Temperature dependence of slip deformation under monotonic/cyclic stresses in Ti-6Al-4V

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論 文 名　：Temperature dependence of slip deformation under monotonic/cyclic stresses in Ti-6Al-4V
（Ti-6Al-4V における単一および繰返し応力下での辷り変形挙動とその温度依存性に関する研究）

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論　文　内　容　の　要　旨

In this paper, the mechanism behind the temperature dependence of effective stress and fatigue crack growth was elucidated in Ti-6Al-4V. It was elucidated that the change in the trend seen in the temperature dependence of effective stress is due to the change in the activated slip systems. Taking into account the deformation process in monotonic deformation, temperature dependence of fatigue crack growth was also investigated. It was elucidated there is no temperature dependence of fatigue crack growth rate in case stress ratio (R) is equal or less than 0.8 while it depends on temperature in case of R = 0.9. The mechanism behind the temperature dependence was discussed in the viewpoint of effective stress intensity factor range. This paper was consisted with five chapters, the abstracts of each chapter are as follows.

In Chapter 1, the temperature dependence on the mechanical properties are reviewed for α alloys, β alloys and α + β alloys. Although the mechanism behind the temperature dependence of α alloys have been well studied, the mechanism in commercial alloys such as Ti-6Al-4V which consists of both α and β phases have not been well discussed yet because of the complexity of its microstructure. It was stressed that it is important to understand the mechanisms behind thermally activated processes which involved in the deformation of Ti-6Al-4V to enhance the utilization of titanium alloys.

In Chapter 2, the temperature dependence of fundamental mechanical properties in bimodal Ti-6Al-4V was obtained, concluding several points. Temperature dependences of yield stress and effective stress change in their trends at approximately at between 225 K and 300 K. The trend of the temperature dependence of effective stress suggests the controlling mechanisms behind yielding changes at the temperature range. Activation volume increases with temperature except for the temperature range between 225 K and 300 K. The temperature dependence of the activation enthalpy obtained in this study suggests that both basal and prismatic slips are dominant at yielding. The detail of the thermally activated process was investigated in the next chapter.

In Chapter 3, in order to assess the activated slip systems which associated with the change in the trend of effective stress, the temperature dependence of activated slip systems was investigated. The trace analysis and Schmid factor distributions indicated that basal and prismatic slips were identically dominant at 77K, and 225 K while pyramidal slips were dominant at 550 K. The onset of the pyramidal slips should lead to the change in the trend of the temperature dependence of effective stress at approximately 325 K, *that is*, the change in the dominant active slip systems with temperature can explain the change in the trend of temperature dependence of the effective stress at approximately 325 K.

In Chapter 4, the study on deformation mechanisms under monotonic loads also intensives to extend the work on to determine deformation mechanisms under cyclic loads. The major intention is to interpret the evolution of temperature dependence of fatigue crack propagation with the change in the stress ratio. Effects of stress ratio on temperature dependence of fatigue crack propagations was investigated. Fatigue crack growth rates were nearly independent from temperature in cases of R = 0.1, 0.7, and 0.8 while it is dependent on temperature in case of R = 0.9. It can be explained by the assumptions that the fatigue crack growth is controlled by the dislocation activities with respect to work-hardening in the conditions of $R \leq 0.8$ while it is controlled by dislocation glide in the condition of R = 0.9. The change in the temperature dependence of the fatigue crack growth rate also suggests the change in the distance between a dislocation source and a crack tip.

In Chapter 5, all results obtained in this study is summarized. It was concluded that the controlling mechanisms behind temperature dependence of yield stress and fatigue crack growth rate with $R \leq 0.8$ are not the same. However, the fatigue crack growth rate with R = 0.9 is expected to be controlled by dislocation glide.