Figure 1: Picture of the pulsed DC-Arc-discharge on target

2. Experimental details

- Commercial PVD-deposition-chamber with 3 arc-sources of 72 mm diameter
- Samples fixed to a double-axed turntable (10 turns/minute)
- About 10 cm distance between sources and samples deposited with Ti[Al]N/C-coatings
- Additional 1.600 A / 300 µsec pulses with a frequency of 100 Hz for each arc-source (figure 2)
- Coatings deposited because of analytical reasons by changing pulsed and unpulsed processes 5 times with a total thickness of about 2 µm
- Different reactive gas additionals were applied: N_2, C_2H_2 and N_2/H_2
- Thickness, Structure and concentrations of the layer constituents have been investigated by REM and GDEOS, respectively
- Rockwell adhesion and micro-hardness have been analyzed by usage of a calo-wear-tester [3] and the nanoindenter UNAT [4], respectively

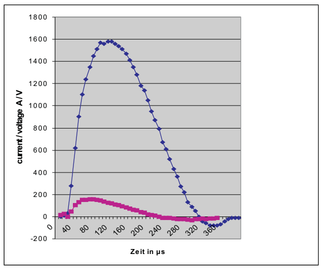

Figure 2: Voltage and current during the additional pulses

3. Results

Adhesion and hardness measurements showed usual levels on each sample (Rockwell adhesion: HF1, micro-hardness: 15...24 Gpa) which means the PulsArc doesn't influence the layer micro-hardness. But for Ti[Al]N-coatings the Nitrogen content increases by 5..10%at (Figure 3, Figure 5). The wear coefficient of Ti[Al]N-coating were found to decrease with increasing pulsed deposition share (figure 4). Another dependence was found for TiC-coatings with the PulsArc-method. Adhesion and wear measurments are in the range of a typical hard coating, but micro-hardness was lowered to values of 7.8 GPa measured with UNAT [4] at an indentation force of 20 mN.
Accessory results were received with an additional H_2-delivery into the process chamber. The suspected much higher H_2-concentration in the hard coatings were not found by semi-quantitative GDOES analysis. But the processing with additional H_2 process gas caused a smoother surface and a higher concentration of nitrogen in the hard coatings (figure 5).
For Ti[Al]N-coatings the processing in H_2 caused a worse micro-hardness (with H_2: 16 GPa, without H_2: 24 Gpa). In TiN-coatings there was almost no influence of the H_2-incredance on the micro-hardness (with H_2: 23 GPa, without H_2: 24 GPa).

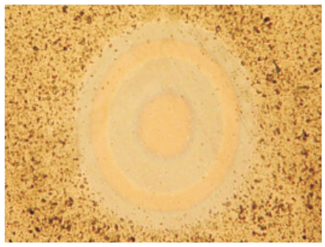

Figure 3: Carlotte grinding of PulsArc/DC-Arc TiN-layer

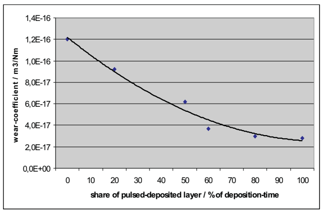

Figure 4: Wear-coefficient in dependence to the pulsed-deposited share of TiAIN-layers

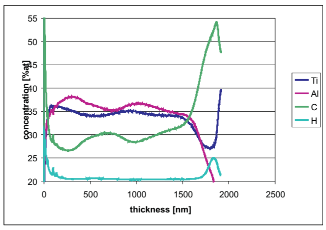

Figure 5: GDOES-spectrum of a layer system of PulsArc-layers and unpulsed layers of TiAlC-H

4. Summary

The properties of hard coatings could substantially be improved with regard to wear by usage of the PulsArc. The latter is advised for industrial applications because of its simple equipment design, efficiency and its reliability.

Acknowledgments

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Literature

[1] M. Büschel, W. Grimm, 'Influence of the Pulsing of a Vacuum Arc on Rate and Droplets', PSE2000
[2] O. Soblev, Diss., TU Magdeburg, 2005
[3] Calo-wear-tester KSG103, INOVAP GmbH, 2005
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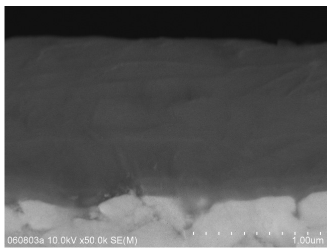

Figure 6: REM of the TiAlC-coating with PulsArc

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