Sensors and Materials, 3 (1988) 123–131
MYU, Tokyo

LETTERS

S & M 0014

New Piezo- and Pyroelectric Sensor Materials of $(BiNa)_{1/2}TiO_3$-based Ceramics

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(Received December 27, 1988; accepted February 14, 1989)

Key words: bismuth sodium titanate, $(BiNa)_{1/2}TiO_3$-based ceramics, ferroelectrics, piezoceramics, pyroceramics, sensor materials

Piezoelectric and pyroelectric properties of bismuth sodium titanate, $(BiNa)_{1/2}TiO_3$(BNT)-based solid solutions, $(BiNa)_{(1-x)/2}(a\cdot Sr + b\cdot Pb + c\cdot Ca)_xTiO_3$ ($a + b + c = 1$)(BNTX[$100x - 100a/100b/100c$]), were studied as lead-free or low lead content piezo- and pyroelectric ceramic sensor materials. A rhombohedral (F_α)-tetragonal (F_β) morphotropic phase boundary (MPB) is shown to exist at $x = 0.13$ by X-ray diffraction data. BNTX[13 − 50/50/0], [13 − 0/50/50], [13 − 0/75/25] and [1 − 0/0/100] ceramics are superior for piezoceramic sensors, with a lower free permittivity, $\varepsilon_{33}^T/\varepsilon_0(\cong 240 \sim 430)$ and a high electromechanical coupling factor, k_t or $k_{33}(\cong 50\%)$. The BNTX ceramics demonstrate that the figures of merit for pyrosensor materials are comparable to those of commercial PZT or $PbTiO_3$-based ceramics.

1. Introduction

The major constituent of piezoelectric ceramic materials is $Pb(Zr\cdot Ti)O_3$ (PZT) or a PZT-based multicomponent system with rhombohedral (F_α)-tetragonal (F_β) compositions near the morphotropic phase boundary (MPB). Control of the PbO atmosphere is very important in obtaining well-sintered ceramics with good reliability and reproducibility. One recent trend in the study on piezo- and/or pyroceramic materials is the use of lead-free or the low lead content compositions to control the atmosphere and to avoid pollution during the sintering process by suppression of PbO evaporation.