Institute for
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INPAC Lectures on Modern Trends in Nanoscience:

Photomechanical Effects and Ultra-Smart Morphing Materials

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Abstract

Our work seeks to set the scientific foundations for making a novel new material that has the ability to morph in response to stress or light. In contrast to common materials that are made of atoms or molecules, and interact through electric fields, we envision a system made of microscopic units that each communicate with all others using light, imbuing the system with enormous processing power and intelligence. Add to each unit the ability to respond to stress and perform actuation, and the system gains the ability to intelligently morph into complex structures.

Making such a smart material requires a hierarchical approach that begins with a demonstration of the fundamental building blocks, followed by studies of how a small number of the building blocks interact with each other when interconnected with light, and culminates with the development of fabrication methods that can be used to make a bulk material from a collection of microscopic building blocks. This talk will review the concept of photomechanical materials/devices and will describe recent progress in transmitting stress on a beam of light using an elastomer as the active material. I will show how the fundamental building blocks, called Photomechanical Optical Devices (POD) can be made into a polymer fiber-optic interferometer containing a nonlinear-optical and photomechanical material -- thus simultaneously having the ability to manipulate light, sense stress, and apply anisotropic stress to its surroundings.

A network of PODs, interconnected by light signals along a fiber, would in principle form the thread of an ultra-smart material with functionality that goes well beyond present materials paradigms. In contrast to a neural network, in which each neuron is connected to a small number of neighbors, I will describe how a linear array of PODS along an optical fiber would interact with all others, processing information, reacting to stress and responding by selectively passing light and stressing the surroundings.