

Photoinduced structural changes in a-GeSe₂ films

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Chalcogenide glasses (ChG's)
Based on group VI elements (S, Se, Te) Sulfides or selenides of Ge, Sb or As, etc.

- ✓ High transparency in the Infrared region ($\lambda \sim 1-30 \mu\text{m}$):
IR optical devices
- ✓ High $\chi^{(3)}$ optical nonlinearity ($\sim 10^3$ times higher than a-SiO₂):
Ultrafast all optical switching for fiber communications
- ✓ Semiconducting:
Photocopying (Xerox) machines, digital x-ray imaging,
- ✓ Photoinduced phenomena (very sensitive to light)

Photoinduced phenomena in Chalcogenide glasses (ChG's)
Upon excitation with light = Band gap (BG light) and >band gap (SBG light)

Reversible Changes in optical, electrical, chemical, mechanical properties

Photoinduced Changes

Ability to recover

Permanent Reversible

Metastable Transient

What is the structural origin?

Photoinduced Structural changes
Results in changes in volume, band gap, refractive index, absorption, etc....

- ✓ Structural changes used for various applications
e.g., Optical memories, optical switching, gratings, micro-lenses, photo resists, laser writing of waveguides, etc.,

Easy to fabricate planer waveguides but losses are large
Laser writing of channel waveguides

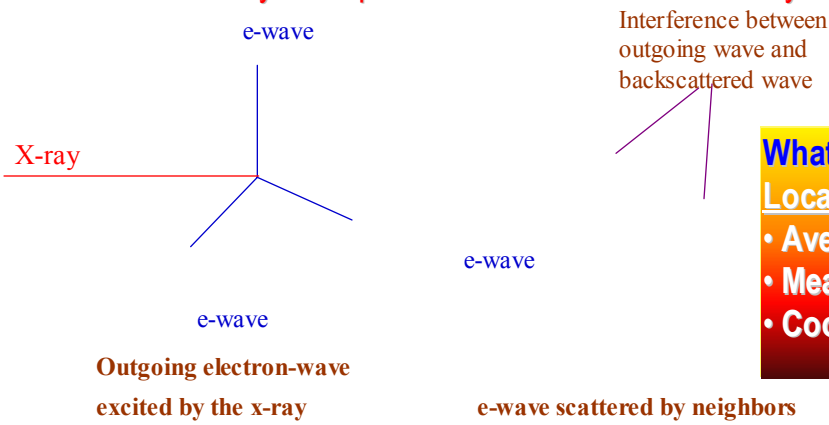
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Illumination used to create channels \Rightarrow less losses and low cost

Understanding photoinduced structural changes important

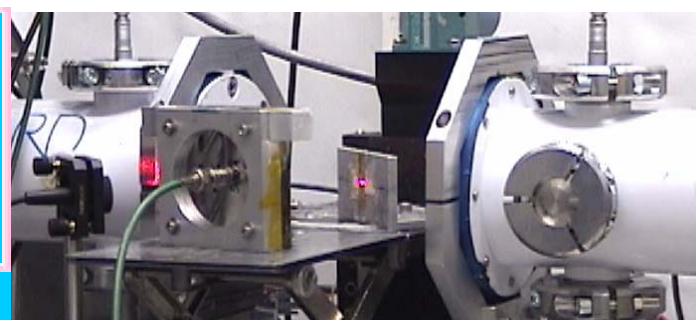
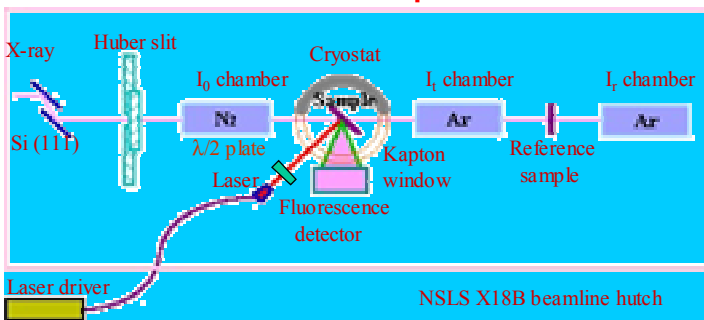
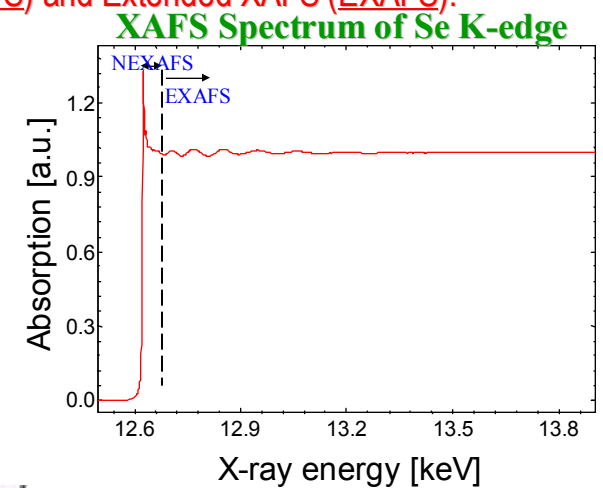
X-ray absorption fine structure (XAFS)

