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A novel category of 3D chiral material with negative Poisson's ratio

Minghui Fu[a], Fengming Liu[a], Lingling Hu[a,*]

[a] *Department of Applied Mechanics and Engineering, School of Engineering, Sun Yat-Sen University, Guangzhou 510275, PR China*

Abstract: A new design thought for 3D auxetic material is proposed based on the rotaion mechanism of chiral honeycombs. Two kinds of cell shape of the 3D auxetic material are studied as example, which are developed from the tetrachiral honeycombs with circular loops and square loops, respectively, with inclined rods connecting the neighbor layers. By replacing the tetrachiral honeycomb layers by other chiral honeycombs, such as trichiral, hexachiral honeycombs, other kinds of 3D chiral material with negative Poisson's ratio can be obtained. Moreover, since the cells' deformation of the 3D material is dominated by that of ligaments and rods under small deformation, the elastic properties of the 3D auxetic material are almost independent of the loops' shape. Thus, the loop can be designed to any shape instead of the traditional circular loop in order to obtain priory mechanical properties under large deformation. Based on beam theory and micromechanical method, the analytical formulas of both the elastic mudulus and Poisson's ratio are deduced for this category of 3D chiral material, which are verified by numerical simulations but also the experiment of 3D printed model. The verification results indicate that the formulas have higher precision and wider application scope. The influence of layer space on the equivalent parameters and the conditions for isotropic realization are discussed base on the analytical formulas. By

* Corresponding author Lingling Hu, e-mail address: hulingl@mail.sysu.edu.cn