Plasma immersion ion implantation of oxygen and nitrogen as a tool for studying the environmental embrittlement in TiAl alloys at elevated temperatures

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Abstract

Titanium aluminide alloys have received much attention in the last decades because of their suitability for intermediate-temperature range (600∘-750∘C) aerospace and power generation applications. These alloys have mechanical properties that are comparable with those of conventional nickel-base superalloys, but at half of their density. However, for engine applications requiring adequate thermal durability at higher (> 750∘C) temperatures, TiAl alloys exhibit insufficient oxidation resistance and suffer from environmental embrittlement associated with the growth of an intermixed TiO2/Al2O3oxide scale rather than the desired continuous Al2O3 scale. The former does not provide a stable barrier against hot gases, and has poor resistance to thermal shocks, which in turn results in spallation. As a consequence, the mechanical properties (fracture and toughness) as well as the ductility of the TiAl alloys are severely degraded. The embrittlement mechanism of TiAl is presently not well understood. In this work, plasma immersion ion implantation of oxygen and nitrogen into the TiAl alloy sub-surface (_˜ 100 nm) has been employed to reproduce and study the conditions that cause environmental embrittlement, with the aim of elucidating the respective mechanism. The GE alloy (Ti-48Al-2Cr-2Nb) has been used for tensile testing as it possesses relatively high ductility at room temperature (ϵR _˜ 1.5 %). It has been found that the mechanical properties of the alloy deteriorate with increasing oxygen/nitrogen implant dose. Furthermore, the implanted oxygen and nitrogen have been shown to follow practically the same behavior leading to localized embrittlement and formation of an embrittled surface layer in which cracks nucleate and then propagate into the bulk. On the basis of the results obtained, it has been established that the embrittlement is largely a surface effect occurring above a critical concentration of oxygen/nitrogen.

Keywords: titanium aluminides, oxygen embrittlement, plasma immersion ion implantation

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