Interface Strength of Low-Dimensional Small Components

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【 Outline of survey 】

Nano-materials usually possess low-dimensional structure, and show exotic properties, which are eminently different from those in bulk materials. Combining the low-dimensional components, we can give various functions to the small devices. On the other hand, there is disorder of atomic structure on the interface between dissimilar materials, and the mismatch of deformation property often brings about complex fracture. Because the size of singular stress field shrinks as the dimension of component reduces, the applicability of the conventional fracture mechanics concept based on the continuum mechanics becomes questionable. In this project, we will develop the methodology of interface fracture experiments, and will conduct observation of the fracture process in detail. Then, we will analyze the failure by the molecular dynamics simulation as well as the continuum mechanics one. Synthesizing the experimental and analytical results, we will investigate the bounds of fracture mechanics (continuum mechanics). Moreover, we will discuss the mechanical fracture criterion of nan-components due to the structural instability on the basis of the atomic mechanics.

【 Expected results 】

(1) We develop the experimental equipment and experimental methodology of interface fracture of low-dimensional components such as thin film, thin wire and small dot. Especially, we focus on the compatibility with the detailed mechanical analysis.
(2) Synthesizing the experimental observation and the numerical analysis (continuum mechanics and atomic mechanics), we explore the fracture mechanism and investigate the bounds of conventional fracture mechanics.
(3) We develop a new fracture mechanics in the atomic level on the basis of the structural instability criterion for the interface fracture of atomic components.

【 References by the principal researcher 】

Hiroyuki Hirakata, Takayuki Kitamura and Yoshitake Yamamoto; Evaluation of Interface Strength of Micro-Dot on Substrate by means of AFM, International Journal of Solid and Structures, Vol. 41/11-12, pp.3243-3253 (2004)

Takayuki Kitamura, Yoshitaka Umeno and Nagatomo Tsuji; Analytical Evaluation of Unstable Deformation Criterion of Atomic Structure and Its Application to Nanostructure, Computational Materials Science, Vol. 29, No. 4, pp.499-510 (2004)

【 Term of project 】 FY 2004 — 2008

【 Budget allocation 】 84,500,000 yen

【 Homepage address 】 http://cyber.kues.kyoto-u.ac.jp/