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Exploiting Auxetics to Design Composite Materials with Enhanced Mechanical Performance

Tiantian Li

Lifeng Wang
Stony Brook University, lifeng.wang@stonybrook.edu

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Exploiting Auxetics to Design Composite Materials with Enhanced Mechanical Performance

Tiantian Li[1], and Lifeng Wang[1]
[(1)] Department of Mechanical Engineering, Stony Brook University, Stony Brook, NY 11794, USA
Email: tiantian.li.1@stonybrook.edu; lifeng.wang@stonybrook.edu.

KEYWORDS:
Auxetics, Composites, 3D printing, Stiffness, Energy absorption, Penetration stiffness

Auxetic materials exhibiting a negative Poisson's ratio are shown to have many desirable properties and broad potential applications. Here, we report a class of high-performance composites in which auxetic lattice structures are used as the reinforcements and the nearly incompressible soft material is employed as the matrix. This coupled geometry and material design concept is enabled by the state-of-the-art additive manufacturing technique. Guided by experimental tests and finite element analyses, we systematically study the compressive behaviour of the 3D printed auxetics reinforced composites and achieve a significant enhancement of their stiffness and energy absorption [1]. This improved mechanical performance is due to the negative Poisson's ratio effect of the auxetic reinforcements, which makes the matrix in a state of biaxial compression and hence provides additional support. Static and dynamic indentation tests show that these auxetic composites achieve an enhanced penetration stiffness. By using digital image processing, we experimentally investigate that the material effectively flows to the site of the impact rather than away from it when hit by an indenter, which makes the auxetic composites denser at the site of the impact and therefore more resistant to indentation. The findings reported here pave the way for developing a new class of auxetic composites that significantly expand their design space and possible applications through a combination of rational design and 3D printing.

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[1] Li, Tiantian, Chen, Yanyu, Hu, Xiaoyi, Li, Yangbo and Wang, Lifeng, 2018. Exploiting negative Poisson's ratio to design 3D-printed composites with enhanced mechanical properties. *Materials and Design*, *142*, pp.247-258.