Polymer Sheets that Self-Fold in Response to Light

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We describe a simple approach to fold polymer sheets in a hands-free manner that uses localized light absorption on a pre-stressed polymer film to induce self-folding. Self-folding is a deterministic 'origami' process, based on the ancient Japanese art of paper folding, that causes a predefined 2D template to fold into a desired 3D structure with high fidelity. Self-folding takes advantage of the multitude of available 2D patterning techniques (*e.g.*, lithography, inkjet printing, screen printing). Self-folding is attractive as a cost-effective 3D fabrication strategy for applications such as packaging, robotic actuators and sensors, biological devices, solar cells, and reconfigurable devices. Most approaches to self-folding use hinges (*i.e.*, regions of a substrate that fold) that have unique chemical composition from the bulk, which requires complicated photolithography or other multiple fabrication steps. Here we demonstrate a simple method for self-folding of polymer sheets utilizing localized light absorption on selected areas of the pre-strained polymer sheet. The ink is patterned via a desktop printer and it defines the location of the 'hinge' on the sheet. The inked areas on the 2D sheet absorb light preferentially, thus causing the polymer sheet to fold locally in the inked regions. The temperature gradients through the depth of the sheet induce localized shrinkage and the sheet folds within seconds. This patterned polymer sheets act as shape memory materials which can be programmed to fold into various 3D structures based on the nature of the light source, the shape and size of the ink patterns, and ink color. By controlling the aforementioned parameters we achieve a complete control of the time and degree of folding, which ultimately govern the final 3D shape of the folded object. This approach is appealing because it uses inexpensive materials and simple patterning techniques to form complex structures.

Jan Genzer received his "Diploma-engineer" degree (Dipl.-Ing.) in Chemical & Materials Engineering from the Institute of Chemical Technology in Prague in 1989. In 1991 he moved to the U.S. to pursue graduate studies at the University of Pennsylvania under the direction of Professor Russ Composto, receiving the Ph.D. degree in Materials Science & Engineering in 1996. After 2 post-doctoral stints with Professor Ed Kramer first at Cornell University (1996-1997) and later at University of California at Santa Barbara (1997-1998), Genzer joined the faculty of chemical engineering at the NC State University as an Assistant Professor in fall 1998. He is currently the Celanese Professor and Associate Department Head in the Department of Chemical & Biomolecular Engineering at NC State University. His honors include: Camille Dreyfus Teacher-Scholar Award, NSF CAREER award, John H. Dillon Award of the American Physical Society, NSF Award for Special Creativity, NC State's Outstanding Teacher Award, NC State Alumni Outstanding Research Award, NC ACS Outstanding Lecturer Award, and others. He is a Fellow of the American Physical Society. Genzer published >200 peer-reviewed journal articles and delivered >180 invited lectures. His group at NC State University is actively involved in research related to the behavior of polymers at interfaces and in confined geometries, with particular emphasis on self-assembly and forced assembly and combinatorial methods. Genzer is the co-director of the Research Triangle Materials Research Science & Engineering Center (RT-MRSEC).