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Thermally Enhanced Mechanically Properties of Arc Evaporated Ti0.34Al0.66N / TiN Multilayers

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The cubic phase $Ti_{1-x}Al_xN$ has been used to coat cutting tools since the late 1980's. It has been shown that the excellent tool performance is closely related to a decomposition of c-$Ti_{1-x}Al_xN$ to c-TiN (cubic) and c-AlN (cubic) at elevated temperatures which generates an age hardening effect. The decrease of hardness at higher annealing temperatures (over aging) is attributed to the second step of the decomposition i.e. c-AlN transforming to h-AlN (hexagonal). Hence, in order to further enhance the high temperature properties of for example a cutting insert, the c-AlN to h-AlN transformation needs to be suppressed. In this work we explore the possibility to control the decomposition temperatures of $Ti_{1-x}Al_xN$ through a multilayer structure.

Cubic $Ti_{0.34}Al_{0.66}N$/TiN multilayers were grown by reactive cathodic arc evaporation using Ti_{33}-Al_{67} and Ti cathodes in a N2 atmosphere to a total thickness of 3µm. The thermal stability of multilayers with layer thicknesses of 50/25, 25/12 and 10/5 nm, and monolithic $Ti_{0.34}Al_{0.66}N$ was investigated using differential scanning calorimetry (DSC). The results show that the first step of decomposition in the multilayers is initiated at a lower temperature compared to the monolithic TiAlN, while the second step is initiated at higher temperature, i.e. the multilayer structure promotes the favorable spinodal decomposition and suppresses the unfavorable transformation into h-AlN. STEM micrographs and EDX maps show a confined growth of the AlN precipitates within the thin TiAlN layers of the multilayer structure. Nanoindentation reveals that, despite the 60 vol% TiN in the as-deposited multilayers show similar or slightly higher hardness than the monolithic $Ti_{0.34}Al_{0.66}N$. In addition, the multilayers show a significantly improved age hardening compared to the monolith.

The enhanced hardening phenomena and improved thermal stability of the multilayer structures are discussed in terms of particle constraints and coherency stresses from neighboring TiN-layers.

Keywords
multilayer
decompositon
age hardening