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Influence of multilayer arrangement on structure and mechanical properties of arc evaporated oxide, nitride, and oxide/nitride coatings within the systems Al-Cr-N and Al-Cr-O

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Aluminium-chromium-based oxides and nitrides, for instance, are typically applied to cutting and forming tools, or milling devices, owing to their outstanding thermo-mechanical properties, wear and oxidation resistance, representing crucial capabilities for such forming and machining tools. In this regard, we have studied the architectural design and resulting mechanical properties of Al-Cr-based oxide, nitride, and oxide/nitride coatings. Therefore, $Al_xCr_{1-x}N$ and $(Al_xCr_{1-x})_2O_3$ multilayers as well as mixtures thereof were synthesised by reactive arc evaporation using powder metallurgically prepared $Al_{0.7}Cr_{0.3}$ targets. By careful adjustment of deposition time and reactive gas configuration, the individual $(Al_xCr_{1-x})_2O_3$, $Al_xCr_{1-x}N$, and multilayers could be designed with different bilayer periods and interfaces. Scanning electron microscopy (SEM) analyses revealed the influence of the deposition time per layer to the architectural structure and surface topology. By reducing the time per layer during the deposition (thus increasing the total number of layers), the $(Al_xCr_{1-x})_2O_3$ and Al_xCr_{1-x} N layers have different thicknesses, resulting in a decreased bilayer period, decreasing roughness and an increasing hardness. According to TEM and XRD results the Al-Cr-based multi-layered coatings indicate a single phase face centred cubic (fcc) structure with a preferred (200) and (220) orientation. With decreasing layer thickness, we observe a slight shift of the diffraction peaks to higher 2□ angles, which suggests reduced compressive stress formation. Evaluation of the full width at half maximum, based on the B1-like cubic (200) XRD peak, reveals a lower grain size for coatings with lower deposition time per layer. Based on our results we can conclude that arc evaporation and the knowledge-based reactive gas flow control and arrangement leads to $Al_xCr_{1-x}N/(Al_xCr_{1-x})_2O_3$ multilayers with excellent hardnesses and moderate surface rouhgnesses, when the bilayer period is optimized.

Keywords
AlxCr1-xN/(AlxCr1-x)2O3 multilayers