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Development of PGMs-modified TiAl-based alloys and their properties: Development of PGMs-modified TiAl-based alloy coatings via mechanical alloying and thermal spray

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ABSTRACT

Titanium aluminides Ti_3Al (α_2), γ-TiAl and $TiAl_3$ have received much attention for potential applications where light weight for energy saving, room temperature corrosion resistance in aqueous solutions, high-temperature oxidation resistance, or where combinations of the above are needed.

Gamma-TiAl of composition Ti-47.5 at.% Al with additions of platinum group metals (PGMs: Pt, Pd, Ru and Ir) was investigated for microstructure, hardness, room temperature aqueous corrosion, high-temperature oxidation resistance, mechanical alloying and consolidation by spark plasma sintering, and coating on titanium Grade 2 and Ti-6Al-4V substrates. Gamma-TiAl of Ti-47.5 at.% Al produced by melting and casting gave a microstructure consisting of γ grains and lamellar grains with alternating of α_2 and γ phase lamellae. Additions of 0.2, 1.0, 1.5, and 2.0 at.% PGMs introduced new phases of high PGM contents. The γ and lamellar phases were still present.

The additions of PGMs significantly improved the aqueous corrosion properties at room temperature, by improving the pitting corrosion resistance of the γ-TiAl alloy by modifying its hydrogen evolution of the cathodic reaction. The presence of PGMs also influenced the oxidation behaviour of γ-TiAl at 950°by forming the Z-phase which stabilized a continuous protective Al_2O_3 phase. However, Ti-47.5 at.% Al, being a two-phase alloy ($\alpha_2+\gamma$), PGMs could not sustain a stable Z-phase, as it transformed into an oxygen supersaturated Ti_3Al, which subsequently led to the formation of $TiO_2+Al_2O_3$, a non-protective oxide mixture. The optimal PGM addition to γ-TiAl was 0.5 at.%, with iridium giving the best room temperature corrosion and high-temperature oxidation resistance.

Mechanical alloying of Ti and Al pure powders with PGM additions gave powders where α_2 and γ were only identified after heat treatment. Consolidation of the mechanically alloyed powders by spark plasma sintering gave different microstructures from the cast alloys, with continuous α_2 and γ phases and evenly distributed nanometer-sized alumina, and much higher hardnesses.

Cold spraying the mechanically alloyed powders on to titanium Grade 2 and Ti-6Al-4V substrates gave coatings of irregular thickness, dense near the substrates with porosity at the top, giving poor oxidation protection.