The 9th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2024
3–7 June 2024, Lisbon, Portugal

AN ENERGY-BASED UNIFIED FRAMEWORK FOR ELECTRO-MECHANICAL PROGRAMMABILITY IN LATTICE METAMATERIALS

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Keywords: *Active honeycomb lattices, Programmable elastic modulus, On-demand sign reversal of Poisson's ratio, Multi-functional piezoelectric lattices*

In this study, we present an energy-based unified framework for achieving electro-mechanical programmability in 2-D honeycomb lattice metamaterials, focusing on bending-dominated, beam-like members. Our approach involves redesigning these bending-dominated, beam-like members with piezoelectric layers in unimorph and bimorph configurations attached to a substrate. By employing Euler-Bernoulli assumptions and the energy method, we derive the stiffness matrix of these members, considering both axial and transverse deformations resulting from mechanical loading and electric voltage across the piezo layer. Subsequently, adopting a bottom-up unit cell-based approach, we analyze the deflections of the unit cell under far-field stresses acting on the honeycomb lattice material and intrinsic stresses resulting from the applied voltage, considering appropriate boundary conditions. This analysis enables the computation of strains in specified directions, leading to closed-form expressions for the voltage-dependent Poisson's ratio and equivalent elastic moduli of the unit cell. The results also reveal the possibility of achieving a sign reversal in Poisson's ratio for specific combinations of cell angle and applied voltage. The proposed energy-based framework offers a pathway for post-manufacturing programmability of mechanical properties in various structural systems across different length scales, unveiling the possibility of tailored mechanical responses while showcasing unprecedented multifunctional properties.

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