Piezoelectric Enhancement of Thermally Annealed Barium Titanate Ceramics

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Barium titanate (BT) is the first practically used piezoelectric ceramics and is still extensively used in multilayer ceramic capacitors (MLCCs). Recently BT has become one of the important components for bismuth-based piezoelectric systems, suggesting that the BT is a key material for lead-free piezoelectrics[1)]. We focus on the classical piezoelectric material, BT, and try to improve its piezoelectric property by optimizing preparation techniques. Cao *et al.* have pointed out a necessity to suppress thermal and mechanical stresses during sample preparation and processing[2)]. In this study, we investigated an influence of thermal annealing on electrical properties of BT ceramics. BT ceramics were prepared from the hydrothermally-derived BT nanoparticles with the particle size of 100 nm and 300 nm (BT01 and BT03, Sakai Chemical Industry) by a two-step sintering method with a modification on a scheme proposed by Karaki *et al.*[3)] and conventional one step sintering. The sintered BT ceramics were polished and cut into plate and bar-type samples, and then thermal annealing was carried out in air at different temperatures, 800–1200 ºC for 4 hours. The crystal structures and microstructures of these ceramics were investigated by X-ray diffractometer and scanning electron microscopy, respectively. Besides, the dielectric, ferroelectric, and piezoelectric properties were investigated for each sample.

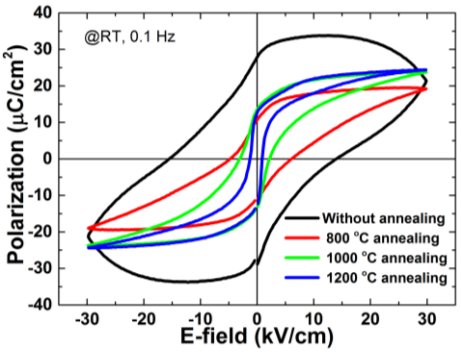

Figure 1. *P-E* hysteresis loops for BT ceramics

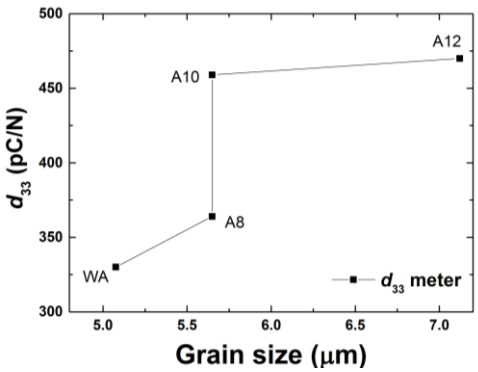

Figure 2. The d_{33} values of BT ceramics

Figure 1 compares the *P-E* hysteresis loops of BT ceramics before and after thermal annealing, while Figure 2 shows the variation of the piezoelectric constant (d_{33}) with their average grain size for the ceramics prepared from BT01. The abbreviated terms WA represents samples before annealing, whereas A8, A10, and A12 in the plot respectively represent samples annealed at 800 ºC, 1000 ºC, and 1200 ºC in air for 4 hours. The significant increase in the d_{33} value is observed after annealing at temperature over 1000 ºC. The annealing temperature significantly affects the d_{33} values of BT ceramics.

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3) T. Karaki, K. Yan, T. Miyamoto, and M. Adachi: *Jpn. J. Appl. Phys*. 46, L97-L98 (2007).