

# Lehigh University Center for Optical Technologies

## Demonstration of 'Optical Switching' in Chalcogenide Films

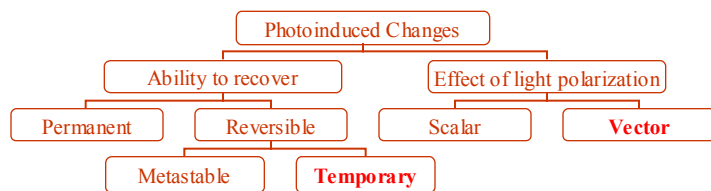
G. Chen and H. Jain

Department of Materials Science & Engineering, and Center for Optical Technologies

Lehigh University, Bethlehem PA, 18015

**Chalcogenide glasses:** sensitive to the near bandgap light illumination

### Classification of photoinduced changes

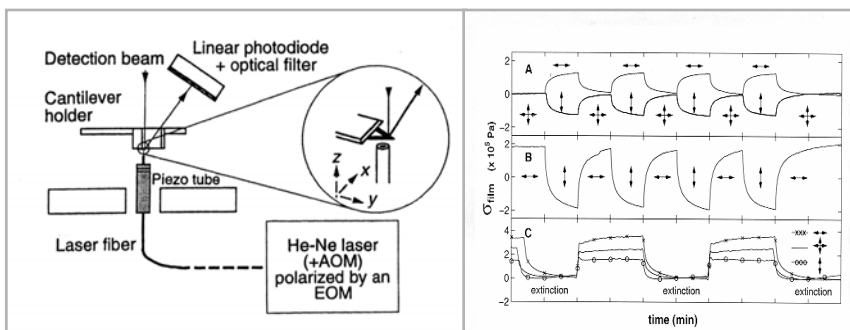


'Vector' + 'Temporary' = 'Smart'

Permanent: cannot be recovered w/o remaking the glass  
 Metastable: recovered on heating to  $\sim T_g$   
 Temporary: recovered on removing the light  
 Scalar: do not depend on the polarization of the light  
 Vector: depend upon the polarization of the light

### Examples of Smart Chalcogenide glasses:

#### The Opto-Mechanical Effect



P. Krecmer et al., "Reversible Nanocontraction and Dilation in a Solid Induced by Polarized Light," *Science*, **277**, 1799 (1997).

As-prepared a-As<sub>50</sub>Se<sub>50</sub> film deposited on an AFM cantilever.

Bandgap light (HeNe laser 633 nm) generates stress which is polarization dependent.  
 contraction //  $E_{\text{laser}}$ , and dilation  $\perp E_{\text{laser}}$

### Photoinduced Optical Anisotropy (POA)

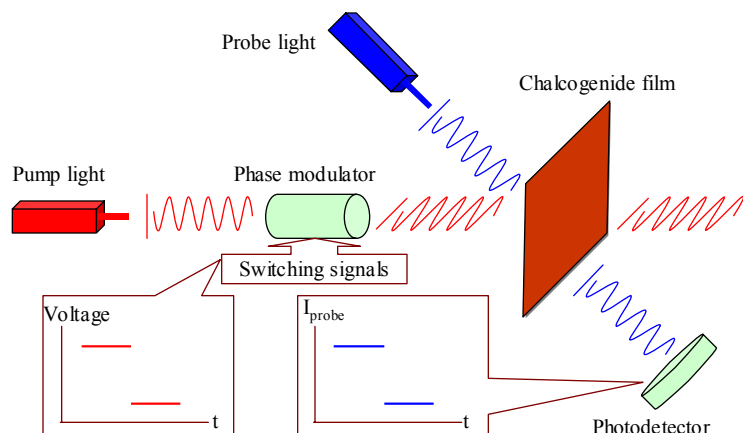
Photoinduced optical anisotropy:

$$\beta = \frac{2(I_{\parallel} - I_{\perp})}{I_{\parallel} + I_{\perp}}$$

$I_{\parallel}$ : probe transmission intensity when  $E_{\text{probe}} \parallel E_{\text{pump}}$   
 $I_{\perp}$ : probe transmission intensity when  $E_{\text{probe}} \perp E_{\text{pump}}$

$\beta$ : =0 (isotropic);  $\neq 0$  (anisotropic)

