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Proceedings of the Advanced Architectures in Photonics 1, 31 (2014).

INVESTMENTS IN EDUCATION DEVELOPMENT
This project is cofinanced by the European Social Fund and the state budget of the Czech Republic

Solution processing of As-S chalcogenide glasses

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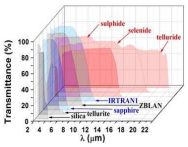
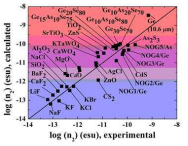
Chalcogenide glasses (ChGs) – properties, applications, processing

Important Properties of ChGs

Infrared Transparency



High Optical Non-linearity



Compounds of S, Se, Te with non-transient metals Ge, Ga, As, Sb, etc.

Optically isotropic, transparent in infrared, high refractive index n = 2 – 3.6

Extremely high optical non-linearity (more than n x 100 vs. silica)

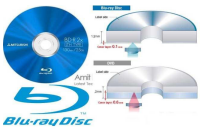
Easy shaping at low temperatures and allow for solution-processing

Applications of ChGs

Infrared Light Transmitting Fibers

Infrared Lenses for Night Vision System

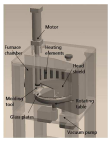
Blue-ray, DVD, CD Data Storage



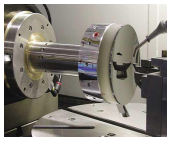
Flat Panel X-ray Detectors (3D-imaging)

Processing of Bulk ChGs

Molding

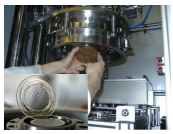


Mechanical Machining



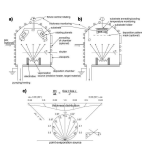
Fiber Drawing

Surface Patterning

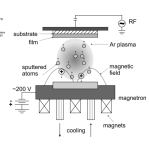


ChG Thin Film Deposition

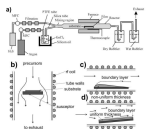
Thermal Evaporation



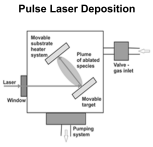
Magnetron Sputtering



Chemical Vapour Deposition

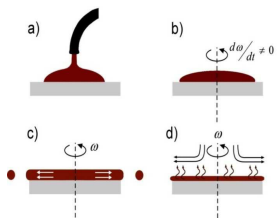


Pulse Laser Deposition

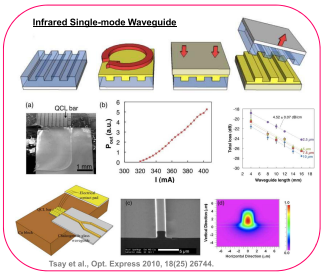


Solution processing of ChGs – not only thin film deposition

Spin-coating



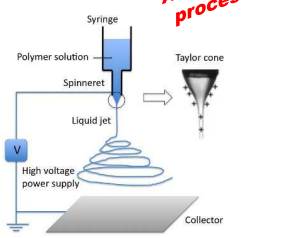
Infrared Single-mode Waveguide



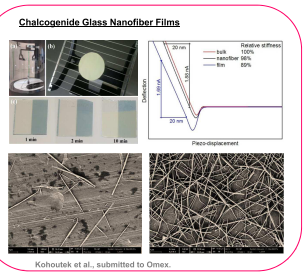
Tsay et al., Opt. Express 2010, 18(25) 26744.

Electrospinning

Anealling free processing !!!

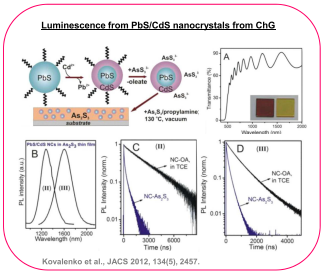


Chalcogenide Glass Nanofiber Films



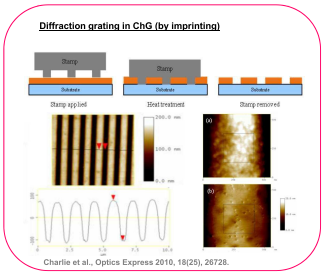
Kohoutek et al., submitted to Omex.

Luminescence from PbS/CdS nanocrystals from ChG



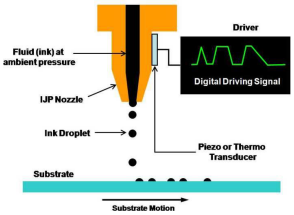
Kovalenko et al., JACS 2012, 134(5), 2457.

