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Influence of the N2 partial pressure on the structure and properties of ZrAlN thin films

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The compositional and structural evolution of ZrAlN thin films as a function of the N_2-to-total pressure ratio (p_{N2}/p_T) and the substrate position during reactive magnetron sputtering are investigated in detail. We therefore used powder-metallurgically prepared ZrAl targets with two different compositions of 70/30at% and 60/40at%. Based on these studies we can show that the Al incorporation to the prepared films as well as their crystalline structure is highly dominated by the reactive gas ratio used. Hysteresis curves are carried out to investigate the different states of target poisoning as a function of the N_2 partial pressure. Furthermore, we correlated these findings with the resulting film structure, chemical composition, morphology and mechanical properties. We demonstrate that for both targets, $Zr_{0.7}Al_{0.3}$ and $Zr_{0.6}Al_{0.4}$, face-centered-cubic (fcc) ZrAlN coatings are obtained when using low p_{N2}/p_T ratios of around 10%, whereas higher ratios lead to the formation of a nanocrystalline material composed of multiple phases. Thermal stability and structural evolution of the ZrAlN coatings are investigated after vacuum annealing up to 1100 °C, by X-ray diffraction analysis, indicating a stabilization of the crystalline fcc structure up to ~800°C. These results are supported by dynamical differential scanning calorimetric and thermogravimetric analysis.

Keywords
ZrAlN
reactive sputtering
thermal stability
phase evolution