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Multi-wavelength and multi-intensity illumination of the GeSbS virgin film

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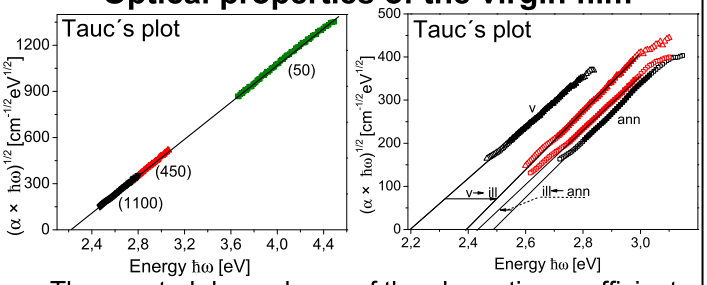
Introduction and aims

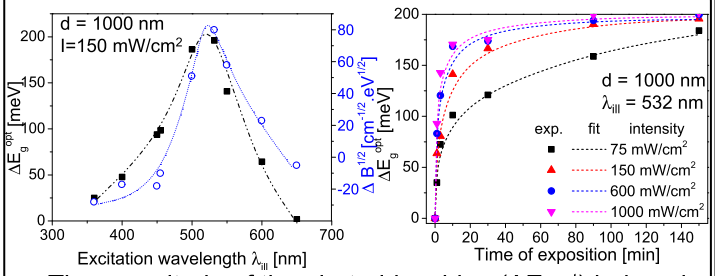
- Amorphous chalcogenides - perspective materials for optical memories, optical elements and data storage media for their unique behavior as high refractive index, high refractive nonlinearity, IR transparency and high intensity photo-induced effects
- Amorphous $Ge_{24.9}Sb_{11.6}S_{63.5}$ film was prepared through thermal evaporation
- It was examined (i) the role of the wavelength and intensity of the excitation light on photo-bleaching, (ii) the role of the thickness on photo-bleaching of the virgin film and (iii) the possibility of high intensity UV illumination.

Optical properties of the virgin film

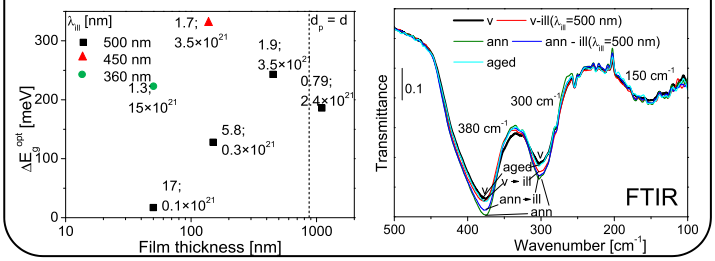


- The spectral dependence of the absorption coefficient for the virgin films for a thickness in a range 50 < d (nm) < 1100 independent of the film thickness.
- Typical changes in SWAE induced by the illumination and annealing. The changes of the parameters E_g^{opt} and $B^{1/2}$ exceed 9 % with respect to the virgin state.

Mild illumination condition I = 150 mW/cm²



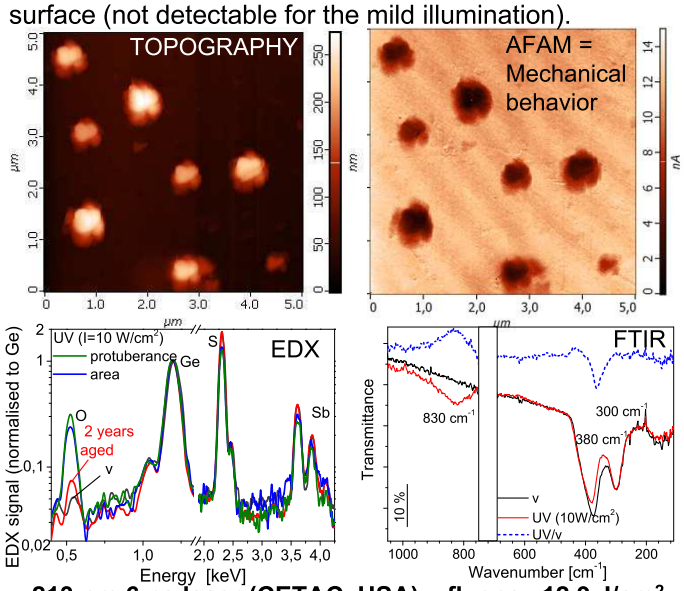
- The magnitude of the photo-bleaching (ΔE_g^{opt}) induced by monochromatic light is strongly spectral dependent.
- The maximal ΔE_g^{opt} values were obtained for the photons with the energy slightly-over the optical band gap E_g^{opt} = 2.2eV ⇔ λ = 560 nm.
- The overall kinetics were dependent on the photon intensity. The saturated state was similar for all the intensities but the rate is dependent on the intensity.
- Spectral sensitivity was only apparent. If the thin film with a thickness corresponding to the penetration depth of the over-band-gap photons was used (film with d = 50 nm illuminated by photons λ_{ill} = 360 nm (E_{ph} = 3.44 eV)), the blue shift of the band gap was observed 220 meV.
- The origin is connected with structural changes (FTIR).



High-intensity UV illumination I > 10 W/cm²

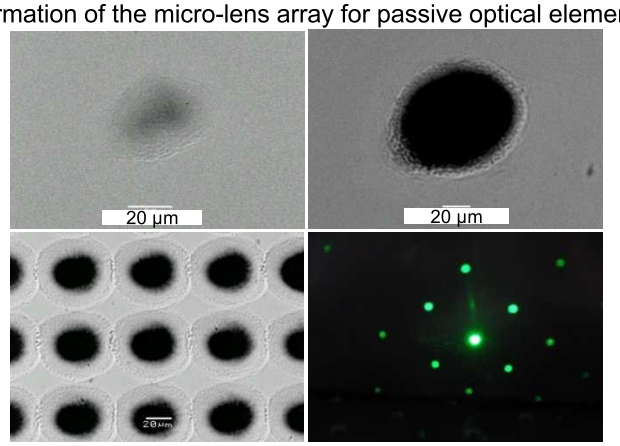
λ_{ill} = 310 and 360 nm, I = 10 W/cm²

- Intensive photo-bleaching connected with formation of protuberances/crystals and massive oxidation of the surface (not detectable for the mild illumination).



213 nm 6 ns laser (CETAC, USA) – fluency 12.9 J/cm²

- Illumination led to the ablation and crater formation. Higher cumulative E (pulses or fluency) ⇔ higher ablated volume.
- Good reproducibility (< 5 % in depth and volume) enable formation of the micro-lens array for passive optical elements.



Conclusion:

- Photo-bleaching of the virgin film, induced by over-band-gap photons is only apparently spectral sensitive.
- The magnitude of photo-bleaching induced by over-band-gap photons primarily depends on the light intensity and penetration depth of the light.
- Illumination of the film with a high intensity UV light in the air leads to significant photo-oxidation or even ablation of the film.

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