Hard Nanocomposite Ti-(Al,Cr,Y)-Si-C-N Coatings with Improved Wear- and Oxidation Resistance Produced by Ion Implantation Assisted Magnetron Sputtering

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The Ti-Al-N and Ti-Cr-N coatings are widely used in practice for metal cutting and forming tools because of their high mechanical and tribological properties, good thermal stability and excellent oxidation resistance. Most recently, research has been extended to multicomponent systems. The Si incorporation into the Ti-Al-N coating resulted in the formation of nanocomposite structure with the (Ti,Al)N crystallites embedded in the amorphous SiN_x matrix. Nanocomposite structure of the Ti-Al-Si-N coatings promoted to the increasing of the hardness and maximal usage temperature. C-doped Ti-Al-N and Ti-Cr-N coatings are characterized by improved tribological properties due to the solid lubricant effect of the amorphous carbon. Addition of the optimal amount of Y drastically improved the oxidation behavior of the Ti-Al-N-based coatings and promoted grain refinement resulting in lower residual stresses in the coatings. The aim of the present work is to study the structure and properties of Ti-(Al,Cr,Y)-Si-C-N coatings produced by ion implantation assisted magnetron sputtering of multicomponent targets.

The TiAlSiCN and TiCrSiCN composite targets with different metals/nonmetals ratios were produced by self-propagating high-temperature synthesis (SHS). The deposition was fulfilled in various environments: Ar, Ar+10%N_2, Ar+15%N_2, and Ar+25%N_2. The magnetron sputtering unit which is combined with metal ion implantation source MEVVA type was used. Higher energy bombardment by Ti^{n+} and Y^{n+} ions was operating either at the initial stage of deposition or assisted during the whole process. The accelerating voltage and the current were kept constant at 30 kV and 10 mA, respectively. The structure, chemical and phase composition of coatings were studied by means of glow discharge optical emission spectroscopy, X-ray diffraction, X-ray photoelectron spectroscopy, transmission and scanning electron microscopy. The coatings were characterised in terms of their hardness, elastic modulus, elastic recovery, adhesion strength, friction coefficient, wear rate, corrosion and oxidation resistance. The lifetime of coated mills and drills was examined.

Results obtained show that coatings with optimal structure and composition have good adhesion to cemented carbide substrates (critical load higher than 40 N), hardness above 25 GPa, Young's modulus up to 350 GPa, elastic recovery up to 60%, friction coefficient against WC+6%Co ball below 0.6 and wear rate better than 10^{-5} $mm^3N^{-1}m^{-1}$. Tribological properties of coatings with maximal hardness were stable in temperature range from 20 to 700^0C. These coatings demonstrated high anti-oxidation properties up to 900^0C and corrosion resistance better than the TiN and TiCN coatings. The developed nanocomposite coatings are found to prolong the lifetime of carbide instruments by 2-6 times compared with the TiN coating.