6th International Conference on Advances in Experimental Structural Engineering
11th International Workshop on Advanced Smart Materials and Smart Structures Technology
August 1-2, 2015, University of Illinois, Urbana-Champaign, United States

Tension-Induced Tunable Corrugation in Two-phase Composite Materials: Mechanisms and Implications

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ABSTRACT
Polymer reinforced composites are abundant in natural and man-made structures. Here, we numerically investigate the deformation response of a two-phase polymer reinforced material under externally applied concentric tension. We show that by carefully designing the inclusion pattern, it is possible to induce corrugations normal to the direction of stretch. By stacking 1D composite fibers to form 2D membranes, these corrugations collectively lead to the formation of membrane channels with tunable shapes and sizes. Furthermore, this mechanism is exploited in creating pop-ups and troughs in 3D laminated plates enabling the development of complex 3D geometries from planar construction. We have found that the corrugation amplitude increases with the stiffness of inclusion and its eccentricity from the tension axis. However, the corrugation amplitude saturates and may even decrease in the limit of large stretch. We discuss the mechanisms leading to the development of corrugations as well as its different implications. We hypothesize that the proposed system provide greater flexibility and controllability in pattern formation and have potential applications in a variety of fields including tunable band gap formation and water treatment.

KEYWORDS: *corrugations, composite fibers*