Mechanical Properties of *x*PMN-(*1-x*)PZT Ceramic Systems

Rattikorn Yimnirun*, Ekarat Meechoowas, Supon Ananta and Tawee Tunkasiri

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

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

ABSTRACT

Most of earlier work on PMN-PZT ceramic systems has been mainly focused on processing and electrical properties, while knowledge on mechanical properties is scarce. This article describes for the first time mechanical properties of the PMN-PZT ceramic systems. The (x) $Pb(Mg_{1/3}Nb_{2/3})O_3$ - (1-x) $Pb(Zr_{0.52}Ti_{0.48})O_3$ (when x = 0, 0.1, 0.3, 0.5, 0.7, 0.9, and 1.0) ceramics are prepared from respective starting materials by a conventional mixed-oxide method. A combination of the Knoop and Vickers indentation techniques is employed to determine the mechanical properties of the ceramics. It is found that the Vickers hardness of the ceramics varies between 5.28 and 7.75 GPa while the Young's modulus values range from 65.9 to 99.6 GPa. The fracture toughness of 2.03 to 3.42 $MPa{\cdot}m^{1/2}$ is obtained from the ceramics tested. In general, it is observed that the mechanical properties of the ceramic systems are largely controlled by those of PMN ceramics.

Key words: PMN-PZT ceramics, Mixed-oxide method, Mechanical properties

INTRODUCTION

With distinct characteristics, lead magnesium niobate ($Pb(Mg_{1/3}Nb_{2/3})O_3$ or PMN) and lead zirconate titanate ($Pb(Zr_1\text{-}xTi_x)O_3$ or PZT) ceramics have been employed extensively in different types of actuator and transducer applications (Cross, 1987; Xu, 1991). As a prototypic relaxor ferroelectric, PMN has advantages of having very high dielectric constant and broader operating temperature range, especially over the room temperature range, as a consequence of the diffuse paraelectric-ferroelectric phase transition which takes place in the vicinity of room temperature. In addition, as a result of their unique microstructural features, PMN ceramics exhibit low loss and non-hysteretic characteristics. However, the PMN ceramics have relatively low electromechanical coupling coefficients as compared to PZT. On the contrary to PMN, PZT ceramics have been utilized more in actuator and transducer applications due to their high electromechanical coupling coefficients near the morphotropic phase boundary (MPB) (Cross, 1987; Xu, 1991; Abe et al., 2000). However, PZT ceramics are fairly lossy as a result of their hysteretic behavior. This makes them unsuitable for applications that require high delicacy and reliability. Furthermore, PZT ceramics normally have very high Curie temperature (T_C) in the vicinity of 400˚C. Usually, many applications require that TC is close to ambient temperature. Therefore, there is a general interest to reduce the TC of PZT ceramics to optimize their uses. Forming a solid-solution of PZT and relaxor ferroelectrics has been one of the techniques employed to improve the properties of