Dependence of ferroelectric performance and crystal structure on composition and heat treatment of (Bi,M)4(Ti,Si)3O12(M=La,Nd) ferroelectric oxide

Yasushi Idemoto, and Eiji Iso
Tokyo University of Science

1. Bi rich (Bi,La)-Ti-Si-O Ferroelectric Material

The La-substituted (Bi4-xLax)Ti3O12 is an attractive lead-free material for ferroelectric random access memory (FeRAM) applications because of its relatively large remanent polarization and fatigue-free characteristics. The bulk materials of Bi3.25+xLa0.75Ti3O12(x=0, 0.15, 0.25) [BLT] and Bi4Si3O12 (BSO) at specific compositional ratio were prepared for ferroelectric materials and some of samples annealed under the vacuum or high oxygen partial pressure(Po2). We investigated the relationship between the physical properties, crystal structure and ferroelectric performance of the sample before and after various heat treatments and changing composition.

From the results, Pr increases with increasing BSO content, but Pr decreased with increasing Bi content. Moreover, Pr decreased and Ec increased by heat treatment in the most of samples. On the other hand, the dielectric constant (ε s) at Tc of BLT remarkably increased by adding BSO. From the crystal structure analysis, the bond length and the bond angles of Ti-O are changed. Consequently, the change of distortion in Ti-O6 octahedra will effect of the change of ferroelectric performance, such as Pr.

2. (Bi,Nd)-Ti-Si-O Ferroelectric Material

We synthesized the new ferroelectric bulk materials of Bi4Si3O12 (BSO) added Bi4-xNdxTi3O12(x=0.75,0.85,1.0,1.2). We investigated the dependence of ferroelectric performance and crystal structure on content and heat treatment for Bi4Si3O12 added Bi4-xNdxTi3O12.

From the results, the remanent polarization (Pr) of Bi4-xNdxTi3O12 (x=0.75, 0.85, 1.2) samples increased by adding BSO. On the other hand, Pr of Bi4-xNdxTi3O12(x=1.0) sample shows a maximum, but Pr decreased by adding BSO. Moreover, Pr decreased by heat treatment in the most of samples. The dielectric constant (ε s) at room temperature and Tc of BSO added Bi4-xNdxTi3O12 remarkably increased by adding BSO. Tc and ε s at Tc decreased and the dielectric loss (tan δ) at Tc remarkably decreased by heat treatment. From the results of neutron diffraction analysis, the bond length of Bi1(Nd)-O6 shows the maximum of BSO added Bi2.8Nd1.2Ti3O12, and it shows the minimum for BSO added Bi3NdTi3O12. The bond length of Bi1(Nd)-O6 increased with decreasing of Nd content, x, of BSO added Bi4-xNdxTi3O12(x<1.0). The total calculated spontaneous ferroelectric polarization(Ps) along a-axis shows a maximum at BSO added Bi3NdTi3O12. The similar tendency was obtained of no BSO addition sample. It was found that the Ps is related to the Pr. Moreover, the bond length of Bi1(Nd)-O6 changes by heat-treatment and it affects to Pr.