Sep 17th, 12:00 AM - Sep 19th, 12:00 AM

# Energy Harvesting in Phase Transforming Materials

Aman Thakkar
*Purdue University*, thakkara@purdue.edu

Nilesh Mankame

Pablo Zavattieri

Andres F.



## Recommended Citation

Thakkar, A., Mankame, N., Zavattieri, P., & F., A. (2018). Energy Harvesting in Phase Transforming Materials. In T. Siegmund & F. Barthelat (Eds.) *Proceedings of the IUTAM Symposium Architectured Materials Mechanics, September 17-19, 2018* , Chicago, IL: Purdue University Libraries Scholarly Publishing Services, 2018. https://docs.lib.purdue.edu/iutam/presentations/abstracts/75

**IUTAM Symposium Architectured Material Mechanics,**
**T. Siegmund, F. Barthelat, eds**
**September 17-19, 2018, Chicago, IL, USA, , Chicago, IL, USA**

# Energy harvesting in phase transforming materials

Aman Thakkar[1], Nilesh Mankame [3], Pablo Zavattieri[2] and Andres F. Arrieta[1]
(1) School of Mechanical Engineering, Purdue University, West Lafayette, Indiana, 47907, USA, thakkara@purdue.edu , aarrieta@purdue.edu
(2) Lyles School of Civil Engineering, Purdue University, West Lafayette, Indiana 47907, USA, zavattie@purdue.edu
(3) Smart Materials and Structures, General Motors Research and Development, Warren, MI 48090, USA,

**KEYWORDS:**
Cellular materials, energy harvesting, wave propagation

Recently a novel class of periodic cellular material called phase transforming cellular materials (PXCM) was introduced for energy absorption application [1]. This material has multiple stable states and the deformations are fully recoverable providing a distinct advantage over conventional energy absorbing materials. Recent studies have explored the dynamic behaviour of these materials and applications of similar materials in the context of bandgap manipulation [2] and impact absorption [3]. However, the opportunity to harvest the lost vibrational energy harvesting caused by the frequent transition between multiple stable states and sudden releases of energy has been largely unexplored.

In this study, we use finite element simulations and high-speed photography to investigate the wave propagation behaviour in specific PXCM topologies. The effect of varying the number of rows and columns in the cellular material is investigated and a continuum limit is identified after which the PXCM behaviour can be treated like material behaviour. The structure is designed so that the deformation sequence is predetermined by varying the sinusoidal beam thickness [4]. This leads to different configuration of the PXCM depending on the state of each row. In each family of configuration, a different wave propagation behaviour is observed due to different reflection and transmission properties depending on the local material topology, i.e. depending on the local state adopted. Since the material is designed for energy absorption, we investigate the behaviour of this material under both, quasistatic and dynamic loading conditions. In conclusion we identify regions of the cellular material where there is energy concentration and propose a piezo embedded PXCM to harvest energy.

**Acknowledgments:**
A. Thakkar and A. F. Arrieta acknowledge the support of the Purdue Research Foundation (PRF). P. Zavattieri and N. Mankame acknowledge the support of the National Science Foundation.

**References**

[1] Restrepo, D., Mankame, N. D., and Zavattieri, P. D., 2015, Phase Transforming Cellular Materials, *Extreme Mech. Lett.*, 4, pp. 52–60.

[2] Debeau, D., Seepersad, C., and Haberman, M. 2018. Impact behavior of negative stiffness honeycomb materials. *Journal of Materials Research,33*(3), 290-299.

[3] BM Goldsberry, MR Haberman 2018, Negative stiffness honeycombs as tunable elastic metamaterials, *Journal of Applied Physics* 123 (9), 091711

[4] Che K, Yuan C, Wu J, Jerry Qi HH, Meaud J. Three-Dimensional-Printed Multistable Mechanical Metamaterials With a Deterministic Deformation Sequence.ASME. *J.Appl.Mech.* 2016;84(1):011004-011004-10.