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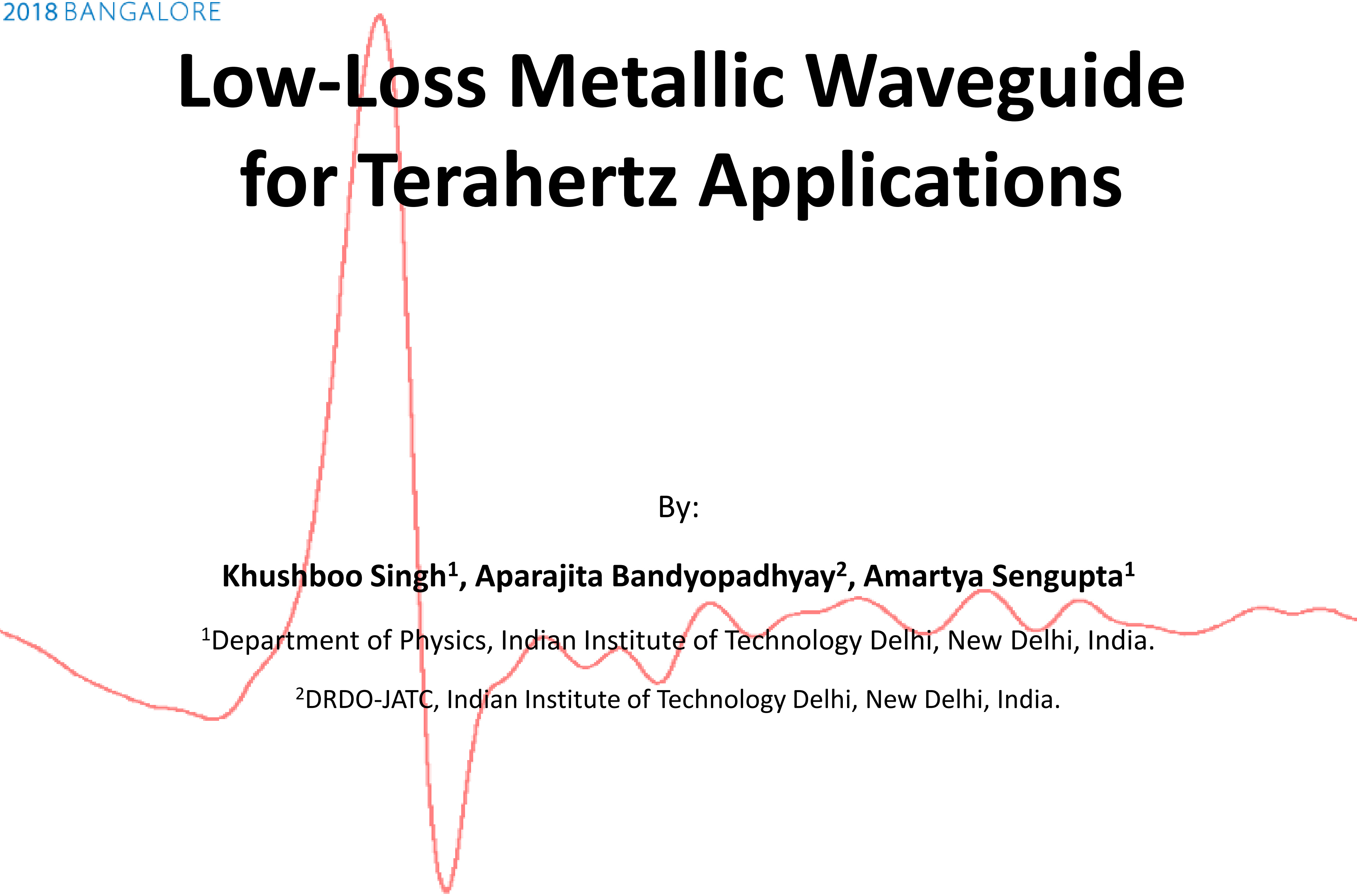


Low-Loss Metallic Waveguide for Terahertz Applications

By:

Khushboo Singh[1], Aparajita Bandyopadhyay[2], Amartya Sengupta[1]

[1]Department of Physics, Indian Institute of Technology Delhi, New Delhi, India.

