Architected Piezoelectric Metamaterials with Electric Auxetic Effect and Multi-deformation Modes

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Abstract

The Poisson effect of conventional materials refers to that when stretched longitudinally, they contract transversely. The same effect exists in the conventional piezoelectrics for electric-deformation modes. Considerable efforts have been devoted to the design of force-induced auxetic metamaterials, providing remarkable potential applications. However, research on piezoelectric metamaterials with electric auxetic effect remains scarce. in this work, the design mechanisms are fully investigated for architected piezoelectric metamaterials with electric auxetic effect. Inspired from the typical re-entrant structures with auxeticity, the geometric parameters design and polarization are investigated to realize the piezoelectric metamaterials with electric auxetic effect. The electric auxetic effect is tunable based on the mechanoelectric coupling effect. Interestingly, the results reveal that the auxetic effects are opposite for the architected piezoelectric metamaterials and mechanics metamaterials. Furthermore, we propose a strategy for heterogeneous piezoelectric metamaterials based on the electric auxetic effect. Multi-deformation modes are realized, such as flexure, twist, and standing wave modes. The novel standing wave mode is capable of achieving bidirectional robotic movement, thus remedying the drawback of conventional standing wave robots, which can only move in one direction. Our work paves the way for the research on electric auxetic metamaterials and facilitates the emergence of more intelligent devices and robots.

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