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Development of transition metal nitride hard coatings through the composition and processing control

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The transition metal nitride hard coatings have been intensively studied by researchers and already widely applied in industries due to their high hardness, good wear, corrosion and oxidation resistance. The design of chemical composition, microstructure and deposition technique of such hard coatings has great influence on their mechanical property and performance during usage. In this work, several transition metal nitride coatings, CrBN, CrTiBN, TiCrBN, TiZrBN, AlCrN, CrSiN, CrZrSiN, CrTiSiN, CrAlSiN, CrCN, ZrCN, CrCN/ZrCN and TiAlN/CrSiN, were grown by the magnetron sputtering, cathodic arc evaporation and high power impulse magnetron sputtering (HIPIMS) processes, respectively. The structure and phase composition of coatings were determined by the X-ray diffraction, transmission electron microscopy (TEM), scanning electron microscopy and X-ray photoelectron spectroscopy. The mechanical properties of the coatings were measured using nanoindentation, HRC-DB and scratch tests. The tribological properties were evaluated using conventional ball-on-disc tribometer. The influences of the boron, carbon and silicon contents on the microstructure, mechanical and corrosion resistance of transition metal nitride coatings were discussed. The chemical composition induced microstructure evolution, including the nano columnar grains, nanocomposite and nanolaminated features were explored by the TEM. The effect of deposition processing method on the plasma density, coating microstructure and mechanical property of coatings was further evaluated. It can concluded that through the proper adjustment of chemical concentration of third element and the selection of deposition technique, such as the multilayer control and using HIPIMS technique, high hardness, adequate adhesion and good wear resistance can be obtained for the transition metal nitride hard coatings. The design concepts of hard coatings correlated to the composition, microstructure and mechanical property were investigated in this study.

Keywords: Transition metal nitride hard coatings, Magnetron sputtering, Cathodic arc deposition, High power impulse magnetron sputtering, Nanocomposite coating, Multilayer coating