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On the phase evolution of Al-Cr intermetallics formed by cathodic arc evaporation

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The controlled low-temperature growth of Al-Cr-based oxide coatings for industrially-scaled protective applications still represents a major scientific and technological challenge. The growth of a crystalline structure and the associated morphology–required to access their outstanding mechanical and thermal properties–are key factors in coating design. Both are strongly influenced by nucleation and atomistic progresses during film growth. In recent studies we could show that in $(Al,Cr)_2O_3$ and $(Al,Cr,Fe)_2O_3$ coatings, nucleation on the surface of droplets influences the phase formation and supports or counteracts the growth of the hexagonal corundum structure. However, the preconditions for these mechanisms, and therefore a potential utilisation of growing single-phased hexagonal coatings, are still not fully understood. In this work we focus on the microstructural evolution of cathodic arc evaporated intermetallic Al-Cr(-Fe) phases into oxides. Thereby, the phase formation in reactive processes with varying oxygen content is compared with post-deposition oxidation of non-reactively processed coatings as well as small pancake-shaped macroparticles ejected from the cathode surface and subsequently separated from the plasma stream. Initially, the formation of intermetallic phases very well corresponds with the binary phase diagram of Al-Cr. The addition of oxygen to the deposition progress results in distinct modifications in microstructure. In order to grow crystalline stoichiometric oxides, a certain threshold value of the reactive gas is required. Albeit the incorporation of Fe (model system based on $Al_{0.7}Cr_{0.3}$) does not significantly improve the oxide formation at low oxygen partial pressure, its incorporation within the prevailing intermetallic phase Al_8Cr_5 results in distinctively different oxide scale formation during post-deposition annealing studies.

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