Accepted Manuscript

A multi-material level set-based topology optimization of flexoelectric composites

Hamid Ghasemi, Harold S. Park, Timon Rabczuk

PII: S0045-7825(17)30756-9
DOI: https://doi.org/10.1016/j.cma.2017.12.005
Reference: CMA 11697

To appear in: *Comput. Methods Appl. Mech. Engrg.*

Received date : 31 May 2017
Revised date : 30 November 2017
Accepted date : 2 December 2017

Please cite this article as: H. Ghasemi, H.S. Park, T. Rabczuk, A multi-material level set-based topology optimization of flexoelectric composites, *Comput. Methods Appl. Mech. Engrg.* (2017), https://doi.org/10.1016/j.cma.2017.12.005

A multi-material level set-based topology optimization of flexoelectric composites

Hamid Ghasemi[2], Harold S. Park[3], Timon Rabczuk[1, 2]

[1] Duy Tan University, Institute of Research & Development, 3 Quang Trung, Danang, Viet Nam
[2] Institute of Structural Mechanics, Bauhaus- Universität Weimar, Marienstraße 15, 99423 Weimar, Germany
[3] Dep. of Mechanical Engineering, Boston University, Boston, MA 02215, USA

Abstract

We present a computational design methodology for topology optimization of multi-material-based flexoelectric composites. The methodology extends our recently proposed design methodology for a single flexoelectric material. We adopt the multi-phase vector level set (LS) model which easily copes with various numbers of phases, efficiently satisfies multiple constraints and intrinsically avoids overlap or vacuum among different phases. We extend the point wise density mapping technique for multi-material design and use the B-spline elements to discretize the partial differential equations (PDEs) of flexoelectricity. The dependence of the objective function on the design variables is incorporated using the adjoint technique. The obtained design sensitivities are used in the Hamilton–Jacobi (H-J) equation to update the LS function. We provide numerical examples for two, three and four phase flexoelectric composites to demonstrate the flexibility of the model as well as the significant enhancement in electromechanical coupling coefficient that can be obtained using multi-material topology optimization for flexoelectric composites.

Keywords: Topology optimization, Flexoelectricity, Level set, Multi-material, B-spline elements

1. Introduction

In dielectric crystals with non-centrosymmetric crystal structure such as quartz and ZnO, electrical polarization is generated upon the application of uniform mechanical strain. This property of certain materials, which is known as piezoelectricity, is caused by relative displacements between the centers of oppositely charged ions. Details about the governing equations of piezoelectricity are available in [1-3].

Corresponding Authors: E-Mail: hamid.ghasemi@uni-weimar.de; parkhs@bu.edu; timon.rabczuk@uni-weimar.de