Improvement of high temperature performance of titanium matrix composites by constructing hierarchical microstructure

Lujun Huang*, Lin Geng
Harbin Institute of Technology, Harbin, China

Abstract:

The improvement of mechanical properties must be achieved by designing and constructing more suitable microstructure, such as hierarchical microstructure and nano microstructure. In order to significantly enhance the creep resistance of titanium alloys, one two-level hierarchical microstructure with micro-TiB whiskers (TiBw) and nano Ti5Si3 reinforcements were constructed to form the modified composites by powder metallurgy combining with in-situ synthesis and precipitation. The micro TiBw reinfrocement were in-situ synthesized around titanium matrix particles, which formed the first scale network microstructure. The nano Ti5Si3 particle were precipitated and distributed in the beta phase around alpha phase which formed the second network microstructure. The results showed that the high temperature strength has been significantly enhanced. The tensile strength at 550oC for Ti6Al4V matrix composites is increased to 1050MPa. Moreover, the creep rate of the modified Ti6Al4V matrix composites was remarkably reduced by an order of magnitude compared with the conventional Ti6Al4V alloys at 550 oC, 600 oC, 650 oC under the stresses between 100 MPa and 350 MPa. Moreover, the rupture time of the composites increased by 20 times, compared with Ti6Al4V alloys at 550 oC/300 MPa. The superior creep resistance can be attributed to the two-level hierarchical microstructures and the two-scale reinforcements. The micro-TiBw reinforcement in the first network boundary contributed to creep resistance primarily by blocking grain boundary sliding, while the nano-Ti5Si3 particles in the second network boundary mainly by hindering phase boundary sliding. In addition, the nano-Ti5Si3 particles were dissolved to smaller-sized Ti5Si3 particles during creep deformation due to high temperature and external stress, which can further continually enhance the creep resistance. Finally, the creep rate during steady-state stage was unprecedentedly decreased, not stable or increased, which manifested superior creep resistance of the composites. The calculated results indicated that the dislocation climb is the dominant mechanism for the composites tested at 550 oC/(250-350) MPa and 650 o
C/(100-250) MPa.