Solution-processed chalcogenide waveguides on planar and curved surfaces

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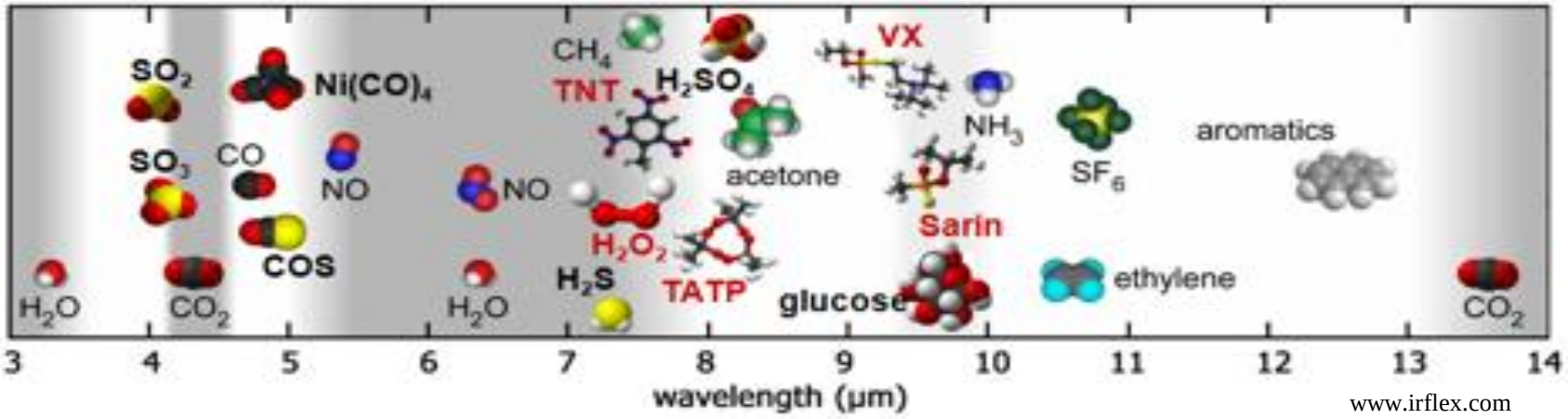
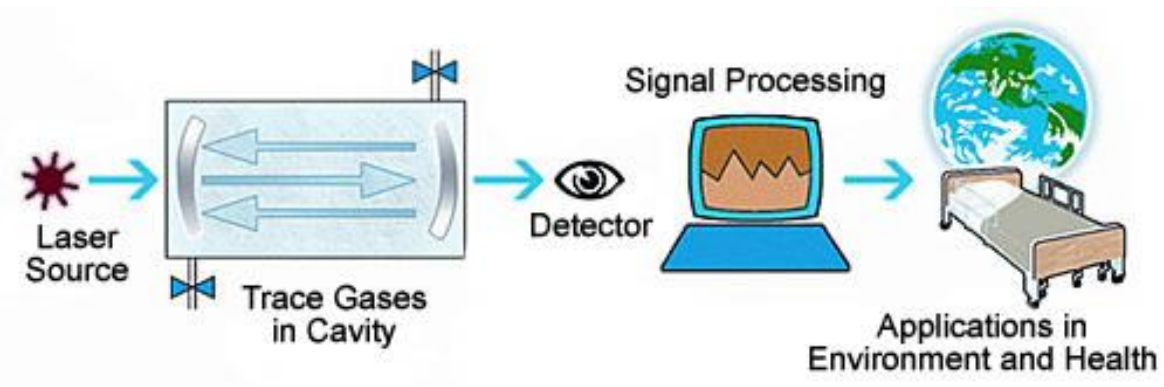
Introduction – Application Driven Research

