

Engineering γ -TiAl alloys: The effects of Sn, Si and Mn on densification, microstructure, and mechanical properties

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Abstract

In the quest to enhance the castability of modified second-generation γ -TiAl intermetallic alloys and improve their mechanical properties, the effects of small additions of Sn, Si, and Mn were investigated and compared in terms of densification, microstructural evolution, and corresponding mechanical properties. The alloys were produced by vacuum arc remelting of blended and cold-pressed precursor powders. The processing parameters were uniformly maintained for all the alloys. According to the results, the relative green density of quaternary-Si (Ti-48Al-2Nb-0.7Cr-0.3Si) compact was the highest with a value of 90.00 ± 0.07 %. The addition of 1 at.%Sn improved the castability of the alloy as indicated by the absence of shrinkage cavities and the highest relative density of 99.87 ± 0.06 %. However, after heat treatment, low values of room temperature yield strength (286 ± 23 MPa) and ultimate tensile strength (486 ± 48 MPa) were obtained as the Sn promoted the growth of γ grains and hindered the nucleation of α_2 and Ti₅Si₃ phases. Conversely, additions of 0.3 at.%Si and 0.3 at.%Mn did not improve the castability of the alloys. However, Si promoted the nucleation of Ti₅Si₃ precipitates which improved the yield strength to 494 ± 31 MPa and uniform elongation to 1.4 ± 0.1 % after heat treatment. Additionally, the quaternary-Si alloy exhibited improved fatigue properties at room temperature with a fatigue limit of 388 MPa. Its fatigue fracture modes were Inter-lamellar and cleavage at lower stress amplitudes, σ fracture mode dominated at higher σ . Mn promoted the nucleation of α_2 , while inter-lamellar-phase to give a moderate value of 426 ± 19 MPa yield strength after heat treatment.