Tribological performance of nanolaminate coatings based on tungsten nitride

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The automotive and aerospace industries widely utilize cutting tools in their manufacturing processes such as knurling, milling, chamfering, turning, drilling, and honing. However, optimizing production costs and using lubricants is an urgent matter. It can be achieved by using a protective hard coating on the surface of the cutting tool. Multilayer transition metal nitrides are extensively utilized for such purposes due to their high functional properties. The present study is focused on WN/NbN nanolayer coatings deposited by CA-PVD on stainless steel substrates. The effect of the substrate bias voltage (-50 V, -100 V, and -200 V.) on the microstructure and tribomechanical properties of multilayers was comprehensively studied.

The N content was approximately 50 at.% in all coatings. However, the niobium concentration slightly increased from 27 to 29 at.%, and the tungsten content reduced from 24 to 21 at.% when bias voltage changed from -200 to -50 V. The bilayer period (Λ) of the nanolayer deposited at -50 V was 13 nm, and U_s of -200 V reduced Λ to 9.5 nm. Coatings developed a dense multilayer structure. According to the GI-XRD and TEM observations, WN layers consisted of a face-centered cubic (fcc) β-W_2N phase. The NbN layers were composed of the fcc δ-NbN and hexagonal ε-NbN phases. It was found that lattice constants decreased with an increase in the U_s. Moreover, the calculated average crystallite sizes slightly decreased for all phases from approximately 2.3 to 5.0 nm. Coating deposited at -50 V exhibited the best mechanical properties and wear resistance: hardness of 35.2 $\pm$ 3.3 GPa, elastic recovery of 55 %, H/E = 0.085, H^3/E^2 = 0.254, friction coefficient of 0.73, and specific wear rate of about $1.01 \cdot 10^{-6}$ mm^3/N·m. The combination of all these factors makes new CA-PVD WN/NbN coatings suitable candidates for protecting cuttings tools.

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