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The synthesis, characterization and targeting ability of nano-scale enrichment polymer layers

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Introduction

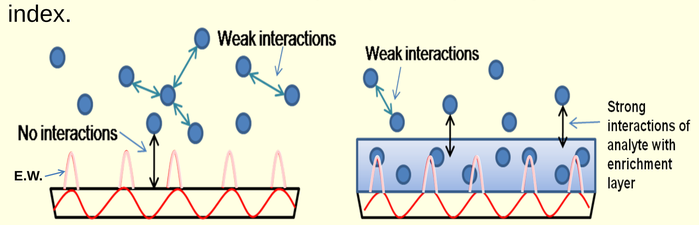
➢Rapid increase in Chalcogenide (ChG) glass research has been spurred on by their excellent optical properties:
- High index contrast (HIC) → compact planar devices
- Photosensitivity (light-induced refractive index change)
- High optical nonlinearity, low two-photon absorption (TPA)
- Large transparency window

➢Nanothick enrichment polymer layer systems (EPLS) are used to attract volatile organic chemicals (VOCs) on ChG waveguide sensors.

➢Ability of polymer layer systems to swell with VOCs determines their applicability as enrichment layers for a "universal" sensor.

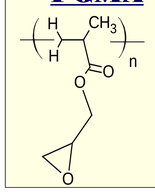
➢Using many polymer layers with different functional groups make the sensor ***"universal"*** to interact with many different analytes but still retain targeting abilities.

➢Detection of analytes is determined by absorption of energy from the evanescent wave (E.W.) and by change of refractive index.

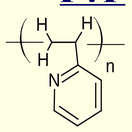


➢Polymers used in the research are Poly(glycidyl methacrylate) (PGMA), Poly acrylic acid (PAA), epoxidized 60% Polybutadiene (EPB60), and Poly(vinylpyridine) (PVP). Structures are below.

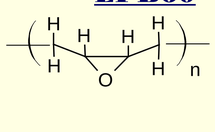
PGMA



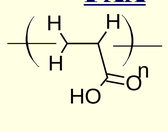
PVP



EPB60



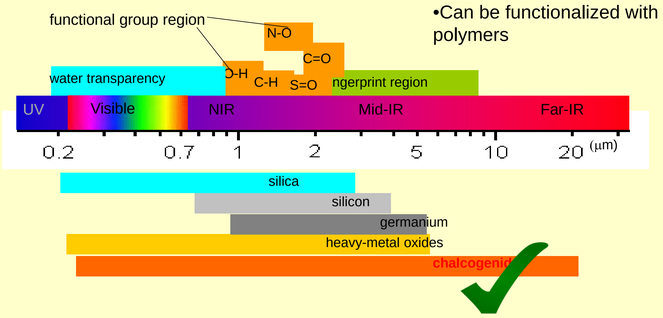
PAA



Important Points on Chalcogenide

Wide transparency windows make chalcogenide glasses ideal materials for biological & chemical sensing

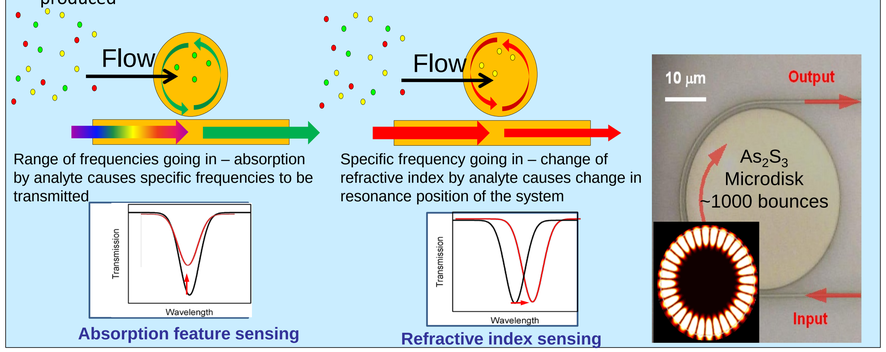
Chalcogenide glasses (ChG) have:
- Excellent IR transparency
- Tailor-able chemistry (S/Se/Te)
- Compatible with CMOS fabrication
- Low loss achievable (dB's/m)
- Can be functionalized with polymers