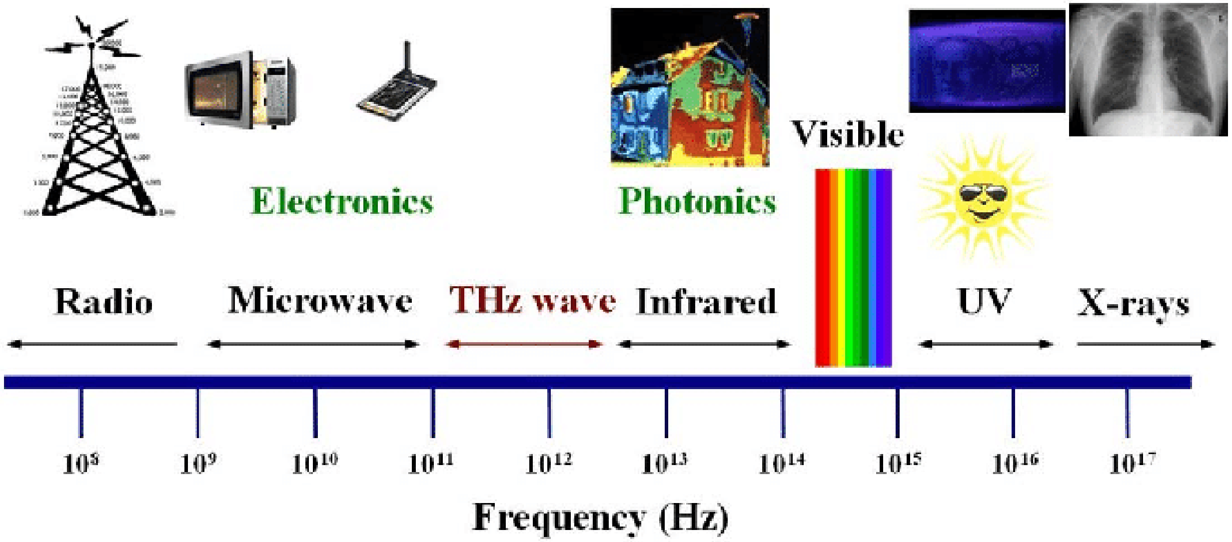
[2]DRDO-JATC, Indian Institute of Technology Delhi, New Delhi, India.

Outline

- Introduction
- Proposed model
- Simulation method
- Result and Discussions
- Conclusions and Future Work
- References

Introduction

- Terahertz (THz) waves are also known as sub-millimeter waves or T-rays.
- It was not much explored until early 1980s due to unavailability of efficient THz sources and detectors.



- Frequency range: 0.3 – 10 THz.
- Wavelength range: 1000 – 30 µm.
- Energy range: 1.2 – 41 meV.

Fig. 1 Electromagnetic wave spectrum showing THz region

Ref. 1 - http://blog.bahaykuboresearch.net/2011/10/04/intense-terahertz-emission-from-undoped-gaasn-type-gaas-and-inasalsb-structures-grown-on-si-substrates/

Properties and Applications

- Low photon energy: cannot photoionise biological tissues like X-rays.
- Less effected by Mie scattering: it is transparent to most dry dielectrics.
- Extreme water absorption: cannot penetrate human body like microwaves.
- Detects molecule specific vibrational and rotational transition.

