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Photoresponsive Polymers: Converting Light to Mechanical Work

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The ability to remotely control the creation of mechanical work, rapidly, with high spatial precision, and over long distances, offers many intriguing possibilities. Whether driving direct conformational changes, initiating reversible chemical reactions to release stored strain, or converting the photon to a local temperature increase, combinations of photoactive units, nanoparticles, ordered mesophases and polymeric networks are providing an expansive array of photo-responsive polymer options. By combining these material responses with kinematic concepts, mechanical devices can be demonstrated that exhibiting tunable and controllable macroscopic deformation, high-frequency oscillation or directional motion. Specifically, we will discuss recent investigation of liquid crystal polymer networks containing main chain and pendent azobenzene moieties (azo-LCN) with modulus $\sim$1.3GPa that are actuated at the absorptive overlap of the cis and trans confirmers (442 nm). Cantilevers and unconstrained beams of these azo-LCNs can be controlled by polarization angle of the source, as well as by a specific optical exposure history (on-off), with responses ranging from lateral motion to oscillations in excess of 30Hz. These phenomena reflect an underlying interaction between the mesophase order, the network architecture and kinematic constraints of the exposed material. In collaboration with Timothy Bunning, Timothy White, Hilmar Koerner, Air Force Research Laboratory; and Nelson Tabiryan, BEAM Co.