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Competition between local lattice strains and distribution of metallic species in $Ti_{1-x}Al_xN$ coatings with fluctuating [Ti]/[Al] ratio

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Abstract

The effect of a locally fluctuating [Ti]/[Al] ratio in the $Ti_{1-x}Al_xN$ coatings on the formation of the lattice strains at the (Ti,Al)N/(Al,Ti)N interfaces and the influence of these interfaces on the stabilization of metastable (Al,Ti)N with face centered cubic structure were investigated using glancing angle X-ray diffraction, transmission electron microscopy and X-ray spectroscopy. A series of $Ti_{1-x}Al_xN$ coatings with different [Ti]/[Al] ratios was deposited using cathodic arc evaporation from a titanium and an aluminum cathode. The overall chemical composition was controlled by the position of the respective sample in the deposition chamber and ranged from x = [Al]/([Ti]+[Al]) = 0.06 to 0.64. The local fluctuations of the [Ti]/[Al] ratio were produced by interrupting the deposition from the titanium cathode. It was shown that such local fluctuations of the [Ti]/[Al] ratio generate large contrary residual stresses at the respective side of the (Ti,Al)N/(Al,Ti)N interface. These stresses were almost completely relieved after annealing at 750°C. The stress relaxation after annealing was accompanied by an equalization of the [Ti]/[Al] ratio and by a decay of the composition fluctuations in the $Ti_{1-x}Al_xN$ coatings. The stress relaxation and the reduction of the local composition gradients were concluded from measured residual stresses, stress-free lattice parameters and local concentration profiles.

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