Sensors and Materials, 1 (1988) 035–046
MYU, Tokyo

S & M 0005

Grain-Oriented and Mn-Doped $(NaBi)_{(1-x)/2}Ca_xBi_4Ti_4O_{15}$ Ceramics for Piezo- and Pyrosensor Materials

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(Received March 5, 1988; Accepted April 10, 1988)

Key words: bismuth layer-structured ferroelectrics, hot forging method, grain orientation, piezoelectric properties, pyroelectric properties

Calcium modifications of $(NaBi)_{(1-x)/2}Ca_xBi_4Ti_4O_{15}$ (NCBT-100x) ceramics, which belong to a bismuth layer-structured ferroelectric (BLSF) family, and their grain orientation effects are studied using the hot forging (H.F.) method on the piezoelectric and pyroelectric properties for their sensor materials. The dielectric constant ε_s is small and almost constant at the wide range of composition ($x = 0$ to $x = 1$). The Curie temperature, T_c, increases as the Ca concentration increases. The grain orientation (H.F.) effects enhance the piezo- and pyroelectric properties by two or more times that of nonoriented ones. The H.F. Mn-doped NCBT-5 ceramics, with a lower free permittivity $\varepsilon_{33}^T/\varepsilon_0$ ($=\sim 130$) and higher electromechanical coupling factor k_{33} ($=33 \sim 40\%$), along with a higher anisotropy, k_{33}/k_{31} ($=13 \sim 17$), are very attractive candidate materials for hydrophone applications at high temperatures or for high-frequency ultrasonic transducers with a high Curie temperature. Pyroelectric properties are also very interesting for sensor materials, and the figure of merit (F_V) is comparable to that of PZ-based or PT-based materials.

1. Introduction

Important ferroelectric or antiferroelectric oxide ceramics for dielectric, piezoelectric, electrostrictive and/or pyroelectric applications are restricted to perovskite-type, tungsten bronze-type, and bismuth layer-structured compounds.[1,2] One recent trend in the study on piezo- and/or pyroceramic compounds is the use