Abstract Title

Dynamic measurement of propagation of nonlinear deformtion by high resolution optical interference techniques

Symposium Track

1. Fundamental Modeling in Nanomechanics

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Abstract body

In a micro-mechanical system like MEMS, depending on a scale-law, the ratio of surface area to volume is bigger compared to that in a large scale structure. Nonlinear and inhomogeneous deformation which causes unexpected degradation of the system is more rather important compared to large scale structures. In an experimental view point to investigate these phenomena and for diagnosis, it is indispensable to measure dynamic behavior of deformation continuously. Conventional contact method cannot be used. In this paper, we introduce two unique optical interference techniques which have very high resolution for deformation in the order of nanometer or sub-nanometer.

The first one is an optical interference technique in which moving interference patterns varying accompanied by the object deformation are treated in time domain based on a Hilbert transform phase analysis algorithm (1). The technique is divided into two methods: microscopic Michelson interferometer to investigate out-of-plane deformation and speckle interferometer to investigate in-plane deformation. These methods were applied to measure dynamic behavior of a micro Scratch Drive Actuator which is a kind of micro translation table driven by scratching force derived by electro-static force between micro-plates and a base plate. In the device, degradation of elements caused by cyclic contacts and deformation under contact state in a micrometer scale become serious problems. Propagation of inhomogeneous deformation of structural elements is analyzed continuously in the sensitivity of several ten nanometers.

For strain analysis in a small scale object, very high resolution to measure deformation is required. To respond to the requirement, we proposed a unique method named “Statistical interferometry”(2) in which statistical uniformity of a speckle phase in fully developed speckle field is used as a kind of standard of deformation measurement. Measurable sensitivity depends not on the accuracy of elements of the system but only on the data number for calculation. We applied the method to measure growing rate of a plant. Temporal variation of deformation between two points on a plant stem was measured. Growing rate to an accuracy of the order of nm/sec per unit mm could be measured. Very interesting fluctuation of the growing rate was found. This amazing dynamic behavior seems to be essential phenomena inherent in a living material. They will be presented precisely in the symposium by Dr. KADONO in Track 8.

Keywords

Nonlinear deformation, Microscopic observation, Michelson interferometer, Speckle interferometry, Statisticao interferometry, MEMS, Growth of plants

References

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