MICROMECHANICS OF FULLY LAMELLAR TiAl ALLOYS

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Fully lamellar gamma titanium aluminides are very promising materials for aerospace applications, due to their increased thrust-to-weight ratios and improved efficiency under aggressive environments at temperatures up to 750 ºC. For that reason, they are projected to replace the heavier Ni- base superalloys currently used for low pressure turbine (LPT) blades manufacturing. However, their ductility is limited due to their inherent anisotropy, associated to the lamellar microstructure. The objective of this work was to study the mechanical response of single colonies of polycrystalline γ-TiAl, as a function of layer thickness and layer orientation, and to relate this mechanical response with the operative deformation mechanisms.

With this aim, micropillars with lamellae oriented at 0º, 45º and 90º with respect to the loading direction were compressed at room temperature and elevated temperature. The results revealed a large plastic anisotropy, that was rationalized, based on slip/twin trace analysis, according to the relative orientation of the main operative deformation modes with respect to the lamellar interfaces. Loading at 45º resulted in the activation of soft longitudinal deformation modes, where both the slip plane and the slip direction were parallel to the interfaces, and therefore, little interaction of dislocations with lamellar interfaces is expected. At 0º loading, deformation was mainly accommodated by harder mixed deformation modes (with an oblique slip plane but a slip direction parallel to the lamellar interfaces), although the lamellar interfaces seemed to be relatively transparent to slip transfer. On the contrary, 90º loading represented the hardest direction and deformation was accommodated by the activation of transverse deformation modes, confined to individual lamellae, together with longitudinal modes that were activated due to their softer nature, despite their very small Schmid factors. Finally, a thorough study of pillar size effects revealed that the results were insensitive to pillar size for dimensions above 5 mm. The results can therefore be successfully applied for developing mesoscale plasticity models that capture the micromechanics of fully lamellar TiAl microstructures at larger length scales

Additionally, microtensile specimens were also milled out of single colonies and in-situ tested in the SEM, to study the role of interlamellar interfaces on the plastic deformation and fracture under tension. EBSD was used before and after the test to study the role of different type of interfaces (true twin, pseudo twin and order variant) on slip/twin transfer.

This study emphasizes the complexity of the micromechanics of fully lamellar TiAl alloys, where the activation of different deformation modes is strongly affected, not only by the lamellar orientation, but also by the character of the interfaces between the different lamellae.

References
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