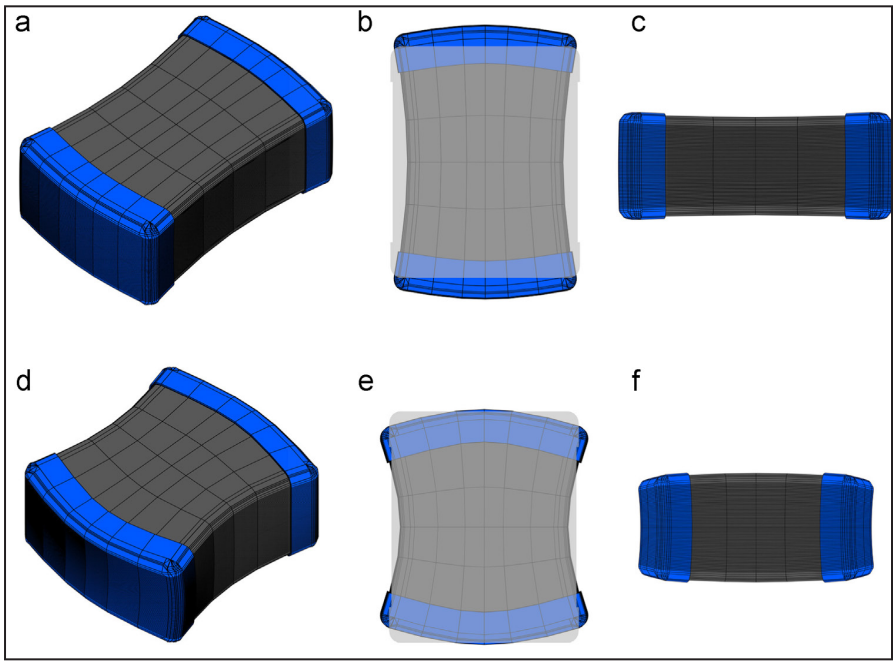
MOUNTAIN-PLAINS CONSORTIUM

RESEARCH BRIEF | MPC 18-343 (project 378) | July 2018

MEMS Sensors for Transportation Structures



the ISSUE

Of all microelectromechanical systems (MEMS), regardless of application, micron-scale spacing of interleaved electrodes and high-dielectric ceramics in multilayer ceramic capacitors (MLCCs) provide exceptionally high capacitances in small volumes. This has led to MLCCs being the preferred type of capacitor in a wide range of applications where size and weight are critical factors. However, crack-related failures of MLCCs remain a significant issue, especially in applications where replacement is particularly difficult or costly such as when they are embedded in elements of transportation infrastructure.

the RESEARCH

The current report presents finite element calculations of acoustic normal modes of all symmetry types, based on an MLCC model with dimensions and internal structure approximately matching those previously reported for a set of type-1210 MLCCs. Internal interleaved layers of electrodes and ceramic are explicitly included in the model, although the geometry of these layers is approximated as orthorhombic to reduce the size of the computational problem. Piezoelectric and dielectric terms are not included in the equation of motion. The inclusion of all modal symmetries in the model is anticipated to facilitate interpretation of resonant ultrasound spectroscopy (RUS) measurements, which are not limited to excitation of specific symmetries. The research reported here is specifically associated with experimental work that has been reported elsewhere on the detection of cracks in MLCCs through RUS and tone-burst electromechanical resonance.

MOUNTAIN-PLAINS CONSORTIUM REGION 8

A University Transportation Center sponsored by the U.S. Department of Transportation serving the Mountain-Plains Region. Consortium members:

Colorado State University
North Dakota State University
South Dakota State University
University of Colorado Denver
University of Denver
University of Utah
Utah State University
University of Wyoming

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Project Title

MEMS Sensors for Transportation Structures

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the **FINDINGS**

Calculations of frequencies and mode shapes, which include all modal symmetries, will aid in interpreting RUS and resonant nonlinear ultrasonics measurements by enabling the identification of measured vibrational modes. They also provide a basis for exploring the dependence of resonant frequencies and nonlinear parameters on the location, size, and orientation of cracks.

the **IMPACT**

As MEMS devices grow in complexity, there is very little information available related to fundamental mechanics behavior. This study provides much-needed data on the range of use of these systems along with being able to develop ranges of operation in terms of frequency and amplitude estimates for sensing and actuation use. The approach and results presented in this study are anticipated to serve a critical role in the development of nondestructive methods for detecting cracks in MLCCs and thus, facilitating enhancements in their reliability. Improved reliability is a key factor for use of MLCCs in transportation infrastructure elements.

For more information on this project, download the entire report at http://www.ugpti.org/resources/reports/details.php?id=915

For more information or additional copies, visit the Web site at www.mountain-plains.org, call (701) 231-7767 or write to Mountain-Plains Consortium, Upper Great Plains Transportation Institute, North Dakota State University, Dept. 2880, PO Box 6050, Fargo, ND 58108-6050.