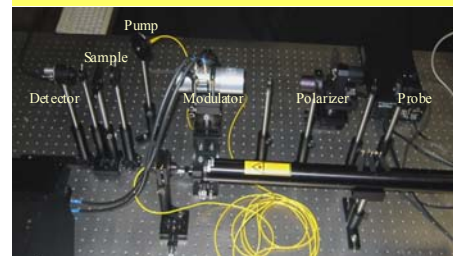
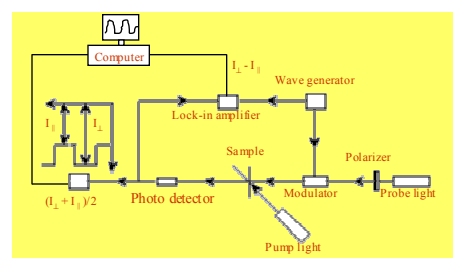
### Demonstration of 'Optical switching' Based on the POA



Using light of one wavelength to switch light of another wavelength.

### Composition-dependent Kinetics

#### Experimental setup



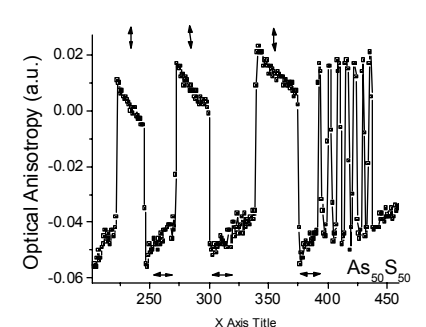
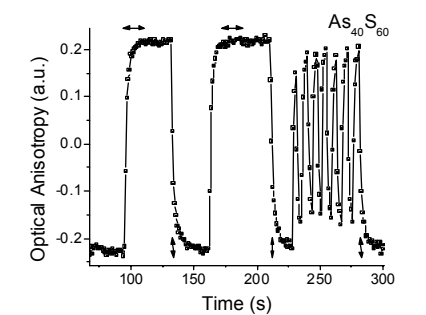
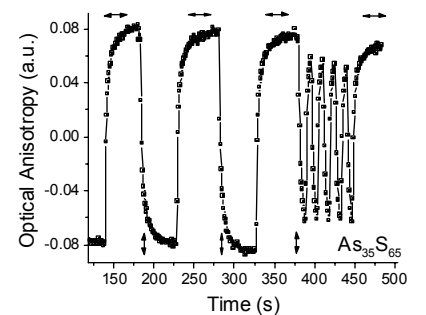
Pump light: Nd: YAG laser 532 nm  
 Probe light: diode laser 670 nm  
 alternating s and p polarization at 1KHz

•The magnitude of POA is the highest for stoichiometric composition.

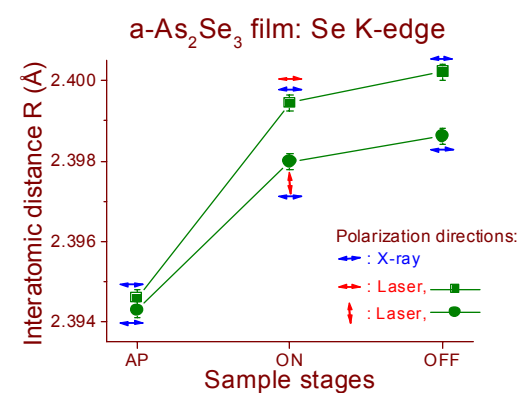
•The kinetics of the POA is inversely proportional to the concentration of chalcogen atoms.

•Directional movement of Se-related anisotropic units by polarized light is responsible for the POA effect.

#### Results

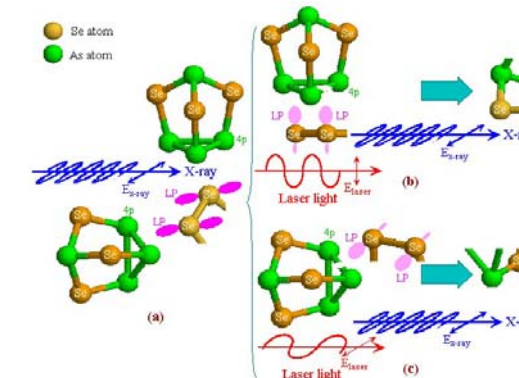


### Atomistic origin



### Atomistic anisotropic photoexpansion

Extended x-ray absorption fine structure  
 Experiments detect anisotropic photoexpansion effected by the  $E_{\text{laser}}$  in a-As<sub>40</sub>Se<sub>60</sub> films.



### Model of anisotropic photoexpansion

The laser beam excites and reorients the Se 4p lone pairs, and helps form anisotropic As-Se bonds along the  $E_{\text{laser}}$  direction. Movement of the Se atoms are affected by the polarization of the laser beam.