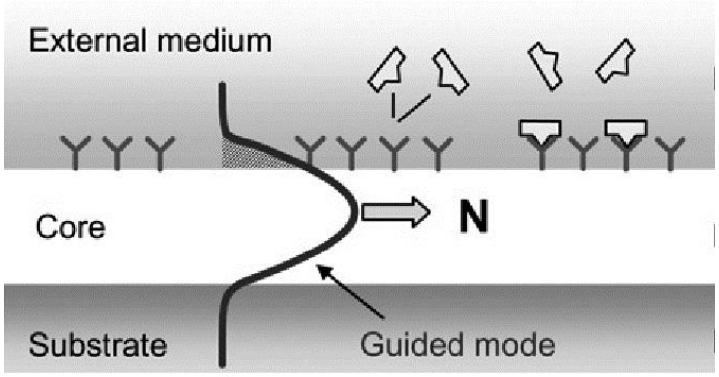
Health and environment sensing in IR



www.irflex.com

Detection scheme: Open-path vs. Guided-wave

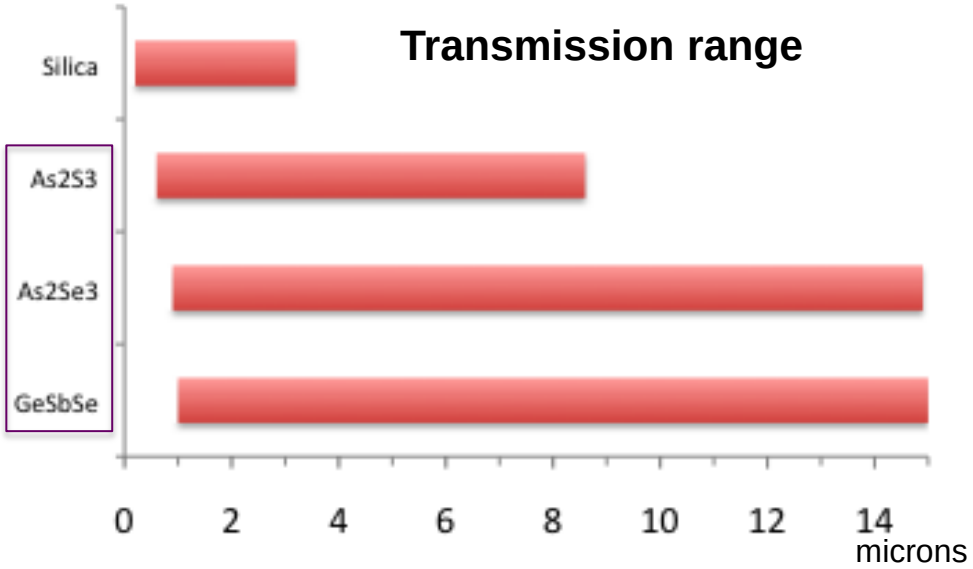




Our research direction↑

Introduction – Chalcogenide Applications

IR waveguiding with chalcogenides



Optical Properties

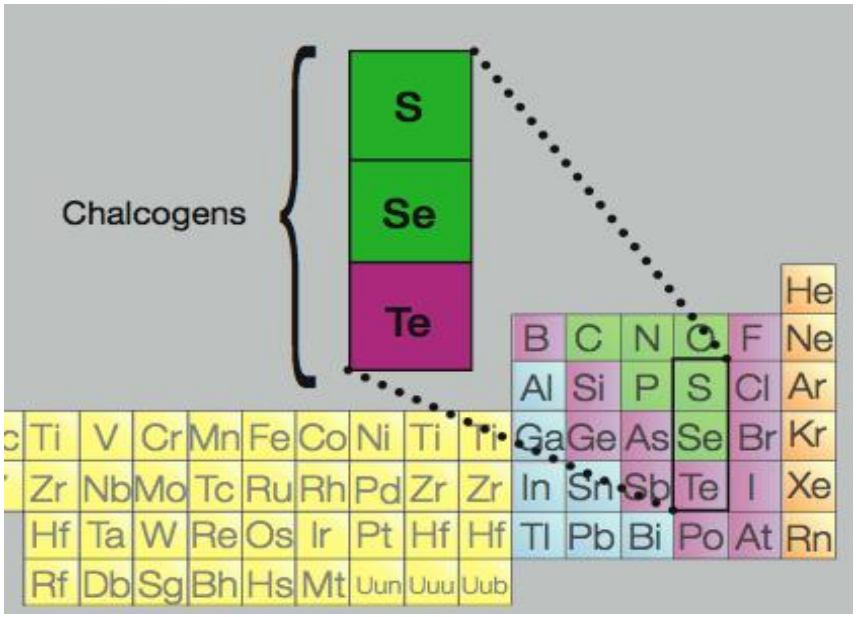
- IR transparent
- High refractive index
- High nonlinearity

Chalcogenide applications

- In the field of photonics, medicine, environmental sensing, communication, security ...
- Detectors, lenses, optical filters, rewritable discs ...