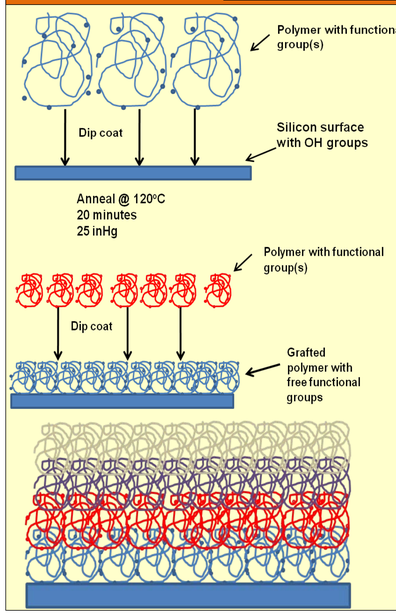
Sensor Design & Sensing Mechanisms

Sensor-on-a-chip: planar integration is the key to *miniaturization*, *low cost*, and *reduced power consumption*

Microdisk resonator traps a specific frequency of light – an increased amount of evanescent waves is produced



Layered System Procedure



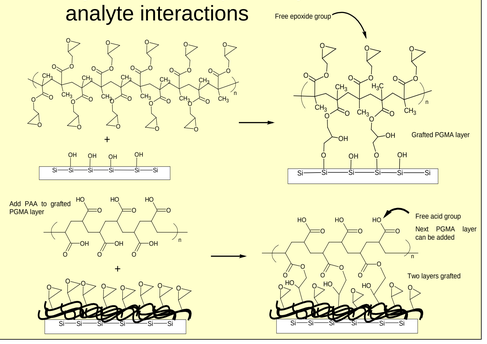
➢Si wafers used as substrates for swelling experiments and Si crystals used for IR experiments

➢Polymers are deposited by dip coating.

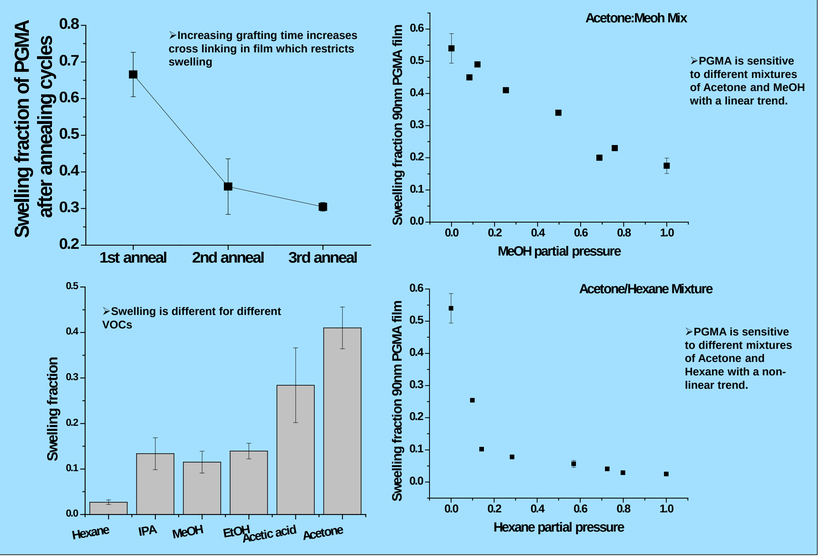
➢Polymers are grafted by annealing and subsequent polymers are dip coated on top of the grafted ones.

➢Layers have different chemistry.

