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Rational design of reconfigurable prismatic architected materials

Johannes T. B. Overvelde, James C. Weaver, Chuck Hoberman & Katia Bertoldi

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Supplementary Information

This file contains Supplementary Text and Data, which Includes Supplementary Methods, a Supplementary Discussion, Supplementary Figures 1-12, Supplementary Table 1 and additional references. The fabrication approaches used to make the cardboard prototypes and 3D printed prototypes are described. Also described are the numerical algorithm that were implemented in Matlab (i) to predict the number of degrees of freedom and corresponding deformation modes of 3D prismatic architected materials with rigid faces, and (ii) to characterize the elastic response of 3D prismatic architected materials with deformable faces. (PDF 40377 kb)

Supplementary Data

This zipped file contains the Matlab code used to generate the prismatic architected materials and determine their mobility and deformation modes. A detailed description of the code is given in the Supplementary Information. (ZIP 33 kb)

Strategy to design prismatic architected materials

Space-filling and periodic assemblies of convex polyhedra are used as a template to construct prismatic architected materials. After selecting a space-filling tessellation, we focus on a unit cell and separate the polyhedra while ensuring that the normals of all periodically-placed face pairs remain aligned. We then extrude the edges of the polyhedra in the direction normal to their faces to construct the extruded unit cell, which is then used to form the architected material. (MP4 1670 kb)

Reconfigurability of prismatic architected materials

Three prototypes of the 3D prismatic architected materials were constructed using cardboard for the rigid faces and double-sided tape for flexible hinges. Depending on the space-filling assembly of polyhedra used as a template, the resulting architected material has different deformation modes or is completely rigid. (MP4 10101 kb)

Enhancing the reconfigurability of prismatic architected materials.

To alter the reconfigurability of the architected materials, we reduce their connectivity by extruding only selected face pairs of the unit cell, while making the remaining faces rigid. As an example, the architected material based on the space-filling assembly of truncated octahedra can made reconfigurable by extruding only 6 of its faces and making the remaining 8 faces rigid. (MP4 9512 kb)

Different modes observed in prismatic architected materials.

A variety of qualitatively different deformation modes can be achieved in the proposed prismatic architected materials besides shear, including internal reconfigurations that do not alter the macroscopic shape of the materials, and uniform expansion along one or two principal directions. (MP4 8025 kb)

3D printed reconfigurable architected materials.

Using multi-material additive manufacturing we fabricated two of the proposed prismatic architected materials. The faces were fabricated using a rigid material, while the hinges were given a finite size and printed using a softer material. The two architectures that were printed are characterized by respectively zero and one deformation modes. (MP4 7133 kb)

PowerPoint slides

PowerPoint slide for Fig. 1

PowerPoint slide for Fig. 2

PowerPoint slide for Fig. 3

PowerPoint slide for Fig. 4

PowerPoint slide for Fig. 5

PowerPoint slide for Fig. 6

Supplementary Movie 4

Actuation of the unit cell. The shape and volume of the unit cell can be actively programmed by strategically positioning inflatable pockets on the hinges of the unit cell. By pressurizing the air pockets, the shape of the unit cell can be effectively controlled. (MOV 8397 kb)

Supplementary Movie 5

Actuation of the metamaterial. Similar to the unit cell, the shape and volume of the metamaterial can be actively programmed by strategically positioning inflatable pockets on the hinges of the unit cells. (MOV 11270 kb)

Supplementary Movie 6

Recovery of the unit cell. The response of the unit cell is always elastic. Even after applying 10,000