

**Explanation of reaction layer fatigue in silicon microstructure  
for development of highly-reliable MEMS devices.**

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**【Outline of survey】**

We are investigating the fracture of micro and nano-scale materials especially the fatigue failure of microscale brittle materials under cyclic loading in order to provide the reliability evaluation method for microelectromechanical system (MEMS) devices, which is currently being employed in various applications in consumer, automobile, aerospace and medical systems.

In this project, we focus on single crystal and polycrystalline silicon, which is one of the most popular structural materials in MEMS. The fracture and its mechanisms of silicon are being investigated. Silicon is a brittle material and there are a lot of discussions of the existence of fatigue failure in it. However, the fracture and strength degradation have been observed in micro mechanical structure fabricated from silicon. The phenomena are sensitive to humidity of environment, which is related to the growth of native oxide layer and the existing oxide on the surface. In addition, the microfabrication technologies used for processing of structure affect the deviation in strength and fatigue life. We will clarify the life estimation method and the model of fatigue failure of silicon with the explanation of these phenomena.

**【Expected results】**

We expect our results will broaden the application area of MEMS devices which uses silicon as mechanical structures. With the explanation of failure mechanism and the life prediction method that we will provide, MEMS device will be applied in mobile application, such as notebook computers and personal data assistant, and in aerospace and automobile applications, which require highly reliable devices.

**【References】**

- Toshiyuki Tsuchiya, M. Hirata, N. Chiba, *et al.*, Cross comparison of thin film tensile-testing methods examined with single-crystal silicon, polysilicon, nickel, and titanium films, *Journal of Microelectromechanical Systems*, Vol. 14. No. 5, pp. 1178-1186 (2005).

**【 Term of project 】** FY2007 - 2011

**【 Budget allocation 】** 7,700,000 yen  
( 2007 direct cost )

**【Homepage address】**

<http://www.nms.me.kyoto-u.ac.jp>