A Mechanical Signature of the Polarization of Light: The Opto-Mechanical Effect in Glass (DMR-0074624)

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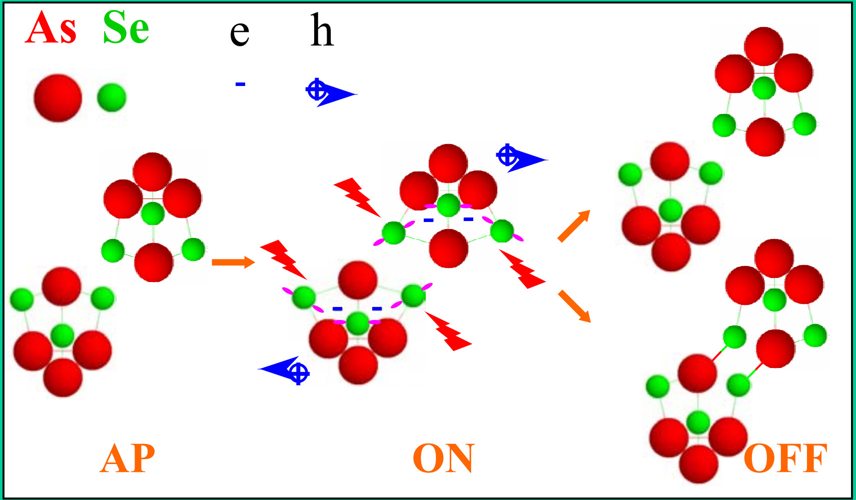
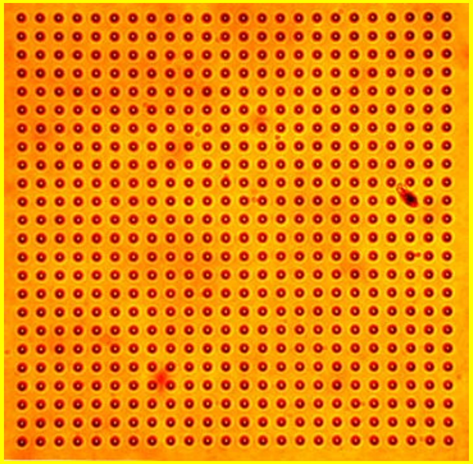
Recent discoveries of photoinduced effects, which are uniquely exhibited by chalcogenide glasses like arsenic selenide, offer opportunity for numerous new applications. For example, a novel 'flexible optics' controlled by light appears feasible in certain films that exhibit temporary, photoinduced dimensional changes. The present in-situ experiments and ab initio simulations have provided a comprehensive model of such phenomena and demonstrated their potential in microphotonics and nanotechnology.

Fundamental understanding

The origin of photoinduced structural changes is traced in molecular clusters like As_4Se_3 (or As_4Se_4) that consist of relatively unstable 'bonding defects'. In as-prepared (AP) film these molecules are connected through weak van der Waals bonds. Exposure to bandgap light makes these molecules negatively charged, thus repelling each and other creating photoexpansion. It also causes the excited Se lone pairs in one molecule to interact with Se/As in neighboring molecules. After the light is turned off, some of the molecules return to the original state, while others crosslink through bond switching and cause contraction.



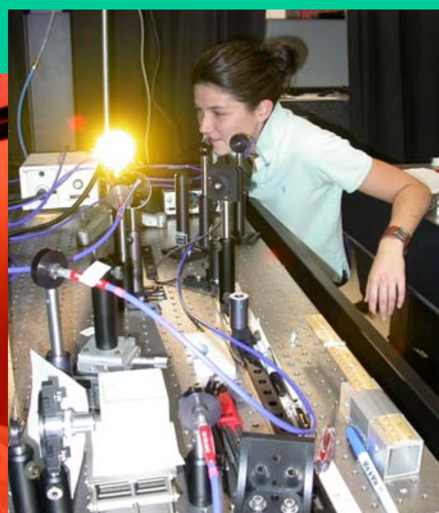
Applications: Guided by our understanding of photo-structural changes, a matrix of 12-micron lenses (e.g. 24x24 in the figure) has been fabricated for night-vision applications.



Broad impact of the glass research project

Human resources and training of students

With a targeted outreach to women and minorities, 6 grads, 6 UGs, 1 pre-college and 2 postdocs (7 women, 2 of Black origin) have been trained in glass research under this project in an international environment. This year, the pre-college student received first prize in International Metallographic Contest (Non-metals UG category) and a special prize at American Ceramic Society (ACerS) poster contest. Her experiment is a highlight of the Glass Science course at Lehigh, and is used for recruiting High School students into ceramics by other universities (see right). Another student was a runner up at the ACerS UG Speaking Contest.



Other fields of science and technology

Our observations of photoinduced structural changes have led to: (a) exploring the effect of electron beam induced changes, which are then exploited in nanolithography and, (b) developing a novel IR sensor for biomedical applications. Thus, new research projects have been initiated for (a) superior glass photoresists in collaboration with Army Research Lab, replacing currently used polymers, and (b) novel IR waveguides in collaboration with colleagues from Lehigh's EE and Penn State.

Presumably the highest resolution structure ever created in a glass by e-beam lithography: the 'nano-wheel' and its center at higher magnification.