

# TRIBOLOGICAL AND MICROMECHANICAL PROPERTIES OF THE NANOSTRUCTURED CARBONITRIDE COATINGS DEPOSITED BY ADVANCED PVD TECHNIQUE

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## Abstract

This research is devoted to the tribological and micromechanical properties of the nanostructured smart coatings (NSC) based on the alternating 2-sublayer {TiMe-CN/TiAlSi-N} composite structure, which were deposited onto bearing steel substrates using the advanced high-power reactive PVD technique. Here notation "Me" denotes chemical elements of Hf or Nb, but index "n" shows the number of spatial periods of the deposited superlattices. The deposited novel NSC containing TiAlSi-CN nanoparticles strengthened by Hf and Nb additives exhibited a coefficient of friction (CoF) within 0.2-0.4.

## Materials and Methods

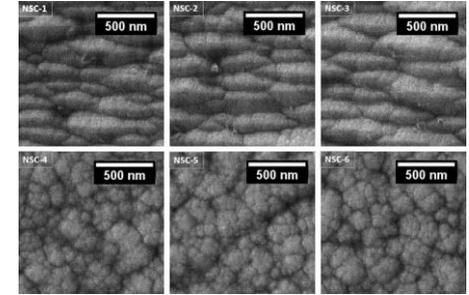
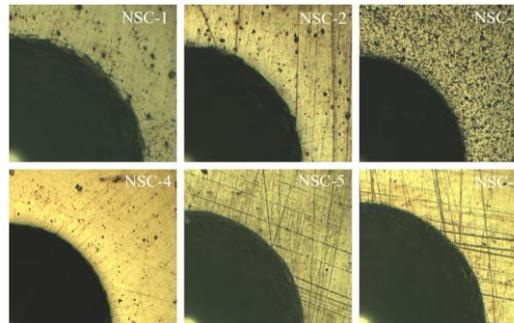
These thin film coatings were deposited onto bearing steel substrates made of 100Cr6 and 107WCR5 type steels using the advanced PVD technique denoted here as the High-Power Ion-Plasma Magnetron Sputtering (HiPIPMS). Sliding friction and wear were measured using a pin-on-disc tribometer (CSM Instruments, CH) under dry friction conditions according to ASTM G99-05. The cross-sectional area of the worn tribotracks was measured using a Mitutoyo SurfTest SJ-500 profilometer. Final cross-sectional area result was calculated, as an average from three independent measurements, and then calculated value of wear rate. The morphology of the coating structures was investigated with a scanning electron microscope (SEM) Tescan Lyra3, equipped with an energy-dispersive X-ray spectrometer (EDS) Oxford Aztec. For determining the adhesion of coatings was used the Rockwell adhesion test method, according to, defined by the DIN 4856: 2018-02 guideline. Apparent microhardness was measured using a micro Vickers tester HM-210B (Mitutoyo, Japan) following the standard ISO 6507. 2D roughness measurements were performed using a Mitutoyo SurfTest SJ-500 surface roughness tester to characterize the coating's surface.

## Results

Table shows tribological and micromechanical parameters of the superlattice-type NSC samples based on the alternating carbonitride/nitride {TiMe-CN/TiAlSi-N} 2-sublayers spatial period of the superlattice where 'Me' denotes atomic elements of Hf or Nb.

Sample label	Coating's Laminated Structure	Thickness, t (nm)	Friction, CoF	Wear rate, (mm <sup>3</sup> /Nm)	Apparent Hardness, HvA (10 gf)	True Hardness, HvC (h→0)	Substrate Hardness, HRC	Adhesion by HRC test
NSC-1	{TiHf-CN/TiAlSi-N} Ti Substrate	4800	0.249	1.68*E-06	2650	2946	54.3	HF2
NSC-2	{TiHf-CN/TiAlSi-N} Ti Substrate	6300	0.254	3.86*E-06	3205	4244	19.2	HF1
NSC-3	{TiHf-CN/TiAlSi-N} Ti Substrate	6200	0.282	1.70*E-05	2844	3766	13.8	HF1
NSC-4	{TiNb-CN/TiAlSi-N} Ti Substrate	4200	0.301	2.52*E-06	2168	2768	18.8	HF1
NSC-5	{TiNb-CN/TiAlSi-N} Ti Substrate	3400	0.396	5.23*E-06	1719	2015	58.7	HF1
NSC-6	{TiNb-CN/TiAlSi-N} Ti Substrate	2300	0.458	5.13*E-06	1777	2145	57.3	HF1

Figure shows the indentations of the (DIN 4856: 2018-02) adhesion test of the coatings, their results correspond to the HF1 and HF2 classification classes, which indicate the acceptable adhesion of the coating.



SEM surface micrographs (plan-view) of the NSC samples doped by the atomic element of Hf (top panel with NSC-1, NSC-2, and NSC-3) and doped by the atomic element of Nb (bottom panel with NSC-4, NSC-5, and NSC-6).

## Conclusions

In current investigation deposited and tested nanostructured thin film coatings (t<6300 nm) on bearing steel. Deposited thin film coatings (TiMe-CN/TiAlSi-N) alloyed by Hf and Nb dopants, which show acceptable results in tribological and mechanical tests. On tribotests, the lowest COF value from the Hf alloyed sample set group (0.24), and the lowest COF value from the Nb adhesion set (0.30). All deposited coatings have acceptable adhesion. The apparent hardness HvA reached 2168 (10 gf) and 3205 (10 gf) of the NSC doped by Nb and Hf respectively.

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