Mechanical and tribological properties of nanostructured CrxAlyN-TiSiN coatings

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Highly demanding tribological applications, such as high speed machining without lubrication, require materials which should be characterized by high hardness, low friction, high oxidation and thermal stability. In this study, a d.c. magnetron sputtering technique was utilized to prepare nanostructured CrₓAlᵧN-TiSiN coatings to meet the challenge.

Coatings were deposited in an industrial unit (CC800/9) equipped with four magnetron sources (two CrAl and two TiSi). By using segmented CrAl targets, fourteen coatings were produced, with Cr and Al concentration varying almost linearly from 6 - 50 at.% and 3 - 35 at%, respectively (the highest Cr concentration corresponds to the lowest Al concentration). Coating chemical composition was determined by XPS and GDOES, while crystallinity was evaluated by XRD. Mechanical properties were measured by nanoindentation technique. Ball-on-disk test (with alumina ball) was carried out in air to evaluate coating tribological properties. Tribo-tracks were studied by optical microscopy, stylus profilometry, and SEM.

According to XRD and XPS measurements all coatings consist of fcc-CrₓAlᵧN and SiNx nitrides. Formation of phases with hexagonal lattice was not observed. Hardness, elastic modulus and H/E² ratio varied between 23 to 35 GPa, 232 to 329 GPa, and 0.18 to 0.37 GPa, respectively. Decrease in friction coefficient from 0.7 to 0.2 with increase in Cr concentration was observed, with correlation factor of 93%. Such an improvement if friction coefficient is attributed to formation of chromium-oxide which acts as a protective tribo-film. Very low wear rates were measured for all coatings (from 6.5 x 10⁻⁸ to 7 x 10⁻⁶ mm³/Nm). A highest correlation of the wear rate was found with the coating hardness and was 70%. The wear rate first decreased, and then increased with the increase in Cr concentration, i.e. decrease in Al concentration, with the lowest value measured at the mid-composition sample (Cr₀.₃₃Al₀.₁₅Ti₀.₁₂Si₀.₀₂N).

Keywords
Low friction and wear
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