【Grant-in-Aid for Specially Promoted Research】

Science and Engineering (Engineering)

Title of Project : Fracture mechanics in single digit nanometer scale

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Research Area : Engineering
Keyword : Fracture, Nano/Micro material mechanics, Material design/Process/Mechanical properties/Evaluation

【Purpose and Background of the Research】

Since recent dramatic advances in nanotechnology utilizing the intriguing functionalities of nano-components (e.g., semiconductor-, optical- and bio-devices) have drawn much attention, high reliability is one of the most important requirements. In such nano-components, the concentrated inhomogeneous deformation field, which brings about the fracture, must be extremely confined to single digit nanometer scale (1-10 nm).

For macro-scale components, the fracture mechanics and criteria have been well established. However, the applicability to the local "fracture" in the single digit nanometer scale is questionable. A new concept might be necessary for the fracture mechanics.

The primary importance of this project is to understand the fracture mechanics and mechanism in nano-components with the single digit nanometer scale deformation concentration.

The final goal of this project is to develop the methodology of fracture experiments, and to establish "Nanoscale Fracture Mechanics" for a local deformation field further confined to "1-10 nm" by the experimental observations and atomic-and-electronic-level simulations.

【Research Methods】

This project covers a variety of advances and challenging developments in experimental techniques, such as the handling and manipulation of nano-components and the detection and control of light load, etc. (Fig.1 : our proposed system) One of the most important issues in this project is the direct measurement of the displacement in the single digit nanometer scale. (Fig. 2: experimental techniques for directly observing the atomic positions and extraction of strain field near a dislocation). The measurement of single-digit nanometer-scale displacement (strain) field can be achieved by applying the applicant's techniques.

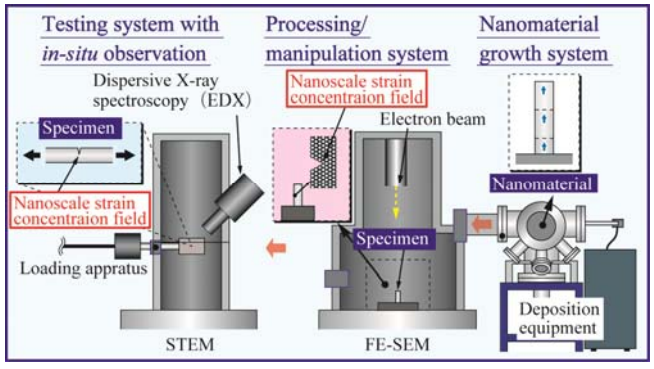

Fig. 1 *In-situ* observation system on single digit nanoscale deformation field.

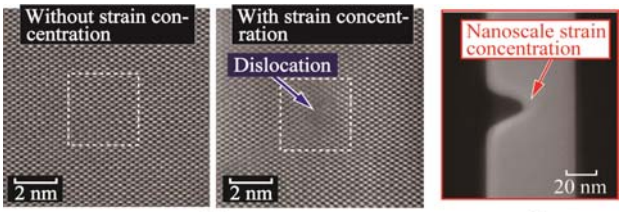

Fig. 2 (a) Strain concentration field around a dislocation (HAADF image), and (b) a nanomaterial with a notch.

【Expected Research Achievements and Scientific Significance】

The targets of this project is (1) to establish the experimental technique on the fracture testing in the single digit nanometer scale strain concentration, and, (2) to understand the mechanics of fracture phenomenon in the nanometer scale. These bring a new frontier in the "fracture mechanics" and contribute to the reliability of nano-components.

【Publications Relevant to the Project】

・T. Kitamura, H. Hirakata, T. Sumigawa, T. Shimada, "Fracture Nanomechanics" (ISBN: 978-9814241830), Pan Stanford Publishing Pte. Ltd., 297 pages (2011).
・T. Sumigawa and T. Kitamura, Chapter 20 "*In-Situ* Mechanical Testing of Nano-Component in TEM", "The Transmission Electron Microscope", Dr. Khan Maaz (Ed.) (ISBN 978-953-51-0450-6), Intech, pp.355-380 (2012).

【Term of Project】 FY2013-2017

【Budget Allocation】 457, 100 Thousand Yen

【Homepage Address and Other Contact Information】

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