Combination of CVD coatings and halogen effect to prevent high-temperature embrittlement in titanium aluminides

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With increasing ecological and economical requirements intermetallic TiAl-based alloys represent an important class of high temperature structural materials providing a unique set of physical and mechanical properties that can lead to substantial payoffs in industrial applications, e.g. for turbine blades or turbolader wheels. With less than half the weight of nickel-base alloys, which are currently in use in combination with excellent high temperature properties, TiAl-based alloys have the ability to reduce the engine weight and to improve efficiency. Because of their insufficient oxidation resistance and embrittlement at higher temperatures (> 700°C) the surface of titanium aluminide alloys has to be modified in order to effectively replace the heavier nickel-base alloys.

A combination of Al enrichment plus additional fluorine treatment is used to protect the alloy against rapid inward diffusion of oxygen at high temperatures which leads to structural damage of the material. Indeed, Al-rich coatings plus fluorine are expected to promote the formation of a protective alumina layer at high temperatures which not only protects the alloy from oxidation, but also impedes embrittlement at high temperatures.

To achieve this aim advanced coatings are produced either by pack cementation or by metal-organic chemical vapor deposition (MOCVD) and additionally fluorine is deposited by spraying with a fluorine polymer. It turns out that Al pack powder mixtures produce a multi-layered coating with the brittle $TiAl_3$ and $TiAl_2$ and an inner zone of TiAl. Whereas Cr-Al pack powder mixtures of reduced chemical Al activity form thinner Al-rich coatings. Here, thin bi-layered coatings of $TiAl_2$ and TiAl are formed. Surface modification via MOCVD produces a very thin coating consisting of Al, O and C. The coating effect on the oxidation behavior of the titanium aluminide alloys is examined under isothermal and thermocyclic conditions (800-1000°C) in air and the mechanical properties of coated and uncoated samples after atmospheric exposure are compared using 4-point bend tests to investigate the room temperature strength and ductility.