Center for Optical Technologies

LEHIGH UNIVERSITY. PENNSTATE 1855

Northampton Community College

Ben Franklin Technology PArtners Northeastern Pennsylvania

Lehigh Carbon COMMUNITY COLLEGE

Characterization of chalcogenide-glass-based waveguide for biosensors

Renbo Song, Xiaodong Mu, Ashtosh Ganjoo, Yujie J. Ding, and Himanshu Jain

Lehigh University, Bethlehem, PA 18015

Motivation:

Fabrication of infrared transmitting waveguides for biosensor and other applications.

➢**Chalcogenide glasses:**

High transmission in infrared & mid-IR region

Non-toxic & simple evaporation technique

Waveguide – formed by illumination

➢**Semiconductor materials:**

Toxic & costly fabrication procedure

Complex etching process or diffusion of impurities for forming waveguide

Background:

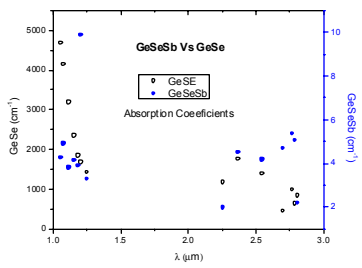
➢-Most pathogens and bio-molecules have characteristic absorption in 2-10 μm wavelength range, therefore we need waveguide working in this range to perform detection.

➢-Chalcogenide glass has high transmission in infrared & mid-IR region.

Waveguide Materials:

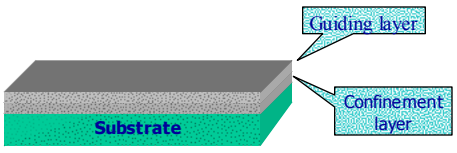
Waveguide medium: GeSeSb or GeSe film deposited on substrate through vacuum evaporation.

Substrate: Si or SiO_2 glass



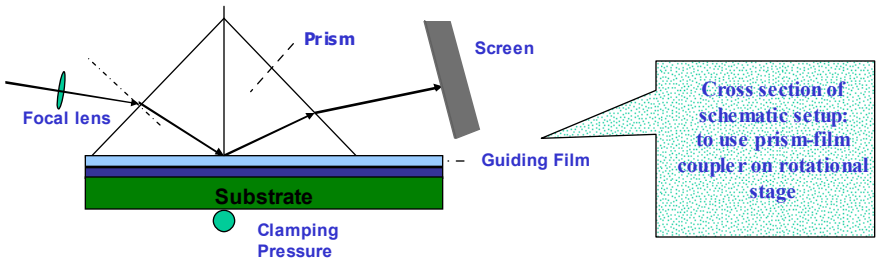
✓Absorption Coefficients for GeSeSb – much lower!

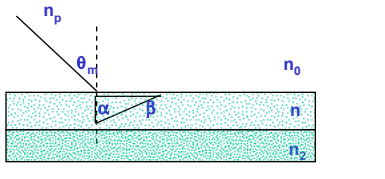
Waveguide Design:



- **Guiding layer:** GeSeSb, *n~2.7*
- **Substrate:** Si – easy to form optical-quality facets for coupling (cleavage), *n~2.4*
- **Confinement layer:** $GeSe_2$, *n~3.5*

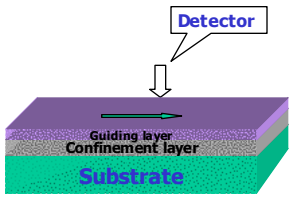
Waveguide Characterization method-prism coupling:





$$n_m = n\sin\alpha = n\sqrt{1-[(m+1)\pi/(\beta d)]^2}$$

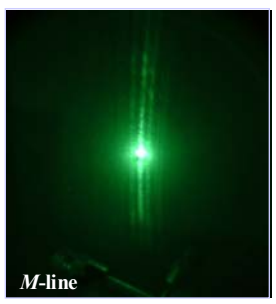
$$n_p \sin\theta_m = n_m$$

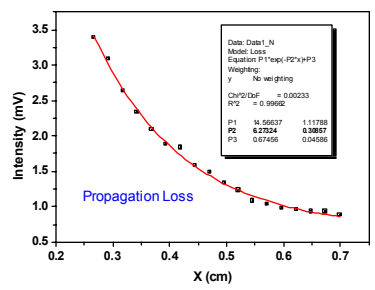


Propagation Loss Measurement:
Intensity of surface-leaked guided-wave ∝ Guided-wave intensity

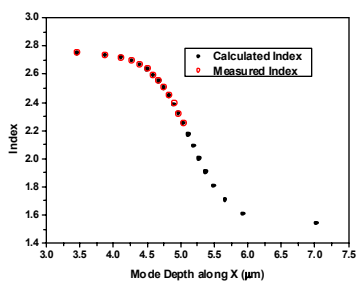
Characterization Results:

(a)$GeSeSb/SiO_2$ waveguide-*m* line & Propagation loss —to be used as guiding layer





(b) Index Profile for $GeSeSb/SiO_2$ waveguide



Fermi Mode Index Model:

$nx = ns + \Delta n/\{1 + \exp[(x-d)/a]\}$

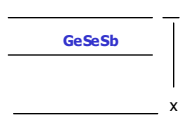
$\lambda = 1.2\mu m$

$ns = 1.535$

$\Delta n = 1.213$

$d = 5.1482$

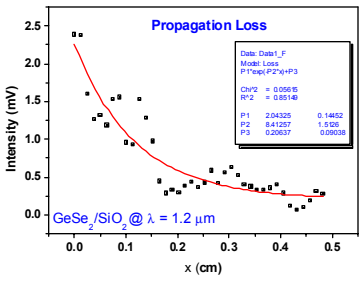
$a = 0.2846$



$n = ns + \Delta n = 2.748$

- Index profile is a Fermi Mode Index Function

(c) $GeSe_2/SiO_2$ waveguide propagation loss and refractive index -to be used as confinement layer

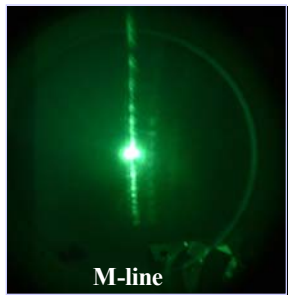


- By measuring TM modes using prism coupling technique at λ=1.2μm:

Refractive Index n≅2.333<2.7

Based on indices for $GeSe_2$ measured by us, $GeSe_2$ can be used to effectively confine IR waves inside GeSeSb layer in slab-waveguide structure

(d) Wave-guiding & End-fire coupling of $GeSeSb/GeSe_2/Si$ waveguide



Conclusions:

- Prism-coupling Technique is developed for characterizing the waveguide in the infrared region
- Material for waveguide, GeSeSb, is successfully selected and characterized
- Planar Waveguide for biosensors is designed & wave-guiding and end-fire coupling are successfully achieved