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Characterization of Binary, Ternary and Quaternary Hard Coatings in the Material System V-Al-C-N Produced by Industrial Scale Reactive Magnetron Sputter Deposition

Aim of the work: deposition of **new coatings** in the material system **V-Al-C-N** on **industrial** plants, to achieve metastable nanostructured hard layers through systematical variation of deposition parameters as power density, plasma pressure and variation of the partial pressure of process-gases (Ar:N₂ and/or CH₄)

Realisation: dc magnetron-sputter industrial deposition system (CemeCon CC800/8) with rf processing mode (for 2 of 4 cathodes)

Process steps:

- heating
- etching
- coating
- cooling

Flexible controlling: variation of many parameters in each process step possible

General approach:

- binary coatings: **VN, VC, AlN, (AlC)**
- ternary coatings **VAIN, VCN, VAIC, AICN**
- V-Al-C-N-coatings**

Results in dc-magnetron-sputtered binary VN-, VC-, ternary VAIN- and quaternary VAICN-coatings:

VN-coatings:

Varied coating parameters Ar:N₂ ratio and U_{bias}

Ar:N ₂ -ratio	U _{bias} in V	L _{cc1}	HV ₀₀₀₅
250/150	-200	34	2830
250/150	-170	38	3050
250/150	-140	25	2560
250/150	-110	23	2500
250/150	-80	22	2440

XRD-spectra: VN crystallite structure of layer with best mechanical properties

VN crystallite size	N in at%	V in at%
6nm	43,18	56,36

Composition measured by means of EPMA-method

VC-coatings:

VC-coatings were deposited in two ways: both components V and C from solid state (targets) and reactive: V from solid state and C from CH₄-gas. Varied coating parameters are Ar:CH₄ flow-ratio and applied d.c. power on the C-Targets.

XRD-spectra of an amorphous VC-layer, deposited by reactive sputtering from V-Target and Ar-CH₄ gas mixture

Friction coefficient against CH₄ gas flow

Friction coefficient against bias voltage at constant CH₄ gas flow

VAIN-coatings

Varied coating parameters are bias voltage, pressure (Ar:N₂ ratio, 1. Ar-flow=const., 2. N₂-flow=const.)

U _{bias} in V at Ar:N ₂ =250/150
-80
-110
-140
-170
-200

Dependence from hardness values on bias voltage

Ar:N ₂ -ratio 1.case	Ar:N ₂ -ratio 2.case
250/30	300/150
250/50	250/150
250/75	200/150
250/100	150/150
250/150	100/150
250/200	

XRD-spectra: VAIN crystallite structure of layer with best mechanical properties

VAICN-coatings

VAICN-coatings were deposited by combining VAIN and C-deposition

XRD-spectra of a VAIN-layer with a VAICN toplayer

Results and Outlook:

Results VN:

- VN-coating nanocrystalline
- average crystallite size ~6nm
- near-stoichiometric
- friction coefficient ~0.7

Results VC:

- reactively deposited coatings are almost amorphous and show poor mechanical properties
- sputtered coatings (V+C-targets) are nanocrystalline
- average crystallite size ~3nm
- friction coefficient variable through C-content (0.2-0.6)

Results VAIN:

- VAIN-coating nanocrystalline
- average crystallite size ~4nm
- near-stoichiometric
- friction coefficient ~0.7
- mechanical properties advantageous

Results V-Al-C-N:

- C-content in VAICN-layers has an impact on friction coefficient, see talk E3-2-7 on May, 1st by Dr. Ziebert
- combination of hard, metastable materials with a low friction coefficient on an industrial machine manageable
- first steps to understand the quaternary V-Al-C-N-layer-system through proceeding binary VN-, VC-, ternary VAIN- and quaternary VAICN-systems are done
- next steps: optimizing the VN-, VAIN- and VAICN layer-systems