Diffraction grating in ChG (by imprinting)

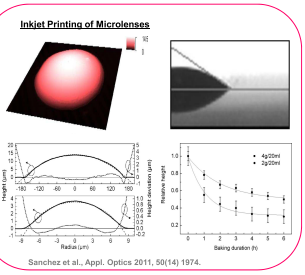


Charlie et al., Optics Express 2010, 18(25), 26728.

Inkjet Printing

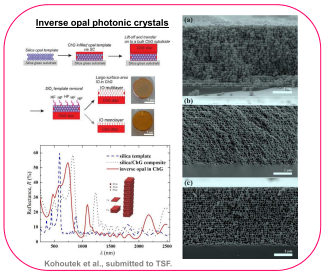


Inkjet Printing of Microlenses



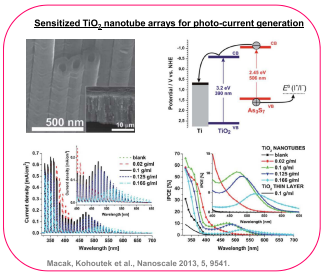
Sanchez et al., Appl. Optics 2011, 50(14) 1974.

Inverse opal photonic crystals



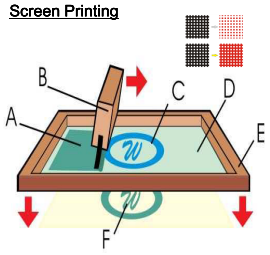
Kohoutek et al., submitted to TSF.

Sensitized TiO_2 nanotube arrays for photo-current generation

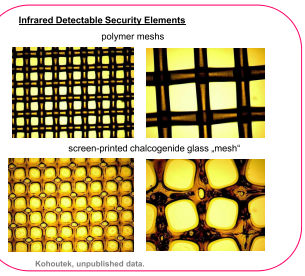


Macak, Kohoutek et al., Nanoscale 2013, 5, 9541.

Screen Printing



Infrared Detectable Security Elements

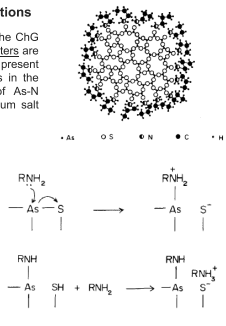


Kohoutek, unpublished data.

Solution processing of ChGs – important issues

Formation of ChG glass solutions

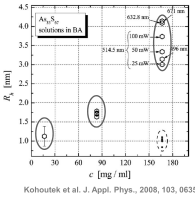
1) In the process of dissolution of the ChG in propylamine solvent the nanoclusters are formed when the free-electron pairs present on nitrogen attack the As-S bonds in the glass leading to the formation of As-N bonds and the quaternary ammonium salt $R\text{-}NH_3^+$ (Chern *et al.*, JAP 1983).



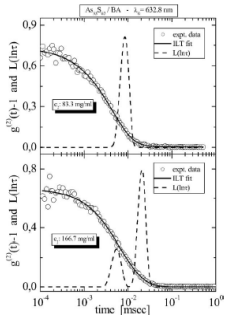
Chern et al., J. Appl. Phys., 1983, 54, 2701.

Cluster size in ChG glass solutions

2) The dissolved ChG is present in amine solution in the form of nanoclusters, with the diameter of several nanometres (Kohoutek *et al.*, JAP 2008) surrounded by molecules of solvent bound to the cluster surfaces. There is a significant excess of free amine solvent.



Kohoutek et al. J. Appl. Phys., 2008, 103, 063511.

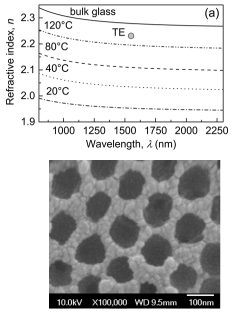


Re-formation of glass network from ChG solutions

3) The glass network is re-formed from the glass solution by aggregation of the nanoclusters. Evaporation of free solvent is promoted by the deposition process.

4) After solidification, the as-deposited glass (film) consists of aggregates with the diameters of some 15–20 times larger than the diameter of the nanoclusters in solution (Norian *et al.*, JAP 1984, Kohoutek et al., JAP 2008). The amount of free solvent trapped in the network is reduced, but is still not negligible.

5) Long-term annealing under vacuum leads to essentially complete release of the solvent from the amorphous network of ChG glass (films). There is a cross-linking of the glass aggregates, followed by significant network densification and reduction in glass volume (film thickness).



T. Kohoutek et al., 2013, Opt. Mater. 36, 390.

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