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Observation of X-ray Induced Diffusion of Ag into *a*-As_2S_3 Film by In-situ XPS

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Background:

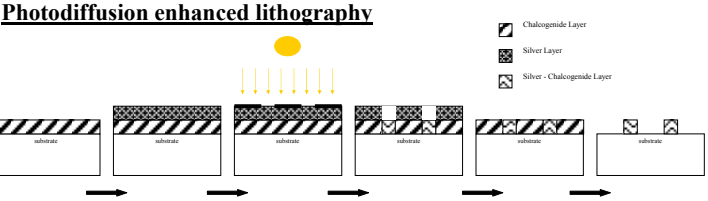
Chalcogenide glasses (ChG – alloys of S, Se, Te with the elements of IV and V groups) are potential new resist materials for lithography. They can act both as a positive as well as a negative photoresist, depending on the composition, pretreatment and the etchant. Furthermore, they offer many advantages:

- easy to deposit as large array in high vacuum
- photosensitive to band gap light (2-2.5 eV), e-beam and X-rays
- resistant to acids often used in semiconductor industry for etching
- resistant to alkaline solvents after irradiation
- show unique radiation-induced diffusion of selected metals (Ag, Cu, Zn, In)

The intensity and final products of photostructural transformations in Ag/As_xS_y glasses determine sensitivity and selectivity of lithography process

Application:

Photodiffusion enhanced lithography

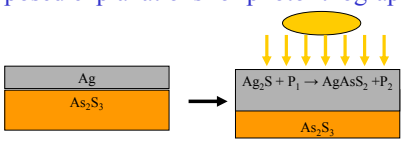


Combine photostructural and compositional changes from photodiffusion of Ag in ChG ⇒ Higher sensitivity and selectivity

Goal:

Establish the mechanism of X-ray induced diffusion of Ag into *a*-As_2S_3

Earlier proposed explanations for photolithography [1]::



It is difficult to product etching profile because:

- There is no experimental information on how the reaction proceeds
- Identity and the distribution of reaction products are not known

Experimental details:

Sample preparation: thermal deposition at UHV vacuum in XPS chamber ~500 Å As_2S_3 + 70 Å Ag

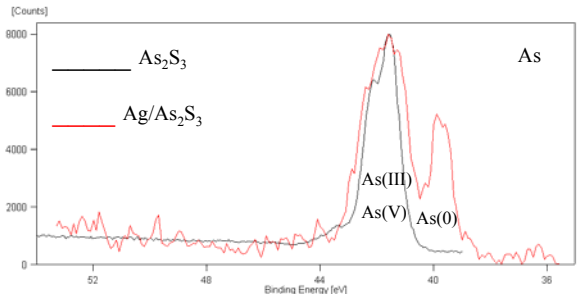
XPS measurements: Scienta ESCA-300, monochromatic Al K_α X-rays, E = 1486.6 eV

Main results:

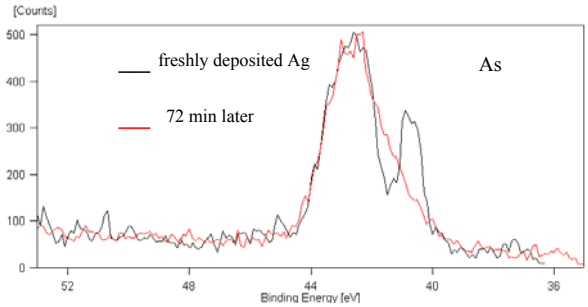
1. Formation of As-enriched layer just after X-ray irradiation on the surface of Ag/As_2S_3

As_2S_3 film: S/As=1.22 **Ag/As_2S_3 layers: S/As=0.73**

2. Part of this As is in metallic form



3. With increasing irradiation time the concentration o metallic As decreases



Conclusions:

- Appearance of metallic As accompanying the possible formation of Ag_2S was observed for the first time in Ag/ChG
- XPS data show two stages of X-ray induced structural transformations in Ag/As_2S_3
- Subsequent transformations of metallic As into As^{5+} is possibly due to formation of $AgAsS_2$ phase

[1] T. Wagner and M. Frumar "Optically induced dissolution of metals in amorphous chalcogenides", in Photo-Induced Metastability in Amorphous Semiconductors, A. Kolob (Ed.), Wiley. Wenham, 2003, p. 160.