【Grant-in-Aid for Scientific Research(S)】
Science and Engineering (Engineering I)

Title of Project：Fatigue Damage and Fracture at Nano-Interface

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Research Area：Mechanical engineering, Machine material/material mechanics

Keyword：Nano-interface, Fatigue, Damage, Fracture, Dislocation, Interface edge, Crack

【Purpose and Background of the Research】

Under fatigue of metal macro-components, the characteristic dislocation structure, where the size of pattern element is about 1 micrometer, is formed and this brings about the crack initiation on the surface. However, the nano-components investigated in this project do not have the space where the structure develops. On the other hand, we recently find the crack propagation along an interface of nano-films under a fatigue loading. These indicate that there exists a damaging mechanism in nano-components under fatigue, which is different from the one in the macro-components. Especially, the interfaces must be the preferential site of damage/ fracture because local stress concentration/ intensification often appears along them. However, there has been no direct evidence found on the mechanism since it is difficult to carry out the precise fatigue experiment and accurate observation on the nano-component.

The targets of this project are the development of experimental methodology of fatigue for the nano-interface, the precise observation of the damage/fracture process and the analysis on the mechanism and mechanics.

【Research Methods】

/ We develop the experimental equipments specialized for the fatigue testing of nano-components and the fabrication technique of multi-layered specimen.

/ Since the fatigue damage usually appear as a change in smoothness of local surface, we combine the fatigue machine with an advanced scanning electron microscope and observe the detail of damaging/cracking process near the interface where the stress concentrates. The dislocation structure, which brings about the smoothness change, is observed as well.

/ Advancing the fabrication method of specimen for controlling the stress field, we clarify the effect of stress intensity in the nano-scale on the fatigue damage/fracture.

/ Using multi-scale simulation techniques from the Finite Element Method to the Molecular Dynamics, we analyze the detailed mechanics of fatigue process.

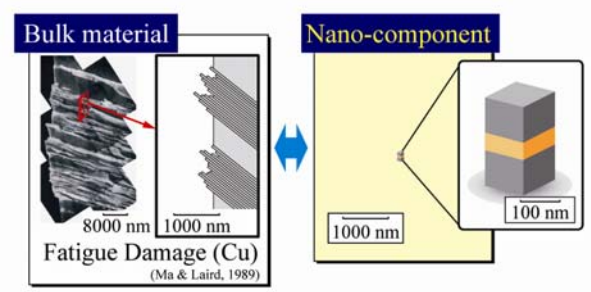

Fig.1 Comparison of sizes between the fatigue damage of a bulk material and a nano-component.

【Expected Research Achievements and Scientific Significance】

This project proves the existence of fatigue damage/fracture along a nano-interface, which has not been observed, and establishes the scientific foundation of nano-mechanics in fatigue. Moreover, the development of experimental methodology eminently contributes the future research works on the strength of nano-components.

Since the nano-devices have various applications expected in industry including the operation in a human body, high reliance is required in the service. As history of developing new machines has proved the importance of preventing the fatigue failure, the achievement of this project significantly contributes the advance of devices with high trust.

【Publications Relevant to the Project】

H. Hirakata, M. Kitazawa and T. Kitamura, Fatigue Crack Growth along Interface between Metal and Ceramics Submicron-thick Films in Inert Environment, Acta Materialia, Vol.54, 89-97 (2006)

H. Hirakata, Y. Takahashi, D.V. Truong and T. Kitamura, Role of Plasticity on Interface Crack Initiation from a Free Edge and Propagation in a Nano-Component, International Journal of Fracture, 145, 261-271 (2007)

【Term of Project】 FY2009-2013
【Budget Allocation】 167,800 Thousand Yen

【Homepage Address and Other Contact Information】

http:// cyber.kues.kyoto-u.ac.jp/