

Anti-wear multilayer coatings based on chromium nitride for wood machining

Adam Gilewicz, Bogdan Warcholinski, Piotr Mysliński, Waldemar Szymanski

INTRODUCTION

Because of anisotropic structure of wood, the coatings for woodworking tools must show excellent impact resistance, good adhesion to the substrate, high hardness and corrosion resistance. The coatings should also enable high performance and good final machined surface quality when high feed and cutting speed are used. The type and architecture of the coating properly matched to type of machining process and processed material can prevent premature or even catastrophic tools' wear.

Technology

- Multilayer PVD device – cathodic arc evaporation
- Substrate – HSS hardened, ground and polished to $R_a \sim 0,02 \mu\text{m}$,
- Substrate cleaning – Chemically and Cr ion etching at Ar pressure 0,5 Pa, etching voltage – 600V, time 10 min,
- Substrate heating - up to 300 °C,
- Reactive gases:
 - nitrogen, pressure 1,8 Pa (CrN),
 - C_2H_2 , flow 10 sccm (CrCN).
- Bias voltage: -70 V,
- Arc current: - 80 A.

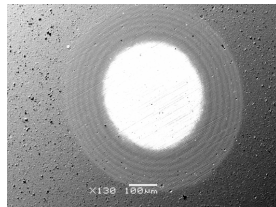
RESULTS

General characteristic

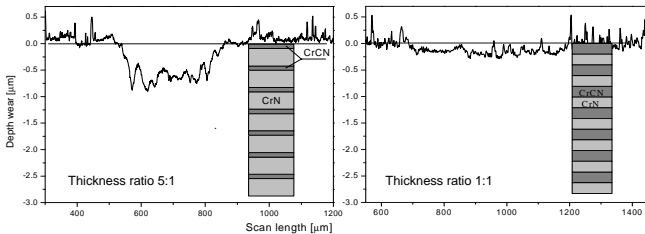
- Thickness of the coatings ~ 3 μm
- Number of CrN/CrCN bilayers - 7
- Carbon content in CrCN layer – about 10 at. %

Properties of multilayer CrN/CrCN coatings.

Multilayer coating architecture			
Bilayer thickness Δ	400 nm	400 nm	400 nm
Thickness ratio of CrN:CrCN layers in bilayer	1:1	2:1	5:1
Critical force L_{c_2}	95 N	115 N	120 N
Stress [GPa]	1.5	1.7	2.0
Microhardness [GPa]	25±3		



Friction and wear

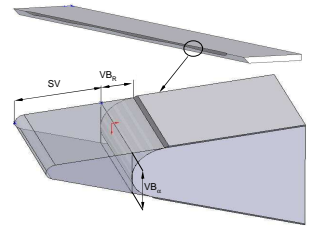
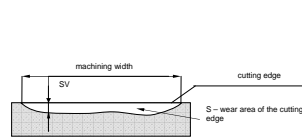


Depth wear of CrN/CrCN coatings

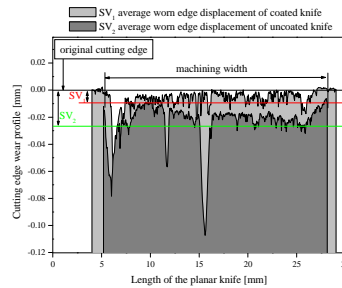
Wear rate of the coatings with different thickness ratio
 (1:1) – $1,3 \times 10^{-7} \text{ mm}^3/\text{Nm}$, (2:1) – $2,2 \times 10^{-7} \text{ mm}^3/\text{Nm}$, (5:1) – $6,8 \times 10^{-7} \text{ mm}^3/\text{Nm}$.

Semi-industrial tests

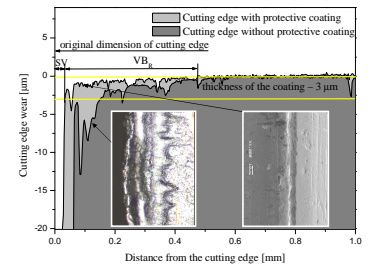
- Tools – planer knives to wood machining (HSS)
- Wood – dry pine with moisture about 8 %
- Cutting params:
 - cutting speed - 36 m/s,
 - feed - 10 m/min,
 - cutting depth - 1mm.



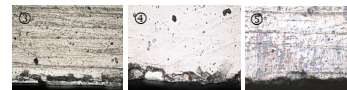
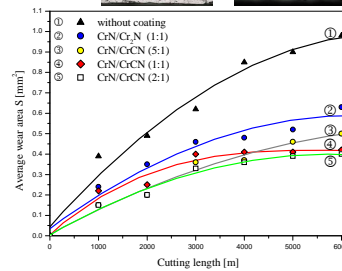
Planar knife with hard coating on the rake face



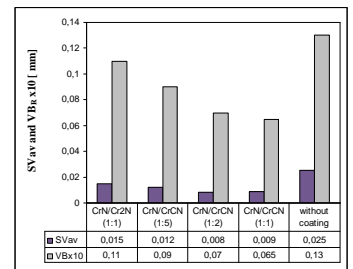
Cutting edge wear profile of planar knives after 6000 m of cutting length for uncoated and coated tool



Cutting edge profile after 6000 m of cutting length



Average wear area of the cutting tools during the cutting of pine



Worn edge displacement (SV) and rake face wear (VB_R) for tested coatings deposited on planar knives

CONCLUSIONS

- Multilayer CrN/CrCN coatings deposited using cathodic arc evaporation show very good anti-wear properties.
- The coatings with thickness ratio 1:1 and 2:1 show similar wear. The coating with thickness ratio 2:1 shows higher adhesion. That points on their industrial application. Planar knives with the coating confirm it.
- Multilayer CrN/CrCN coatings meaningfully reduce the wear of tested planar knives. So modified cutting edge shows longer lifetime of the tool, two to three times.