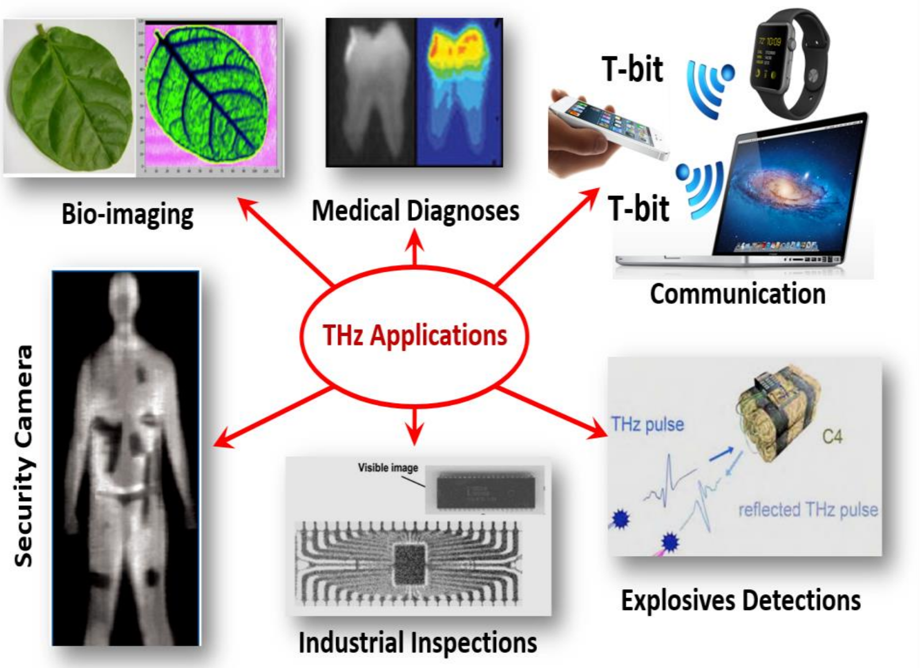


Fig. 2 Applications of THz waves in different fields

Ref. 2- http://www.imp.tu-darmstadt.de/forschung_imp/ont_imp/ntt.de.jsp

Proposed Waveguide Model

- T-rays cannot propagate long distance in atmosphere due to extreme water absorption.
- Metallic hollow core waveguides offer THz propagation with low loss.
- In proposed model, two interface layers of Gallium-doped zinc oxide (GZO) and Indium doped tin oxide (ITO) has been added.
- Addition of interface layers solve the problem of ohmic losses.
- The thicknesses of the layers have been optimized.

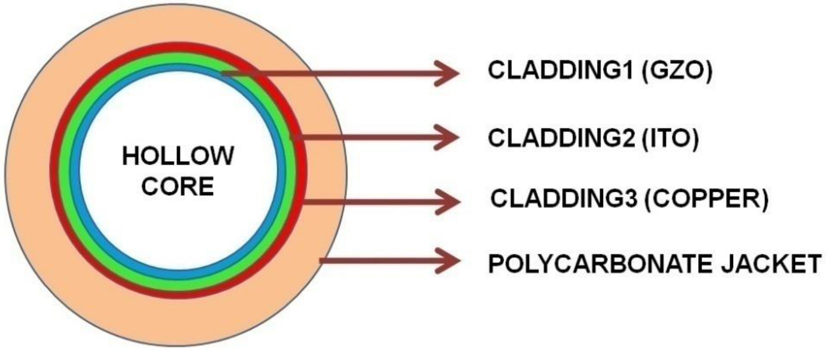


Fig. 3 2D structure of proposed model

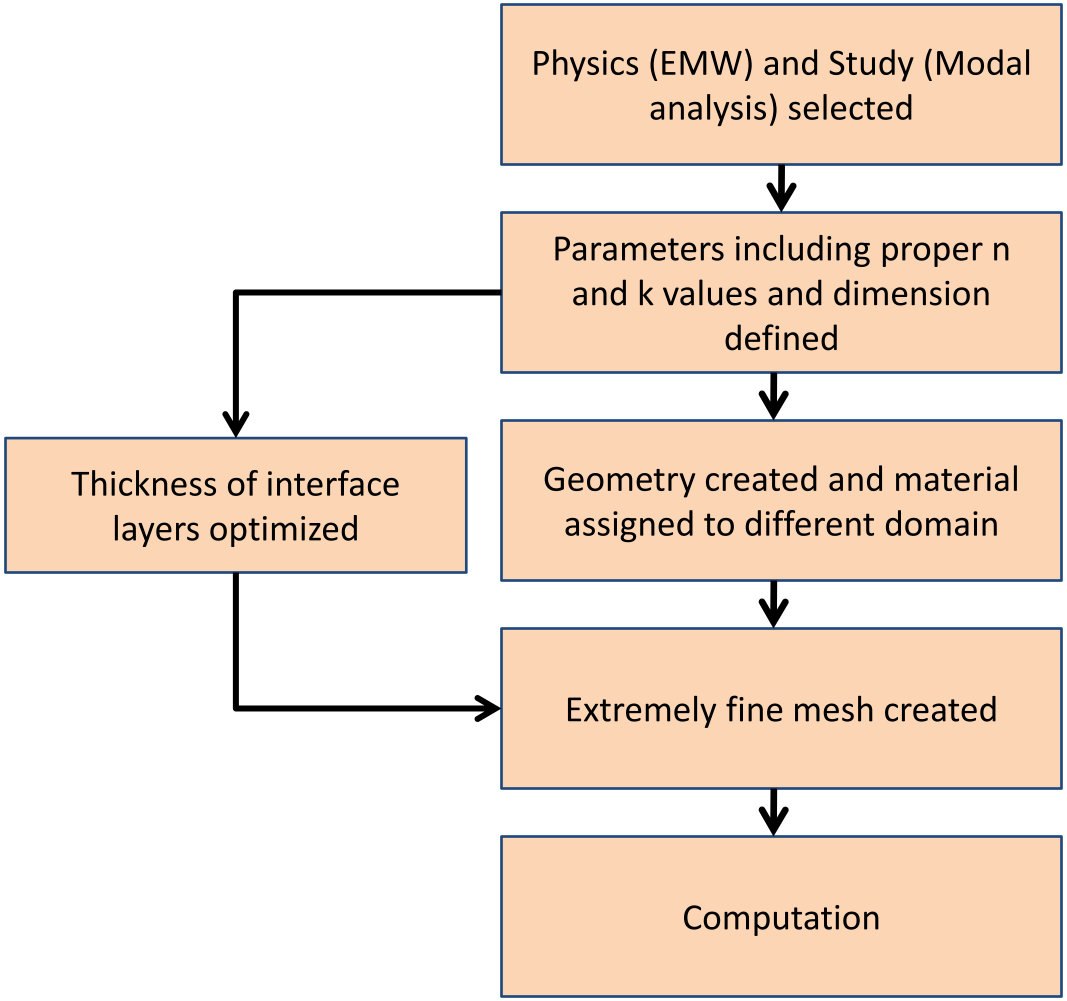
- The attenuation for the core-confined mode has been calculated using :

