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# HARNESSING MECHANICAL INSTABILITIES IN SOFT METAMATERIALS FOR RESPONSIVE, BENDABLE AND FOLDABLE DEVICES



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### ABSTRACT:

Reconfigurable soft materials that can bend, fold, or transform the structural symmetry in response to external stimuli have attracted significant interests in design of flexible electronics, color displays, smart windows, actuators, sensors, and photonic/phononic devices. Here, we demonstrate the design of soft metamaterials from elastomers, pH and temperature sensitive hydrogels, and shape memory polymers. These metamaterials are membranes consisting of periodic void arrays with controlled size (from microns to millimeters), shape, orientation, and symmetry. When modest stresses are applied to the membranes, large changes in volume are observed, which expand or close void space entirely by rotating the hinges between unit cells, resulting in symmetry breaking and a negative Poisson's ratio approaching to -1.

We then exploit kirigami (cutting + folding) principles to design highly collapsible/expandable and foldable devices. By introducing simple fractal cuts of various motifs, we show super-flexible and super-conformable sheets that can be integrated with conventional rigid devices (e.g., LEDs, circuits, and RF antenna) without sacrificing device performance during collapsing or stretching.

### BIOGRAPHY:

Shu Yang is a Professor in the Department of Materials Science & Engineering at University of Pennsylvania. Her group is interested in mimicking nature's hierarchical structures for unique optical, mechanical and surface/interface properties. Specifically, her group synthesizes, fabricates and assembles polymers, liquid crystals and colloidal particles with precise size, shape, and morphology for responsive, bendable and foldable materials and devices.

Yang received her BS degree from Fudan University, China in 1992, and Ph. D. degree from Chemistry and Chemical Biology under the supervision of Professor Christopher K. Ober in Materials Science and Engineering at Cornell University in 1999. She then joined Bell Laboratories, Lucent Technologies as a Member of Technical Staff before coming to Penn in 2004. She is a recipient of ICI (1999) and Unilever (2001) student awards from American Chemical Society (ACS) for outstanding research in polymer science and engineering. She was selected to Frontier of Engineering symposium by the National Academy of Engineering in 2002, and later as a speaker at Japan-American Frontiers of Engineering Symposium in 2011. She was selected by MIT's Technology Review as one of the world's top 100 young innovators under age of 35 in 2004.