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High-temperature performance of quaternary system (Ti, Al, Cr) N deposited by HiPIMS

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c-TiAlN coatings have been widely used in advanced machining due to their excellent outstanding mechanical, thermal and tribological properties. To withstand oxidation ≥ 950 °C, we studied the influence of Cr additions on the structure, mechanical properties and oxidation resistance, including the oxide scale characterization, of different nitride TixAlyCr1-x-yN coatings deposited on WC-Co and Si wafer by High-power impulse magnetron sputtering. The properties of c-Al0,62Ti0,38N were studied as a reference. The film at 850°C was oxidized and formed a bi-layered oxide scale with dense Al2O3 outer-layer and porous TiO2 sub-layer then at 950°C because of the fast Ti ions diffusion to the surface, the formation of the continuous and protective Al oxide layer was impeded. TGA measurements showed that Cr rich coatings showed different oxidation kinetics depending on their chemical composition. The surface hardness of the coatings was obtained by a nano-indentation test and it has shown that the Cr content can stabilize the hardness and the Young modulus independently the Al/Ti ratio. The structural evolution during annealing of TixAlyCr1-x-yN coating by XRD diffraction at different temperatures revealed that all coatings kept the B1 structure until 950°C. Cross-section observations by TEM of the oxidized coatings have shown that the addition of Cr promoted the formation of a TiO2 layer over a gradient Cr(Al)2O3 layer. Thanks, to-depth profile analysis by SIMS after oxidation at 950°C under an alternative atmosphere containing16O and18O, it has been possible to give information on the different mechanisms controlling each oxide scales. The growth of the oxide layer appears at three levels: a rutile TiO2 on the external surface was formed followed with intermediate Al-rich gradient Cr(Al)2O3 layer then a Cr2O3 layer at the interface with the coated nitride layer.

Keywords
TiAlCrN HiPIMS coatings
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