$$\alpha = \left(\frac{u_{nm}}{2\pi}\right)^2 \left(\frac{\lambda^2}{a^3}\right) \mathrm{Re}\left(\frac{1}{\sqrt{n^2 - 1}}\right)$$

where, u_{nm} is the m^{th} root of n^{th} order Bessel function, λ is the operating wavelength, a is the radius of core and n is the complex effective mode index.

Simulation

- The proposed 2D structure was simulated in RF module.



Physics (EMW) and Study (Modal analysis) selected

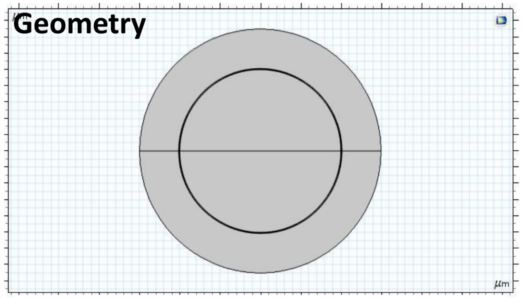
Parameters including proper n and k values and dimension defined

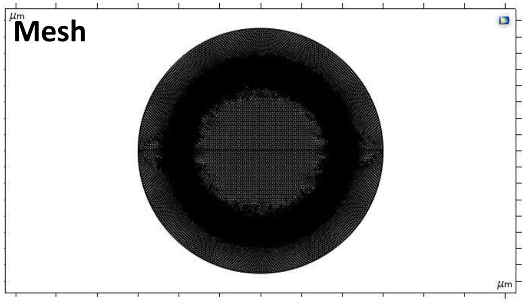
Thickness of interface layers optimized

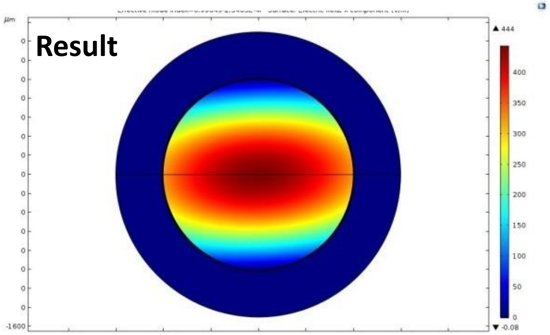
Geometry created and material assigned to different domain

