

Design, characterization and functionalization of chalcogenide glass waveguides for infrared evanescent wave sensing

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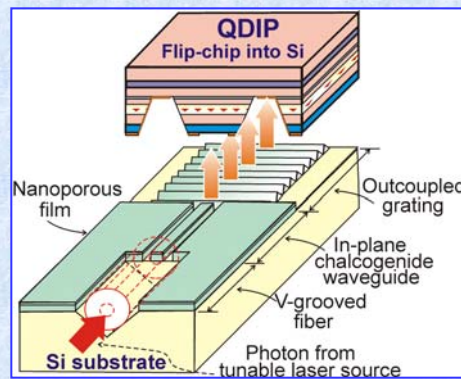
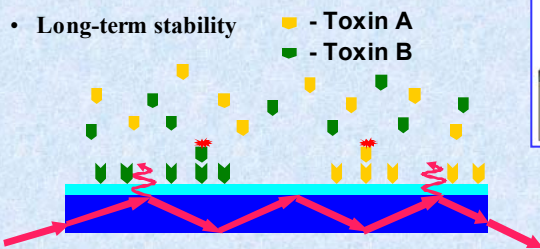
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Objective:

Design, fabricate, functionalize and integrate optical waveguide sensors for remote, chemical analysis over a region by IR spectroscopic methods.

Key Features

- Increased sensitivity to biomolecules
- High Selectivity and Identification of specific chemical compounds
- Immunity to matrix elements
- Potential for Multi-component Detection
- Small size
- Long-term stability



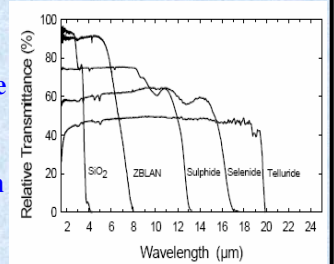
Lehigh-PSU Biosensor Design

Material: Chalcogenide Glasses

High transparency in the infrared region ($\lambda \sim 1-25 \mu\text{m}$) \Rightarrow IR Optical devices

Sensitive to visible light \Rightarrow Easy to manipulate structure (refractive index, band gap, absorption, etc.,) by light.

Easy to fabricate (large areas, any substrate, room temperature) \Rightarrow Low cost

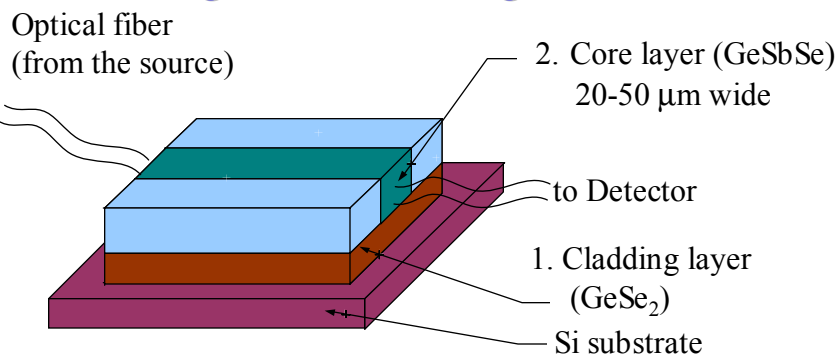


Vibrational mode signature of most toxins are in the IR region and so chalcogenide glasses are needed for their detection
Combination of chalcogenide materials with IR detection creates numerous applications in the civil, medical and military areas

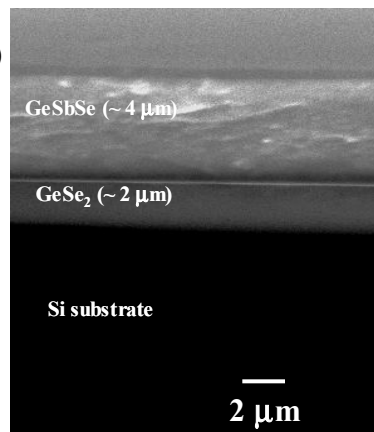
Leaky evanescent wave in a chalcogenide waveguide is absorbed by the toxins on the surface, and thus detected in the transmitted intensity

