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In-situ micromechanical testing reveals the influence of droplets on mechanical properties of a multi-layered AlCrN/AlCrSiN arc-evaporated coating in as-deposited and annealed state

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Experimental determination of mechanical properties is a key task for the development of nanostructured functional materials. It is also essential to understand the behaviour of these materials upon thermal loading in terms of the evolution of metastable phases, microstructure and mechanical properties. Recently, in-situ micro-cantilever bending tests have been established for the mechanical testing of magnetron sputtered coatings. In the case of arc-evaporation, a possible influence of macro-defects on the mechanical properties of the coatings is of demanding scientific interest. In this contribution, a multi-layered arc evaporated hard protective coating composed of equally thin hexagonal AlCrN and metastable cubic AlCrSiN sublayers, with a bilayer period of ~65 nm, was investigated using micromechanical bending tests in a scanning electron microscope (SEM) in the as-deposited state and after annealing at 1100°C. SEM on the cross sections of the coating before and after annealing showed a stable multi-layered architecture, whereas the bilayer period increased after annealing to ~73 nm, which is associated with the phase decomposition of the metastable constituents. Young's modulus E, fracture stress σ_F and fracture toughness K_{Ic}, were evaluated by bending of focused ion beam milled micro-cantilevers, both in as-deposited and annealed states. The measured properties indicated that elastic properties (E) change during annealing due to the phase transformation, whereas fracture properties (σ_F, K_{Ic}) are nearly unaffected. Furthermore, a set of micro-cantilevers including macrodefects was prepared and investigated, where a reduction of elastic and fracture properties of ~40% was revealed. In summary, the micro-cantilever bending method, already known for the testing of magnetron sputtered coatings, was, for the first time, successfully applied for testing of arc-evaporated protective coatings, providing information on the influence of macrodefects on the coating's mechanical properties.

Keywords
AlCrN
micromechanical testing
droplet influence