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On the reactive-element effect of Y in the oxidation of CrAlYN films

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CrAlYN coatings were deposited by magnetron sputtering on M2 steels for improvement of the oxidation resistance and hardness properties. Two different average aluminium concentrations were selected (16 and 25 at.%) and variable yttrium content (1.2 to 5.7 at.%). The coated steel samples were submitted to thermal annealing in air during 2 hours to investigate the oxidation resistance, thermal stability and diffusion processes. The best performance is obtained for the CrAlYN coating with ~16 at.% of Al and intermediate values of Y (3.4 at.%) where the initial cubic phase (fcc-CrAlN) was preserved under a thin mixed $(Cr,Al)_2O_3$ oxide layer. The CrAlYN coatings with higher aluminium contents showed lower thermal stability decomposing into h-AlN and Cr phases accompanied by metallic elements diffused from the steel substrates. The role of Y in the oxidation mechanism was investigated using XRD, GDOES and analytical TEM techniques. The result of the oxidation processes is highly influenced by the concentration of yttrium present in the film. CrAlYN coating (1.2 at.% Y) was not able to prevent the iron diffusion along the coating reaching the surface where gets oxidized.
Higher Y amount (independently of the aluminium content) avoided the iron diffusion but favoured extremely the penetration of oxygen inwards leading to partial or full oxidation. HAAD-STEM images and EDX elemental map obtained from the oxidized films demonstrated the segregation of yttrium at the column boundaries (film) and grain boundaries and interface (scale). These experimental evidences confirm the role of yttrium affecting the ion transport processes retarding the oxide scale growth.

Keywords
Reactive element
oxidation resistance
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high temperature