Snap Buckling of a Constrained Photomechanical Switch Driven By Elastic Instability

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Abstract

Photomechanical materials experience strains in response to light of certain wavelengths. These remotely triggered, photo-induced strains lead to large-scale deformations, presenting significant opportunities for wireless actuators and light-driven morphing structures. A large space of possible mechanical behaviors exist for these materials since their response depends on a variety of system parameters such as the wavelength and polarization of light, material anisotropies and patterning, molecular morphology, etc. In addition, sample geometry, boundary conditions, and contact conditions add to the response complexity. Accurate simulations that address both material responses and coupled nonlinear structural responses are needed in order to streamline experimental efforts as well as for predicting system performance for useful work in functional devices. Based on preliminary experimental results, we examine a photomechanical snap-toggle device (Fig. 1) in which an elastic strip of light responsive material is buckled into contact with a rigid pin. Selective light irradiation leads to an elastic instability and eventual rapid snap buckling into a second stable configuration.

In this study we model the structure (Fig. 1) as a 2D, linear elastic solid using the structural mechanics module in the finite element software package COMSOL Multiphysics®. A key feature of the model is the implementation of the light induced strain field in the initial strain subnode under the linear elastic materials node. We demonstrate the approach to and rapid snapping motion associated with elastic instability. Preliminary data suggests important model parameters affecting critical photo-strains leading to snap-buckling.

In contrast to the well-studied phenomena of snap-through of circular arches, we present a design that features same-sided snap-buckling. This particular design may prove useful in applications where limited space toggling or mechanical logic gates (not-gates) are required. This study lays a foundation for designing light triggered actuators in which contact and boundary conditions play a crucial role in enhancing the complexity of generated motion.

Figures used in the abstract

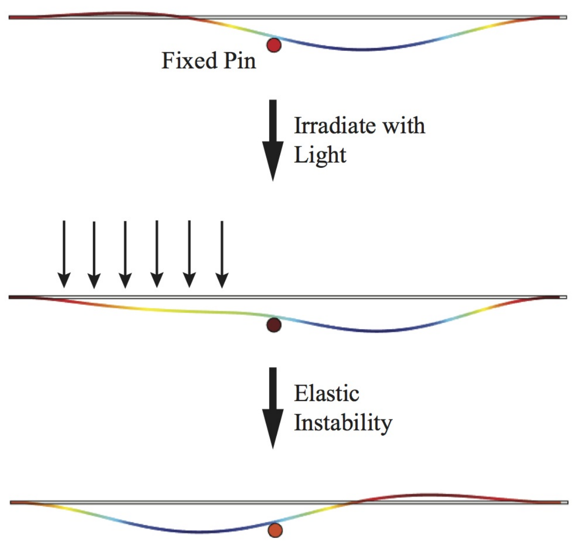

Figure 1: An elastic, light responsive beam is first buckled by compressing the right end. The fixed pin constrains its motion. Irradiation with uv or 445nm light leads to deformation toward an elastic instability and then rapid snap buckling into the stable configuration with the left end buckled downward.

Figure 2

Figure 3

Figure 4