TOPICS

Perovskite-type Piezoelectric Ceramics with a Preferred Orientation

Electrical & Magnetic Materials Lab. Toshihiko Tani

A novel processing method has been developed for perovskite-type bulk ceramics with a preferred crystalline orientation. Uniaxually oriented bismuth potassium sodium titanate (BNKT) exhibited superior piezoelectric properties to randomly oriented polycrystals.

It has been known that the uniaxial grain orientation of layered perovskite-type materials enhanced the piezoelectric and pyroelectric properties [1, 2]. The processing methods exploited the highly anisotropic nature of the crystal structures. Most of the industrially important ferroelectric materials are, however, in the regular perovskite-type with pseudoisotropic lattice structures. Fabrication of textured perovskite-type materials is enabled by the use of a heteroepitaxial template and a reactive grain growth [3].

Plate-like bismuth titanate particles were mixed with reactants for a perovskite-type guest, $Bi_{0.5}(Na,K)_{0.5}TiO_3$. Slurries containing the mixed powders were cast in a tape, in which the host particles were uniaxially aligned. The guest, BNKT, was in-situ formed with epitaxy on/in the surface of the host upon heating. Subsequent heat treatment converted the host into the guest and promoted the growth of the oriented nuclei.

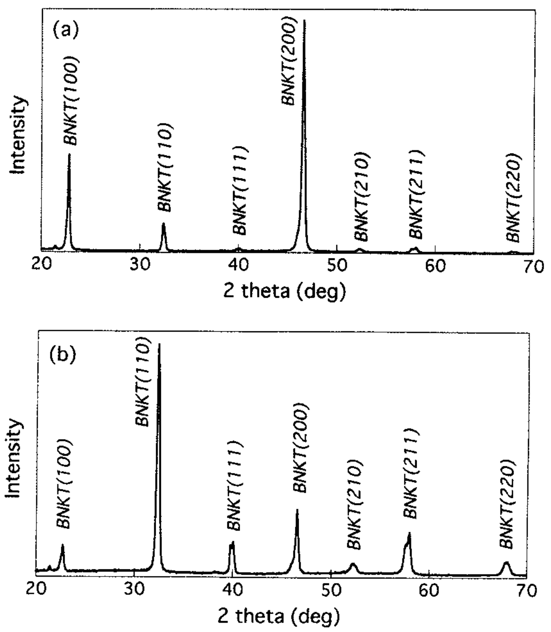

Fig. 1 XRD patterns for the polished and annealed surfaces of pressureless sintered specimens at 1150 ˚C for 10 hrs, processed through (a) RTGG, and (b) a conventional method.

Fig. 1 gives XRD patterns for the polished and annealed surfaces of BNKT ceramics prepared by the reactive templated grain growth (RTGG) and by a conventional powder processing. The diffraction intensity ratio of pseudocubic (200) to (110) is markedly high for the RTGG specimen when compared to the ratio for the randomly oriented polycrystals. The Lotgering factor (F), the relative XRD intensity ratio, reached as high as 0.9 for the annealed surfaces of the oriented ceramics.

Table 1 lists the dielectric and piezoelectric properties of the BNKT specimens with high F values as well as those of the reference specimen with the same composition. The BNKT ceramics with a preferred {100} orientation have lower dielectric losses than the randomly oriented ceramics whereas similar dielectric constants to the reference specimen. The texture displays remarkable effects on the piezoelectric properties: the highly textured ceramics exhibited electromechanical coupling Kp values higher by 40 %, and, piezoelectric d_{31} value higher by 60 %, for pressureless-sintered specimens, than the specimen prepared by the conventional method. The enhanced d_{31} and g_{31} values would make the BNKT-based system more attractive for lead-free sensor applications.

References

1) Igarashi, H., et al., : Ceram. Bull., **57**-9 (1978), 815
2) Takenaka, T. and Sakata, K. : Sensors and Materials, **1**(1988), 35
3) Tani, T. : J. Korean. Phys. Soc., in press.

Table 1 Dielectric and piezoelectric properties of BNKT ceramics.

Preparation method	Conventional /sintered	RTGG /sintered	RTGG /hot-pressed
Relative density (%)	99.2	97.0	98.6
Lotgering factor	0	0.92	0.90
$\varepsilon^T_{33}/\varepsilon_0$ (at 1 kHz)	593	595	644
tan δ (at 1 kHz)	0.025	0.014	0.013
Poisson's ratio	0.250	0.180	0.176
Kt	0.427	0.443	0.467
Kp	0.295	0.402	0.431
d_{31} (pC/N)	-36.7	-57.4	-63.1
g_{31} (10^{-3} Vm/N)	-7.2	-11.2	-11.4