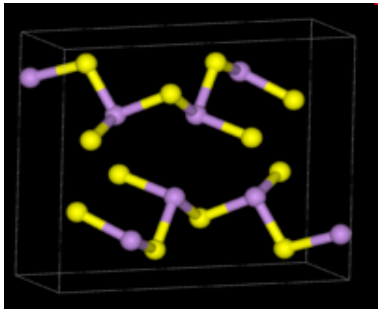
Introduction - Chalcogenide Glass

Chalcogenide material and our pick: arsenic sulfide As_2S_3



S.J. Madden, et al. *Optics & photonics News* (2008)

- Glass structure: Amorphous but locally layer-like
- High glass transition temperature
- Flexible to add other elements
- Dissolvable in amine
- Photo-sensitive



Other IR transparent materials:

KBr, AgCl, CaF_2, BaF_2, ZnSe, MgF_2, Ge, KCl, ZnS, SiO_2, NaCl

What's important:

Transmission range, index of refraction, processing conditions

Introduction –Solution process

Solution-processed chalcogenide waveguides on planar and curved surfaces

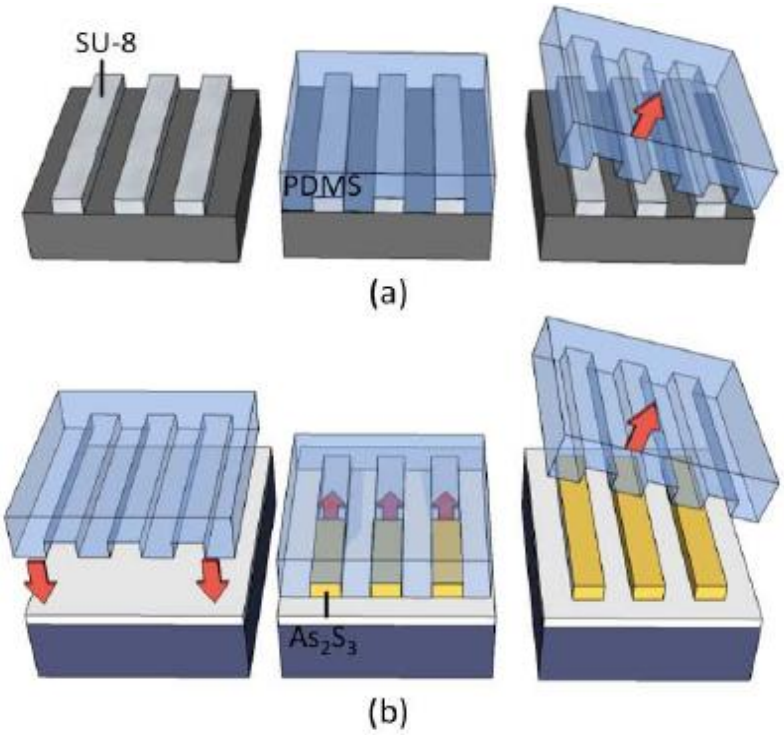
- Pioneered by Chern & Lauks in the 80s
- Advantageous in cost-saving, flexibility and integration
- Deposition on curved surfaces for light guiding, sensing…

	Laser write or Ion diffusion	Vacuum deposition + lithography	Solution process
Cost	> 400K	V expensive	A few K
Flexibility	3D but worse	2D	3D & 2D
Integration	No	No	Yes
Size	Bigger	Small	Small
Processing Time	Long	Long	Short
Temperature	Low	High	Low

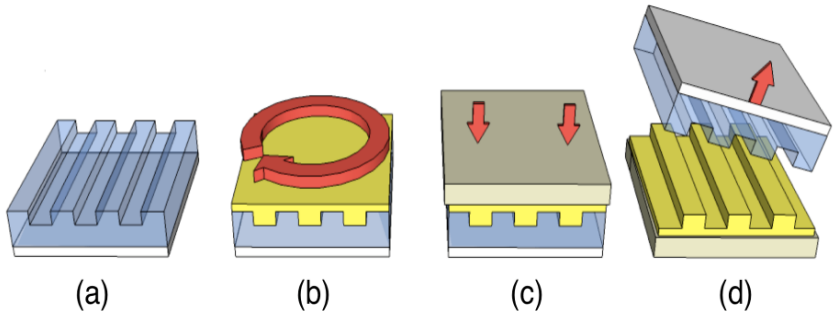
Solution methods – MIMIC & µTM

Step 1: Dissolution (propylamine in our case)

