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Role of yttrium addition on the oxidation behaviour of arc-evaporated AlCrN films deposited on M2 tool steel

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New economical and ecological tendencies move the industrials towards higher and higher machining speeds together with a drastic restriction of lubricant-cooling fluids. As a consequence, the surface of coated tools has to withstand extreme conditions, especially in terms of temperature. Simple transition metals nitrides cannot sustain such severe conditions and a new generation of coating enriched in aluminium has been developed. It is the case of AlTiN and more recently AlCrN films. Moreover, the beneficial effect of Y is well known in the field of bulk refractory materials, but its effect when introduced into a coating is little investigated. Aim of this paper is then to characterize the high temperature oxidation behaviour of AlCr(Y)N coatings deposited on a tool steel. Influence of the microstructure and of the yttrium will be put into the light through a metallurgical and thermogravimetric approach.
3 µm-thick films were synthesized from an Al64Cr36 or Al63Cr35.5Y1.5 target into a PVD random arc reactor, using a constant evaporation intensity of 80 A. Deposition was conducted for a bias voltage applied in the range of -30V / -60V and at a deposition pressure of 3Pa.
Surface defects were observed by SEM and quantitatively measured by electrochemistry. Evolution of phases and microstructure with the temperature was deduced from in situ XRD measurements. Quantitative oxidation experiments were performed in thermobalance using dry air. Isothermal tests at 800, 850 and 900°C were carried out giving us access to both kinetic (kp) and thermodynamic (Ea) parameters. The onset temperature of oxidation was also deduced from a dynamic heating from the room temperature up to 1100°C.
Films are very dense and compact with tiny open porosity rates. XRD analysis reveals a single-phase fcc CrN-type nitride with a 20-30 nm grain size, stable up to 900°C. Quantitative analysis indicates a very high resistance against oxidation. Thermograms reveal a parabolic evolution of mass gain, suggesting an oxidation process limited by the transport.

Keywords
oxidation resistance,microstructure, SEM, High temperature in situ XRD