Effect of Uniaxial Stress on Hysteresis Properties of 0.1PMN–0.9PZT Ceramic

Athipong Ngamjarurojana*, Supattra Wongsaenmai, Rungnapa Tipakontitikul, Supon Ananta and Rattikorn Yimnirun

Department of Physics, Faculty of Science, Chiang Mai University, Chiang Mai 50200, Thailand

**Corresponding author. E-mail : Athipong@chiangmai.ac.th*

ABSTRACT

PMN-PZT ceramic composite with formula 0.1Pb($Mg_{1/3}Nb_{2/3}$)O_3–0.9Pb($Zr_{0.52}Ti_{0.48}$)O_3 or 0.1PMN–0.9PZT was prepared by a conventional mixed-oxide method. A planarelectromechanical coupling coefficient (kp) value of the ceramic was measured by a resonance method. The kp value of the ceramic was calculated to be 0.47. In addition, the uniaxial stress dependence of hysteresis properties of 0.1PMN–0.9PZT ceramic was investigated by measuring the ferroelectric parameters, i.e., remanent polarization (P_r), spontaneous polarization (P_s) and coercive field (E_c) as a function of applied stress. It has been shown that sizes of hysteresis loop of the ceramic change with increasing stress. The P_r, P_s and E_c values also vary with the applied stress. The P_r and P_s decrease significantly, while Ec increases, with increasing stress.

Key words: PMN-PZT, Planar electromechanical coupling coefficient (k_p), Hysteresis properties, Uniaxial stress

INTRODUCTION

Lead magnesium niobate (Pb($Mg_{1/3}Nb_{2/3}$)O_3 or PMN) and lead zirconate titanate (Pb(Zr_xTi_{1-x})O_3 or PZT) ceramics have been widely used in actuator and transducer applications (Cross, 1996; Veihland et al., 2001). PMN is a well-established relaxor-type ferroelectric of perovskite structure with excellent dielectric properties. It has advantages of having broader operating temperature range, low loss and non-hysteretic characteristics. PZT ceramics have relatively-high electromechanical coupling coefficients as compared to PMN (Zhao et al., 1999). However, PZT ceramics are fairly lossy as a result of their highly-hysteretic behavior. With these complementary features, ceramics in PMN-PZT system are expected to have a combination of excellent properties of both ceramics.

The electromechanical coupling coefficient (k) is an indicator of the effectiveness with which a piezoelectric material converts electrical energy into mechanical energy or vice versa (Haertling, 1999). A high k is usually desirable for efficient energy conversion. For a thin disc of piezoelectric ceramic, the planar electromechanical coupling coefficient (k_p) expresses a radial coupling, i.e., the coupling between an electric field parallel to the direction in which the ceramic element is polarized (direction 3) and mechanical effect that produces radial vibrations, relative to the direction of the polarization (direction 1 and direction 2).

In many actuator and transducer applications, the ceramics are subjected to high mechanical-stress field. A prior knowledge of how the material properties change under different load conditions is crucial for proper design of a device and for suitable selection of