Extremely fine mesh created

Computation







Results

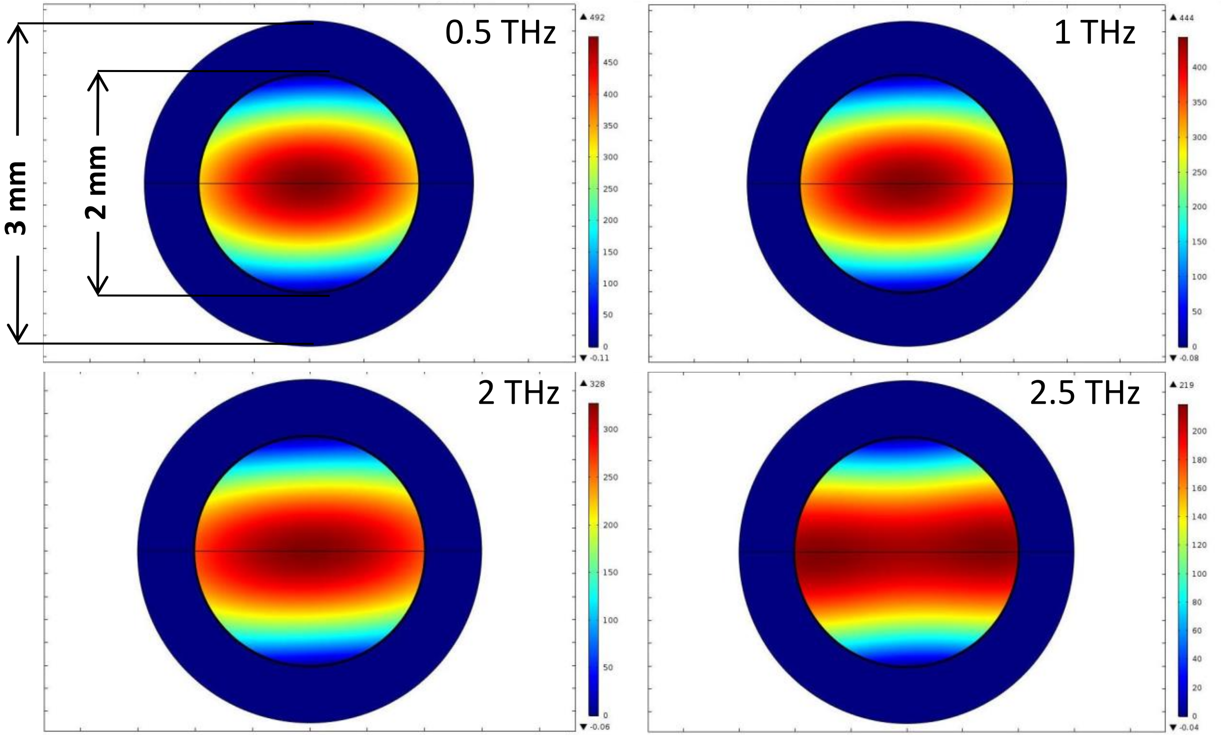
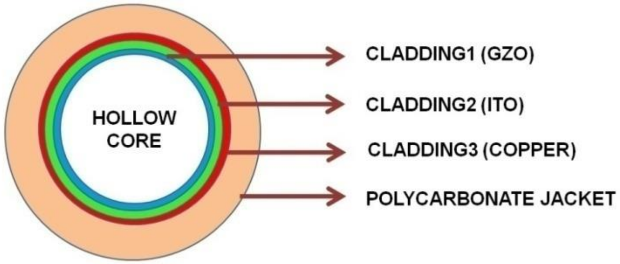


Fig. 4 2D surface plot of low loss mode in THz waveguide at (a) 0.5 THz (b) 1 THz (c) 2 THz and (d) 2.5 THz



Layer	Material	Optimized thickness (µm)
Cladding 1	GZO	5
Cladding 2	ITO	8
Cladding 3	Copper	1

