Title: High piezoelectric sensitivity and hydrostatic figures of merit in unidirectional porous ferroelectric ceramics fabricated by freeze casting

Authors: Yan Zhang, James Roscow, Mengying Xie, Chris Bowen

PII: S0955-2219(18)30295-4
DOI: https://doi.org/10.1016/j.jeurceramsoc.2018.04.067
Reference: JECS 11877

To appear in: *Journal of the European Ceramic Society*

Received date: 9-1-2018
Revised date: 27-4-2018
Accepted date: 30-4-2018

Please cite this article as: Zhang Y, Roscow J, Xie M, Bowen C, High piezoelectric sensitivity and hydrostatic figures of merit in unidirectional porous ferroelectric ceramics fabricated by freeze casting, *Journal of the European Ceramic Society* (2010), https://doi.org/10.1016/j.jeurceramsoc.2018.04.067

High piezoelectric sensitivity and hydrostatic figures of merit in unidirectional porous ferroelectric ceramics fabricated by freeze casting

Yan Zhang, James Roscow, Mengying Xie*, Chris Bowen

Department of Mechanical Engineering, University of Bath, BA2 7AY, United Kingdom

**E-mail address: m.xie@bath.ac.uk, yanzhangmaterial@hotmail.com*

High performance lead zirconate titanate (PZT) ceramics with aligned porosity for sensing applications were fabricated by an ice-templating method. To demonstrate the enhanced properties of these materials and their potential for sensor and hydrophone applications, the piezoelectric voltage constants (g_{33} and g_{31}), hydrostatic parameters (d_h, g_h, $-d_{33}/d_{31}$, $d_h g_h$ and $d_h g_h/tan\delta$) and AC conductivity as a function of the porosity in directions both parallel and perpendicular to the freezing temperature gradient were studied. As the porosity level was increased, PZT poled parallel to the freezing direction exhibited the highest d_h, $-d_{33}/d_{31}$ and figures of merit $d_h g_h$, $d_h g_h/tan\delta$ compared to the dense and PZT poled perpendicular to the freezing direction. The g_h, g_{33} and g_{31} coefficients were highest for the PZT poled perpendicular to the freezing direction; the g_h was 150% to 850% times higher than dense PZT, and was attributed to the high piezoelectric activity and reduced permittivity in this orientation. This work demonstrates that piezoelectric ceramics produced with aligned pores by freeze casting are a promising candidate for a range of sensor applications and the polarisation orientation relative to the freezing direction can be used to tailor the microstructure and optimise sensitivity for sensor and hydrostatic transducer applications.

Keywords: piezoelectric, PZT, aligned pore, hydrostatic, figure of merit

Introduction

Piezoelectric materials represent a popular class of active materials used in many areas[1-3], such as SONAR applications, vibration energy harvesting, structural health monitoring and non-destructive evaluation. For uniaxial sensing applications, the piezoelectric voltage constants g_{33} and g_{31} are important parameters since they represent the electric field produced per unit stress, and are of interest for accelerometers, force, pressure and acoustic sensors. Hydrophones that operate under hydrostatic