Ge- based chalcogenides are selected for fabricating the multi layer waveguides

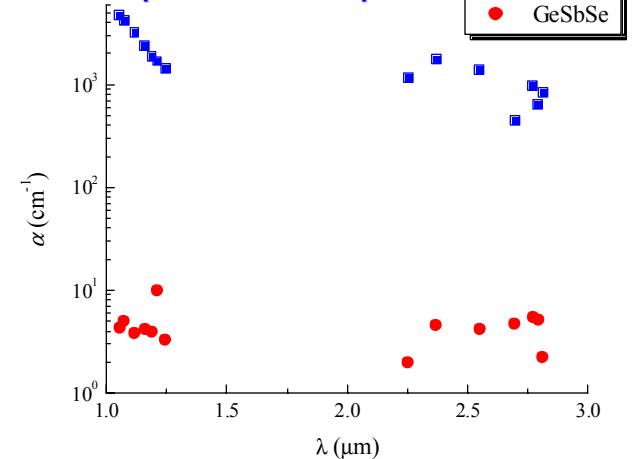
Sensing element design



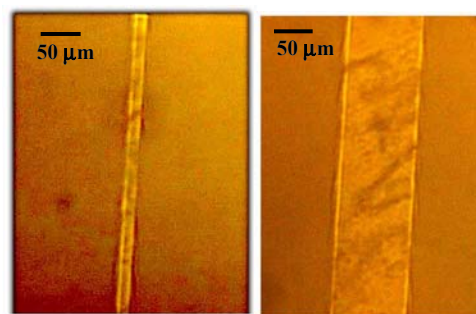
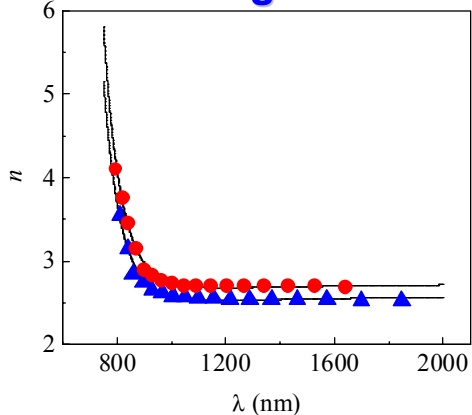
Cross-sectional view



Optical absorption



Laser writing and the resulting changes in refractive index



Channel waveguides

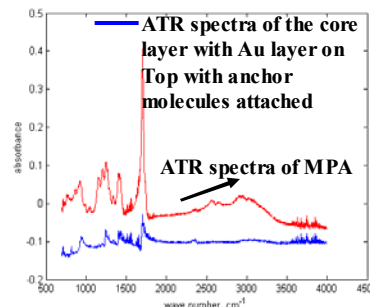
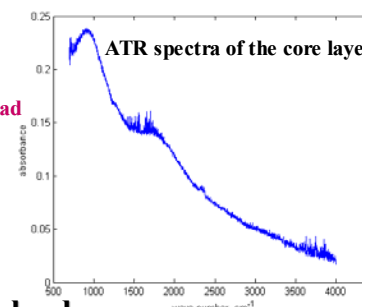
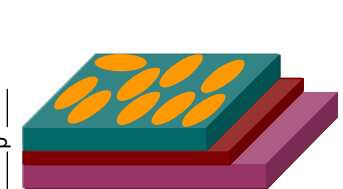
Guiding characteristics @ 1.56 μm



- Fire end coupling of 1560 nm light through a single mode fiber
- In and out coupling through microscope objectives
- Proper alignment by a XYZ translational stage

Changes in the refractive index of GeSbSe layer with laser writing

Functionalization of GeSbSe layer and attachment



- ❖ Top clad layer coated with thin Au islands
- ❖ Anchor molecules MPA (Mercaptopropionic acid) attached to Au islands successfully
- ❖ Antibodies are then attached to -COOH head pointing outwards

Conclusions

- ❖ Multilayered waveguides fabricated successfully
- ❖ Low loss materials determined for the core and cladding layer
- ❖ Refractive index changes of 5 – 6 % achieved
- ❖ Channel waveguides successfully written
- ❖ Waveguiding confirmed
- ❖ Au islands deposited for functionalization of the core layer
- ❖ SAM formed by successfully attaching anchor molecules to the gold layer
- ❖ ATR confirmed the attachment of MPA (anchor molecules) to the Au layer with the relevant peaks and signatures
- ❖ Other anchor molecules being tested for attachment
- ❖ Bio toxins being tested for attachment to the anchor molecules and detection