Size Effects on the Ferroelectric Properties in Ultrafine Particles and Improvement of the Hysteresis of Piezoelectric PZT Actuators.

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This paper reports size effects on the phase transition property and on the domain structure property in ferroelectrics. Crystalline $PbTiO_3$ fine particles were synthesized by an alkoxide method. The average size of particles was determined from the full width at half maximum of their X-ray diffraction peak. The soft-mode behavior of fine particles was investigated by Raman scattering measurements as the functions of temperature and pressure. The transition temperature of particles larger than 50 nm coincides with that of the bulk crystal. For the particles below 30 nm in size, however, the transition temperature deceases from the value of bulk crystal as the particle size decreases. There is no significant change in the transition pressure between fine particles with 20 nm and the bulk crystal.

The investigation of the size effect on the domain structure was carried out using an actuator with fine-grained ceramics. The fine-grained actuator was made of lead zirconate titanate (PZT) powders obtained by the alkoxide method followed by a hot isostatically press (HIP) or a hot-press method at the low temperature as low as 800°C. Measurements of the hysteresis in the piezoelectric strain show that the fine-grained actuator has lower hysteresis characteristics than those of the actuator of same composition prepared by a conventional mixed oxide method and a conventional sintering technique. The transmission electron microscope (TEM) observations suggest that the improved hysleresis characteristics seem to be related to the pinning effect against the domain wall movement by the traces formed by the alkoxide prepared starting powders in the component grains.