Step 2: Deposition and curing



Micro-molding in capillaries



Micro transfer molding

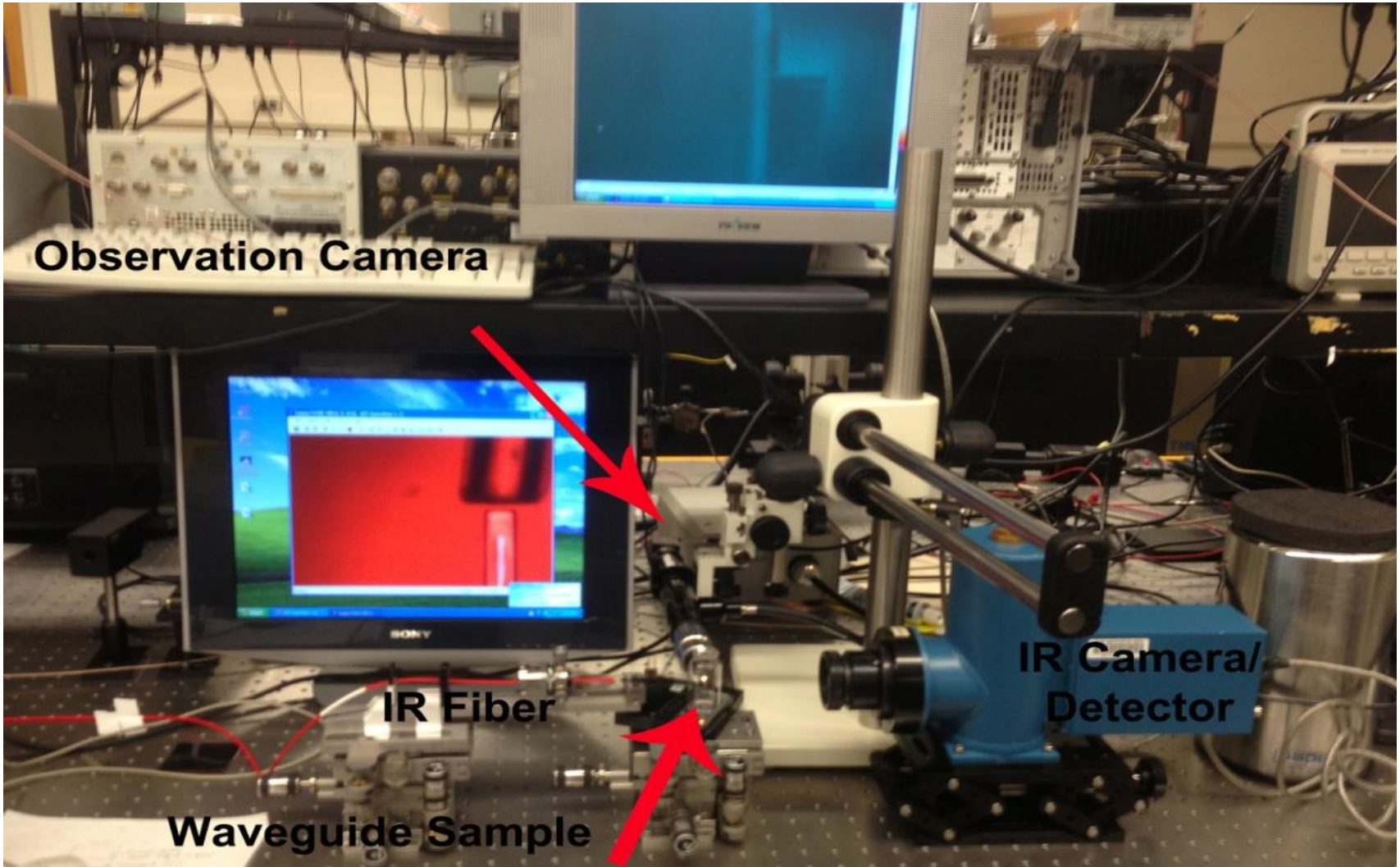
PMDS molding gives the flexibility and integration capability

