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Evaluation of Damage Development due to Static Compressive Stress in Piezoelectric Ceramics

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Summary

Piezoelectric ceramics have superior material properties such as quick response, high ability of energy conversion, large generation of force per volume, etc. By making use of those properties, piezoelectric ceramics are employed in sensors, actuators, etc. The resonant property is also applied to ultrasonic transducers. Since the resonance frequency depends on material properties as well as shape and dimension, variation of material properties causes change of the resonance frequency. Therefore the variation of material properties can be evaluated by the change of the resonance frequency reversely.

Material properties of piezoelectric ceramics, on the other hand, change due to domain switching and internal defects such as a cavity and micro-crack, whose development leads to the final fracture. Within the framework of the continuum damage mechanics, such internal damage is related to variation of material properties theoretically. Thus development of the internal damage can be evaluated by the variation of material properties such as an elastic coefficient indirectly.

In the present paper, cylindrical specimens of lead zirconate titanate (PZT) were subjected to static compressive stress and characteristics of the fracture under compression was clarified. The fracture test was interrupted with certain interval, and then resonance and anti-resonance frequencies and electrostatic capacity were measured by means of an impedance analyzer. The interruption and measurement were repeated with the stress increased up to the fracture. Material properties of the specimen were evaluated by the electrical properties, and variation of the material properties in the process of the fracture were clarified experimentally.

Furthermore, internal damage developed in the specimen was evaluated by the variation of the elastic coefficient indirectly as a damage variable on the basis of the continuum damage mechanics. On the other hand, as direct evaluation of the internal damage, length of micro-cracks and area fraction of cavities on the fracture surface were measured through SEM micrographs. Variation of density of the specimen was also measured by the Archimedes method, then damage variables based on the length of micro-cracks and the variation of the density were also estimated.

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