Pathways toward Commodity Mechanical Metamaterials: Harnessing Traditional Paper and Nonwoven Processing to Produce Auxetics with Natural Fibers

Meisha L. Shofner (Professor), Prateek Verma, Fariha Rubaiya, Li Tao, Lauren M. Garten, and Anselm C. Griffin
Georgia Institute of Technology, School of Materials Science and Engineering
801 Ferst Drive
Atlanta, Georgia, United States
Email: meisha.shofner@mse.gatech.edu

Among mechanical metamaterials, auxetic materials and structures have been studied extensively to understand the mechanism(s) that drive their mechanical response. Specifically, auxetics possess a negative Poisson's ratio, meaning that they experience transverse expansion when subjected to axial tension. This behavior, also termed auxeticity, is used to provide enhanced performance in composite materials, materials for energy dissipation, and textiles. Auxeticity has been realized in a variety of engineered structures such as reentrant foams, helical auxetic yarns, chiral networks, and knitted fabrics. In our work, we examine the auxetic response of fiber networks, including different types of papers and nonwoven fabrics. Even though these materials have a less precise structure than many auxetics, we find that an out-of-plane auxetic response is pervasively present in these structures and is not restricted to a single type of network structure. Fiber networks like those found in machine-made papers, handsheets, and felts can be auxetic in their as-produced state, whereas other nonwoven structures, like needle-punched nonwoven fabrics, can be made auxetic through additional processing steps. In this presentation, we will discuss the processing-structure-property relationships that are related to the auxetic response in natural fiber networks, including cellulose fiber, nanocellulose, and wool. Overall, these results suggest a pathway for producing a class of commodity auxetics which could promote wider use of these mechanical metamaterials as well as additional applications for natural fibers that utilize existing products in a new way.

Dr. Meisha Shofner is a Professor in the School of Materials Science and Engineering at the Georgia Institute of Technology, joining the faculty in 2005 following post-doctoral training at Rensselaer Polytechnic Institute. She earned her B.S. in Mechanical Engineering from the University of Texas at Austin and her Ph.D. in Materials Science from Rice University. Prior to beginning graduate school, she was employed by FMC as a Design Engineer, designing and testing subsea oilfield equipment. At Georgia Tech, Dr. Shofner's group investigates structure-property-relationships in polymers and composites, focusing on scalable processing approaches relevant to emerging materials such as mechanical metamaterials and sustainable polymers. Dr. Shofner is a Fellow in the Royal Society of Chemistry and a registered Professional Engineer in Georgia.