Modulation in X-ray absorption coefficient around an X-ray absorption edge: Near Edge XAFS (NEXAFS) and Extended XAFS (EXAFS).



What can we obtain from EXAFS?
Local structure around a specific element.

- Average interatomic distance (R)
- Mean square relative displacement (MSRD).
- Coordination number (CN).



Experimental details:

Samples:
Normally deposited a-GeSe₂ films
Obliquely deposited a-GeSe₂ films (80°)
Optical gap: 2.0 eV

Illumination sources:
Nd:YAG laser (532 nm)
Semiconductor laser (660 nm)
Before, during and after illumination
@ X23A2 beam line (NSLS, BNL)

Why obliquely deposited films:
Structure is more flexible (more porous)
Magnitude of photo-induced changes larger

Schematic sketch of the in-situ XAFS setup. X-ray absorption spectrum of a-GeSe₂ film beyond Ge and Se K-edge

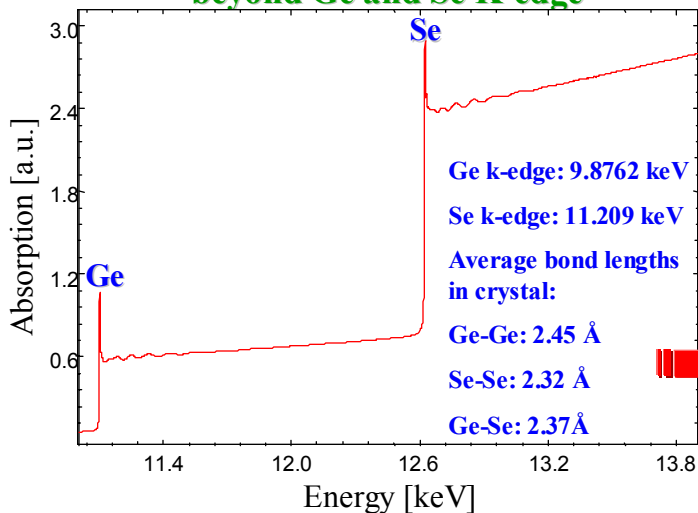
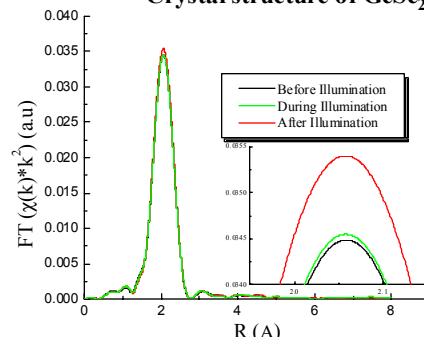


Image of the real setup.



Conclusions:

Preliminary results show that:

- Obliquely deposited GeSe₂ films show a larger change in their structure as compared to normally deposited films
- Illumination seems to bring an ordering in the structure, the cause may be the formation of more Ge-Se bonds upon illumination
- A transient part of changes is observed during illumination
- Further clarifications are needed to understand these changes fully for understanding changes in refractive index, etc.

