Mechanical Strength and Material Property Evaluation of Textured PMN-PZT Polycrystalline Ceramic

R. Pérez-Moyet, D.P. Sherman, A.A. Heitmann, and J.B. Blottman*
Sensor and Sonar Systems Department, Naval Undersea Warfare Center
1176 Howell Street, Newport, RI, 02841
*J.B. Blottman: john.blottman@navy.mil

Piezoelectric materials are essential to the design and development of new, state-of-the-art transduction devices. In polycrystalline form, the crystallographic orientation of the grain structure is randomly oriented, providing only a fraction of the potential electromechanical response during operation. To achieve ideal performance, full alignment of the microstructure is required and this can be realized in single crystal form. The drawback being that a piezoelectric single crystal lacks a complex grain structure. Crystallographic texturing of a polycrystalline ceramic affords a means to achieve enhanced electromechanical performance without sacrificing the mechanical robustness of the material. In this investigation, [001] oriented and poled $Pb(Mg_{1/3}Nb_{2/3})O_3$-$Pb(Zr,Ti)O_3$ (PMN-PZT) textured ceramics are evaluated, characterized, and compared with their polycrystalline counterparts. The influence of tape-casting process and the texturing of the microstructure on the electromechanical performance are investigated through contrast with random oriented powder processed and tape-cast PMN-PZT polycrystalline ceramics. This report documents the electromechanical performance, mechanical strength, and fracture behavior of textured and random oriented ceramic specimens. Comparisons between textured, random oriented, and single crystal PMN-PZT are made. The influence of the increased sample thickness necessary for the mechanical testing of the textured specimens on the resultant microstructure and material performance is discussed.