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Combination of a chemical vapor deposition coating and plasma immersion ion implantation of fluorine for oxidation protection and suppression of oxygen embrittlement in titanium aluminide alloys

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The ongoing gradual replacement of heavy nickel-based superalloys with lightweight titanium aluminide (TiAl) intermetallic alloys is a long-term development objective in demanding applications such as the manufacture of aerospace and automotive engine components. TiAl alloys, however, are prone to destructive oxidation and oxygen embrittlement when exposed to oxidizing gases at temperatures above 700°C. Therefore, the successful use of this class of advanced structural materials in components operating under conditions of environmental oxidation at elevated temperatures will ultimately depend on their oxidation resistance. We have developed a method of oxidation protection of TiAl alloys, which solves satisfactorily the above-mentioned problems. The method involves two steps, namely formation of an aluminum-rich coating by chemical vapor deposition (CVD) followed by plasma immersion ion implantation (PIII) of fluorine to provide conditions necessary for activating the so-called halogen effect. The aim of combining a CVD coating and a fluorine PIII treatment is to prevent oxygen diffusion and dissolution into the Ti-rich α_2-phase substrate material, which is an integral part of most of the technical alloys being used at present. Preliminary mechanical testing performed on an unprotected reference alloy of a composition of Ti-48Al-2Cr-2Nb has shown drastic degradation in its mechanical properties after exposure in hot air at 900°C for 100 h, namely 23% loss in strength and 38% reduction in ductility. In contrast, the application of a CVD coating in conjunction with surface fluorination by PIII has been shown to enhance the environmental durability of the TiAl alloy after long-term oxidation at 900°C in that the alloy is capable of maintaining up to 90% of its initial mechanical properties (strength and ductility). We present here experimental results detailing both the CVD and the PIII processing steps.

Keywords
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