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Designing anisotropic metamaterials with wave propagation isolation properties

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The advancement of additive manufacturing has led to a new paradigm in the design of materials. New artificial materials arose, not through chemically modified material units but rather through appropriately coined inner material architectures. The wording metamaterials has been employed to designate the potential of creating static and dynamic behaviors which are typically not encountered in common engineering materials. Up to now a considerable amount of works have been dedicated to a class of metamaterials named auxetics, because of their property of laterally expand when stretched. In the current work, we present a systematic approach to create two-dimensional orthotropic metamaterials with a non auxetic material behavior that exhibit wave propagation isolation features. To that scope, we employ polygonal-shaped unit cell material architectures that lead to highly anisotropic material designs in a systematic manner. We compute the anisotropic metamaterial's wave propagation characteristics for all propagating material directions. Thereupon, we identify a material direction of vanishing longitudinal and shear phase velocities. We observe that the vanishing phase velocity direction coincides with the material direction with the weakest normal mechanical modulus. We discuss on the role of Poisson's ratio and shear stiffness obtained by wave propagation features, deriving overall conclusions on the underlying structural mechanisms.

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