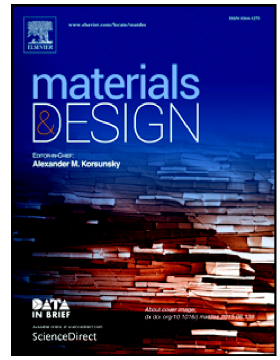
Accepted Manuscript



Failure mode, ferroelastic behavior and toughening effect of bismuth titanate ferroelectric ceramics under uniaxial compression load

Yu Chen, Jiageng Xu, Shaoxiong Xie, Rui Nie, Jing Yuan, Qingyuan Wang, Jianguo Zhu

PII: S0264-1275(18)30334-4
DOI: doi:10.1016/j.matdes.2018.04.055
Reference: JMADE 3868

To appear in: *Materials & Design*

Received date: 20 January 2018
Revised date: 9 April 2018
Accepted date: 19 April 2018

Failure mode, ferroelastic behavior and toughening effect of bismuth titanate ferroelectric ceramics under uniaxial compression load

Yu Chen[a, b], Jiageng Xu[c], Shaoxiong Xie[d], Rui Nie[b], Jing Yuan[b], Qingyuan Wang[a, d, e*], Jianguo Zhu[b*]

[a]*School of Mechanical Engineering, Chengdu University, Chengdu 610106, China*
[b]*College of Materials Science and Engineering, Sichuan University, Chengdu 610065, China*
[c]*School of Architecture and Civil Engineering, Chengdu University, Chengdu 610106, China*
[d]*College of Architecture and Environment, Sichuan University, Chengdu 610065, China*
[e]*Failure mechanics and Engineering Disaster Prevention and Mitigation Key Laboratory of Sichuan Province, Chengdu 610065, China*

Abstract

A typic BLSF ceramics: bismuth titanate ($Bi_4Ti_3O_{12}$), whose failure mode, ferroelastic behavior and toughening effect under uniaxial compression load were comprehensively assessed. Firstly, a series of crystallographic parameters including lattice constants (*a*, *b*, *c* and *v*), orthorhombicity (*g*) and single-crystal distortion (S^0_{lattice}) were calculated from XRD patterns. The ferroelastic behavior referred to the 90^o switching of domains with compression stress was identified by the nonlinear stress-strain curve, and the underlying micromechanism was more accurately described by the non-180^o domain wall motion. SEM observation on the fracture surface of the broken sample reveals its failure mode in terms of microcrack initiation and propagation behaviors. Further, a simplified domain distribution model was constructed for unpoled ferroelectric ceramics based on a constitutive framework, which deduced their constitutive relation subjected to uniaxial compression load. The ferroelasticity induced toughening was verified by indentation test, and further analyzed by a micromechanics model of crack propagation. The expression of toughening effect ($\Delta\Gamma/\Gamma$) was also deduced from the indentation fracture mechanics. Finally, the evolution in mechanical properties (including coercive stress (σ_c), switching strain (ε_{zz}), apparent elastic modulus (E) and compression strength (σ_{cf})) of $Bi_4Ti_3O_{12}$ ceramics with the doping content of W was also quantified by the compression test.

Keywords: $Bi_4Ti_3O_{12}$ ceramics; ferroelastic domain switching; microcracks; compression load; toughening effect

1. Introduction

Ferroelectric materials are one important category of functional materials with the piezoelectric effect which enables the conversion between mechanical energy and electrical energy, which have been commonly used as sensitive element for many electric devices including piezoelectric sensors, electromechanical transducer,

*The corresponding author QY. Wang, Tel/Fax: +86 28 85405389; E-mail: wangqy@scu.edu.cn;
*The corresponding author JG. Zhu, Tel/Fax: +86 28 85412022; E-mail: nic0400@scu.edu.cn;