Piezoelectric Enhancement of Bismuth-based Piezoelectric Materials with Pseudo-cubic Symmetry based on Nano/Macro Complex Domain Configurations

S. Wada[1, *], R. Ariizumi[1], T. Aizawa[1], Sarah Najwa[1], S. Ueno[1] N. Kumada[1] C. Moriyoshi[2] and Y. Kuroiwa[2]
[1]Material Science and Technology, University of Yamanashi
4-4-37 Takeda, Kofu, Yamanashi 400-8510, Japan
[2]Department of Physical Science, Hiroshima University
1-3-1 Kagamiyama, Higashi-Hiroshima, Hiroshima 739-8526, Japan
*Satoshi Wada: swada@yamanashi.ac.jp

It is well known that for the relaxor-based ferroelectrics, the domain configuration is dependent on chemical composition and orientation. This means that if relaxor-based lead-free ferroelectrics are prepared, it can be expected that they might have high piezoelectric performances. Recently, we reported that BT-$Bi(Zn_{1/2}Ti_{1/2})O_3$ (BT-BZT) and BT-$Bi(Mg_{1/2}Ti_{1/2})O_3$ (BT-BMT) were relaxor ferroelectrics with high T_{max} (temperature with maximum dielectric constant) over 250 ˚C. Thus, it is possible to control domain configurations by solid solution system between the above relaxors and normal ferroelectric such as $BiFeO_3$ (BF) with high T_c of 830 ˚C. In this study, the BT-BMT-BF and BT-BZT-BF system ceramics were prepared using a conventional solid–state reaction and their crystal structure and electrical properties were investigated. A single phase of perovskite was prepared for these ceramics with various compositions except for a few. TEM observation revealed that BT-BMT had no domain configuration while BF-rich ceramics had normal rhombohedral domain configurations. Moreover, the ceramic with the intermediate composition between relaxor and BF had nanodomain configuration with domain sizes less than 50 nm. For the ceramics, the temperature dependences of dielectric constants were measured at various frequencies, and the T_{max} was determined. As the results, the T_{max} increased with increasing BF content, while T_{max} decreased with increasing BT content. Finally, their strain vs. electric-field behaviors were measured, and the relaxors showed typical electrostrictive behavior while BF-rich ceramics showed typical butterfly-like ferroelectric strain behavior. For the ceramics with nanodomain configuration, the strain curve with hysteresis was clearly observed and the apparent d_{33}^* ($=S_{max}/E_{max}$) from the slope was over 850 pC/N.