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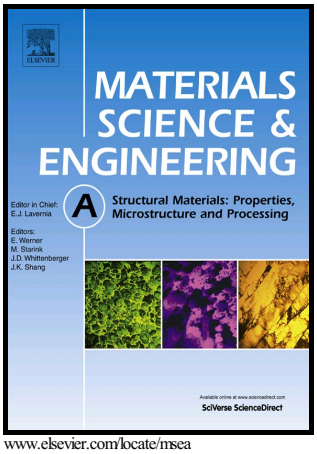

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Cyclic Deformation and Microcrack Initiation During Stress Controlled High Cycle Fatigue of a Titanium Alloy

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Abstract:

Cyclic plastic deformation, slip characteristics and crack nucleation in Ti-6Al-2Sn-2Zr-3Mo-1Cr-2Nb-0.1Si (TC21) with different morphologies of equiaxed and lamellar α phase were systematically analyzed during high-cycle fatigue. The heterogeneous plastic deformation could take place within different α morphologies during high-cycle fatigue even though the cyclic stress amplitude is much less than yield strength. Slip is the dominant deformation mode in the equiaxed primary α, while the slip and $(10\bar{1}1)$ deformation twin are prevalent in the primary α lath. Interactions between slip, twin and interface result in ledges at the primary α lath interface. The relationship between cyclic slip irreversibility, accumulated irreversible strain, and fatigue life is established. A critical parameter, accumulated irreversible strain per area in the crack initiation region (region Ⅰ), was calculated to be $(8.1\pm2)\times10^{-4}\cdot\mu m^{-2}$ for initiating fatigue crack. Fatigue cracks will nucleate when the accumulated irreversible strain exceeds the critical value. The primary α lath is the dominant site for crack initiation. The cracks initiate and propagate in interface and slip band, and easily connect each other in the primary α lath. In comparison, most cracks lie within an individual or occupy several equiaxed α phases and often cease in front of the phase boundary, which delays the connection of microcracks. It indicates that the primary α lath is more detrimental than the equiaxed primary α phase during high cycle fatigue.

Keywords: Titanium alloy; High–cycle fatigue; Slip irreversibility; Fatigue crack initiation