論 文 内 容 の 要 旨

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Commercial x-ray targets for computed tomography (CT) applications consist of two major components, a metal disc made of the titanium-zirconium-molybdenum (TZM) alloy, and a surface layer in the bombarding region made of the tungsten-rhenium (W-Re) alloy. The target must endure extremely high temperature, associated with high thermal stress, and mechanical stress due to the centrifugal force induced by high speed rotation of the target. Therefore, studies on high temperature fracture and fatigue behavior of these materials would be the most important for reliability assessment and safety design of the x-ray target. However, they have been rarely reported and high temperature fracture and fatigue behavior of these materials has been not always clarified. In the present study, high temperature fracture toughness was evaluated for two kind of TZM alloys, one with higher C content and the other with higher O content. Moreover, effect of forging rate on high temperature fracture toughness was discussed. Fatigue properties at room temperature and 1000 °C were evaluated for three kinds of materials, layered W-Re/TZM, bulk W-Re and bulk TZM, and a fatigue failure definition in the high temperature fatigue test was investigated to evaluate high temperature fatigue strength. The fatigue processes of these x-ray target materials at high temperature were also investigated.

Chapter 1: Introduction – The background of x-ray tube application and basic knowledge of refractory metals properties have been introduced. The current status of researches on high temperature fracture toughness and fatigue behavior of tungsten and molybdenum alloys has been reviewed. The scope and objective of the present study have been also addressed.

Chapter 2: High Temperature Fracture Toughness of TZM Alloys – High temperature fracture toughness of two TZM alloys with different kinds of grain boundary particles was successfully evaluated using the convenient J_{IC} test method. The result indicated that the J_{IC} values at temperatures ranged from 800 °C to 1000 °C were almost constant regardless of temperature, while the J_{IC} values of the TZM with higher C content were higher than those of the TZM with higher O content. The TZM with different forging rates showed similar J_{IC} values, which suggested the effect of forging rate would be not significant at high temperatures.

Chapter 3: High Temperature Fatigue Characteristics of W-Re and TZM Alloys – High temperature fatigue characteristics of W-Re and TZM were successfully evaluated under load-controlled four point bending test at 1000 °C by introducing a fatigue failure criterion as two-times increase of initial compliance, which was corresponding to nucleation and propagation of multiple cracks from specimen surface. The layered W-Re/TZM specimen exhibited the similar fatigue strength to the bulk W-Re specimen. The bulk TZM showed much lower fatigue strength compared to the layered W-Re/TZM and the bulk W-Re. The total crack length measured on the specimen surface at 1000 °C would be a dominant indicator for evaluating progress of fatigue damage.

Chapter 4: Conclusions – The conclusions obtained in the current work have been summarized. Also the problems remained and future work have been addressed.