Application difference between these two methods

Measurement setup

Key components:

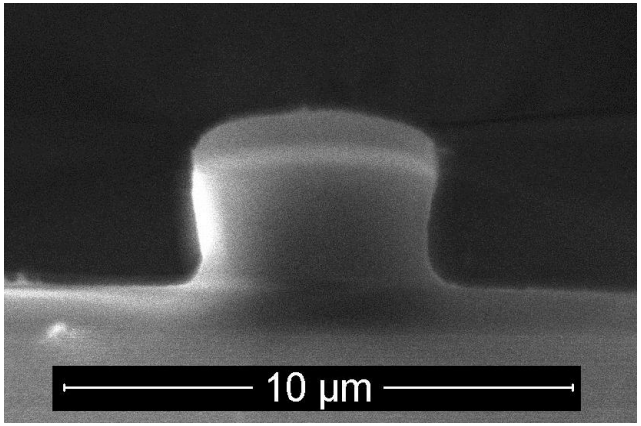
- 150mW pulsed laser tunable from 2.4 to 3.7μm
- 9μm core single-mode fluoride fiber



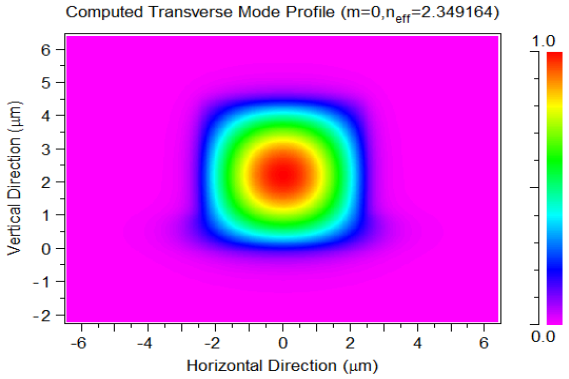
Results – waveguides on flat surfaces

IR transmission test from 2.4 to 3.7μm

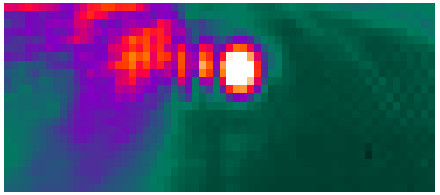
Waveguide SEM profile

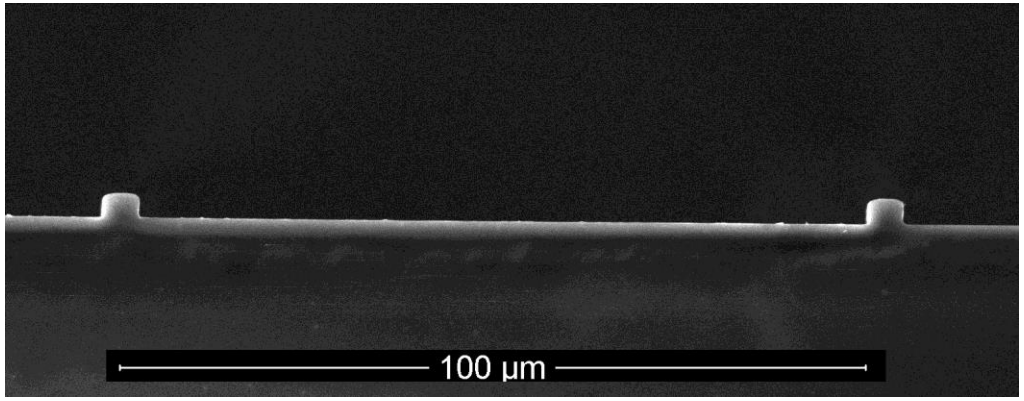


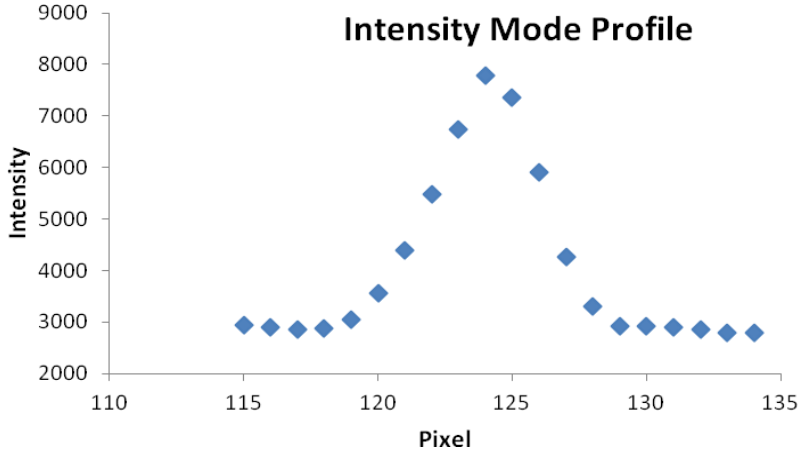
Simulated mode profile



Captured mode profile





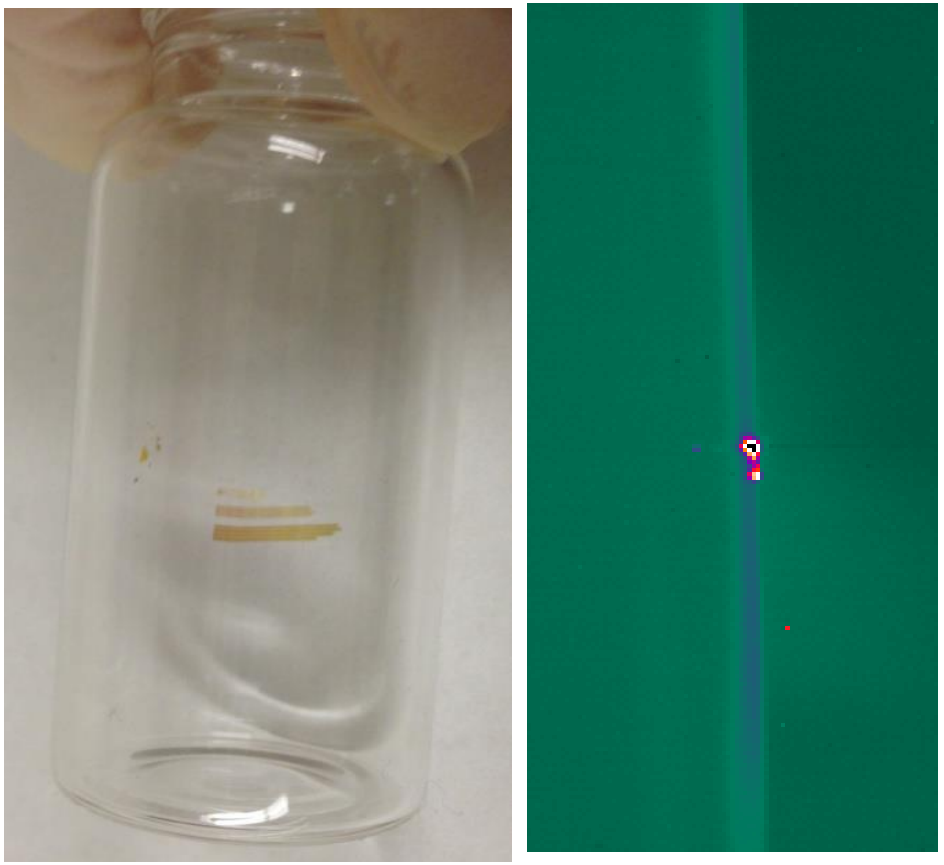


Results – waveguides on curved surfaces

Preliminary light guiding test

Why on a bottle?

- Compact size
- Integration requirement
- Some applications require patterning on unconventional surfaces or in the 3rd dimension: gas sensing



Discussion

Choice of substrates:

- Presented: lithium niobate (high index) and glass bottle
- Problem: uneven cleaved surface, weakly guiding, mode profile distortion, loss
- Strategy: Si wafers with oxide layer on top (flat substrates) and quartz tubes (curved substrates)

Next step experiments:

- Measure waveguide loss in this range
- Minimize loss by processing treatment optimization
- Pattern one round of waveguide on a tube and optimize the transmission

Conclusion

- Demonstrated the feasibility of fabricating chalcogenide waveguide on planar and curved surfaces through solution-processing
- Demonstrated 2.4-3.7 μm IR transmission in such waveguides
- Future experiment should focus on collecting quantitative data with appropriate substrate choices
- Gas detection can be demonstrated (eg. carbon dioxide absorption)

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