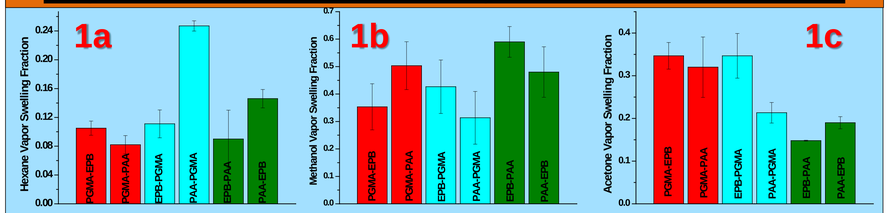
➢Polymers grafted to silicon wafers and crystals for in depth study of EPLS-analyte interactions

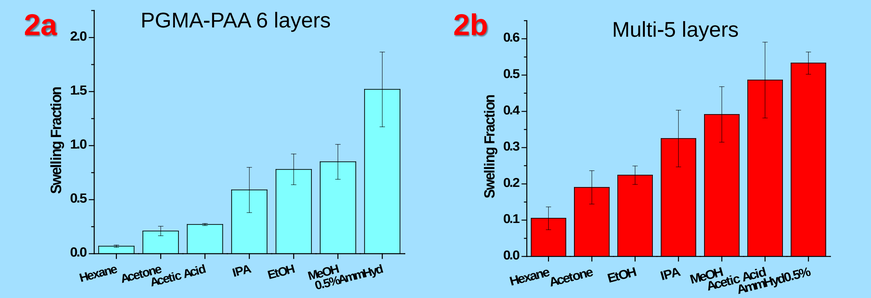


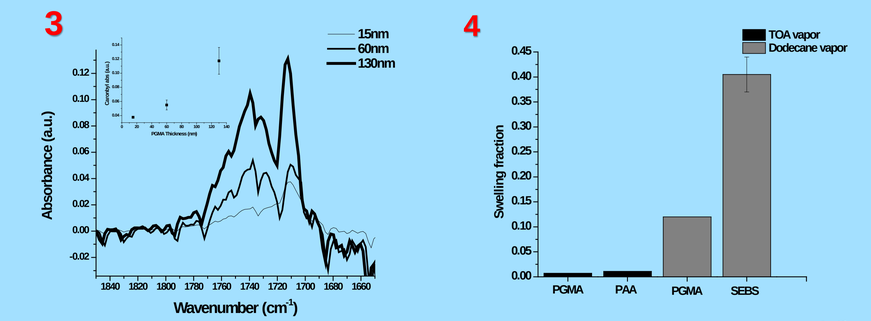
PGMA: Cross linking, Swelling and Mixtures



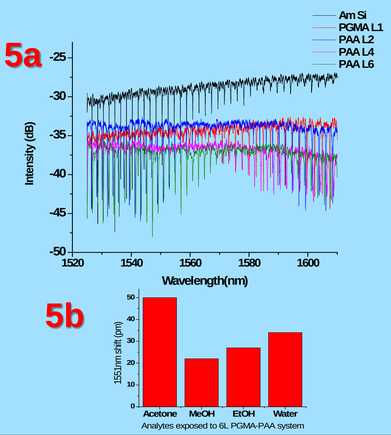
Layer order, enrichment systems, & resonators







1. Swelling of two layer polymer systems with different VOCs for layering order analysis
   a) Hexane
   b) Methanol
   c) Acetone
2. Swelling of polymer enrichment systems with VOCs
   a) PGMA-PAA system, 6 layers total
   b) Multi-polymer system, 5 layers total
3. Thickness affects on absorption strength in FTIR
4. Identification of capable targeting polymers for selected organic chemicals
5. (a) Coating Am-Si resonators with polymers significantly changes resonance coupling. (b) Analyte absorbed onto polymer coated Am-Si resonator demonstrate resonance peak shift and the degree of the shift is analyte dependent



Summary

➢Polymers can be grafted to silicon wafers, crystals and ChG resonator devices through epoxy group functionality found in PGMA.

➢Multi-system swells to different extents with different analytes.

➢PGMA is sensitive to mixtures.

➢Polymers coated onto Amorphous silicon resonators demonstrate sensitivity to chemical vapors by shifting resonance frequency.

Acknowledgements

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•J. David Musgraves[1]

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