Table 1 Thickness obtained after optimization

Results

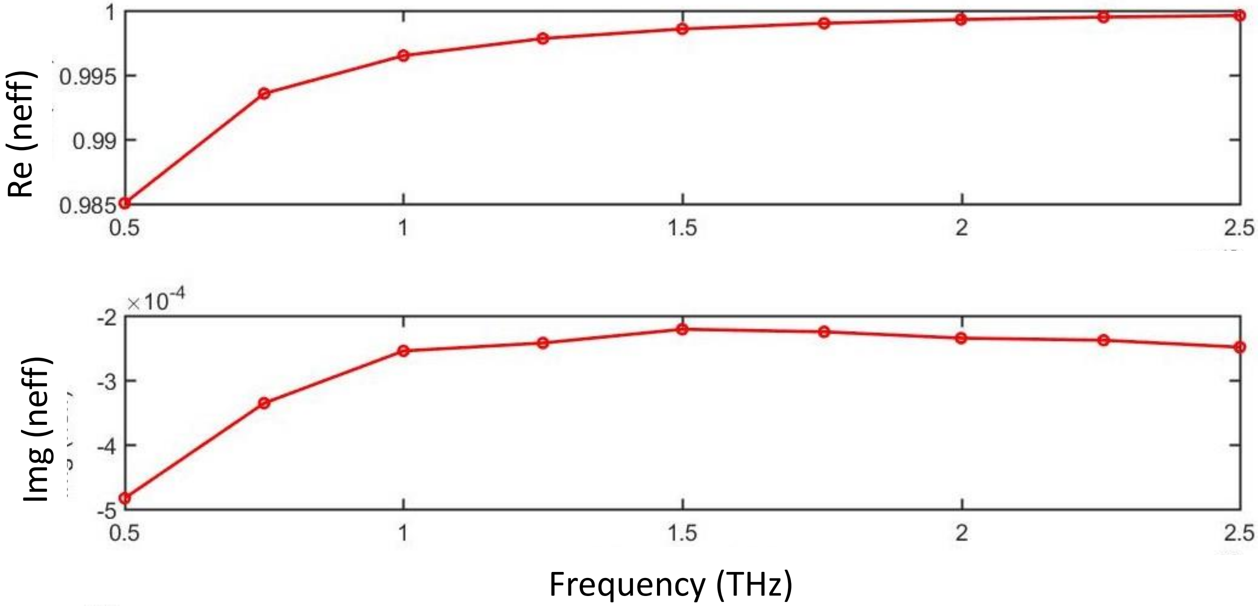


Fig. 5 Variation of effective mode index with operating

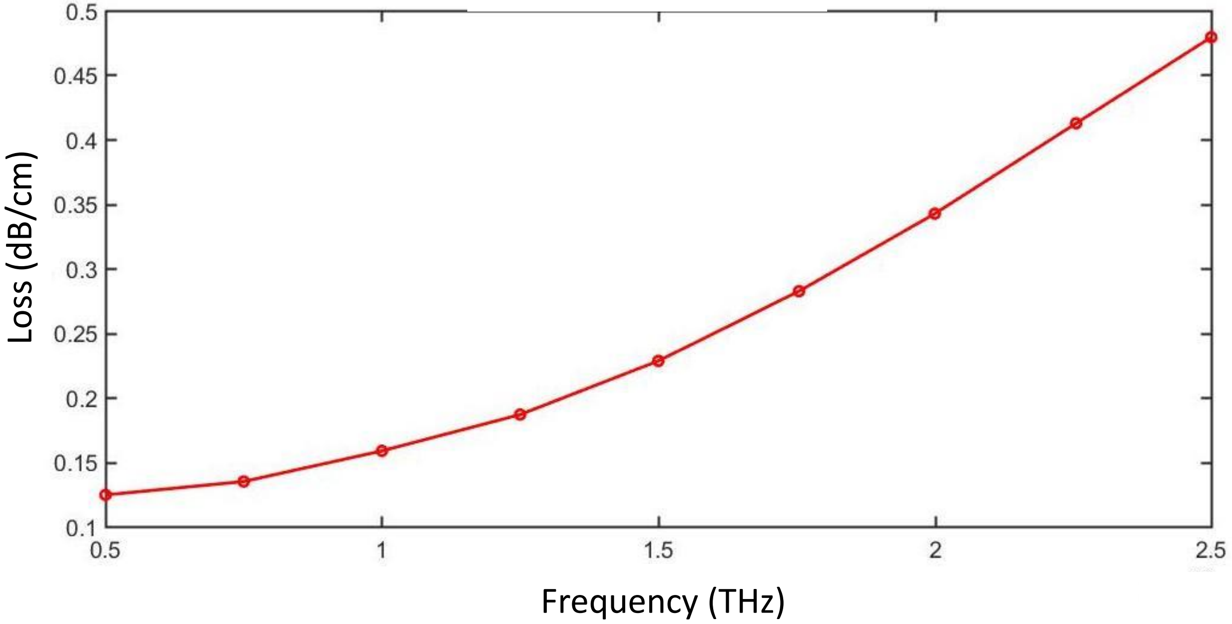


Fig. 6 Plot of core-confined mode loss at different frequencies

Results

- In order to optimize the thickness, the core-confined loss for different thicknesses have been calculated at 1 THz.
- The loss decreased as the thickness was reduced, and after 10 µm the loss almost saturated.

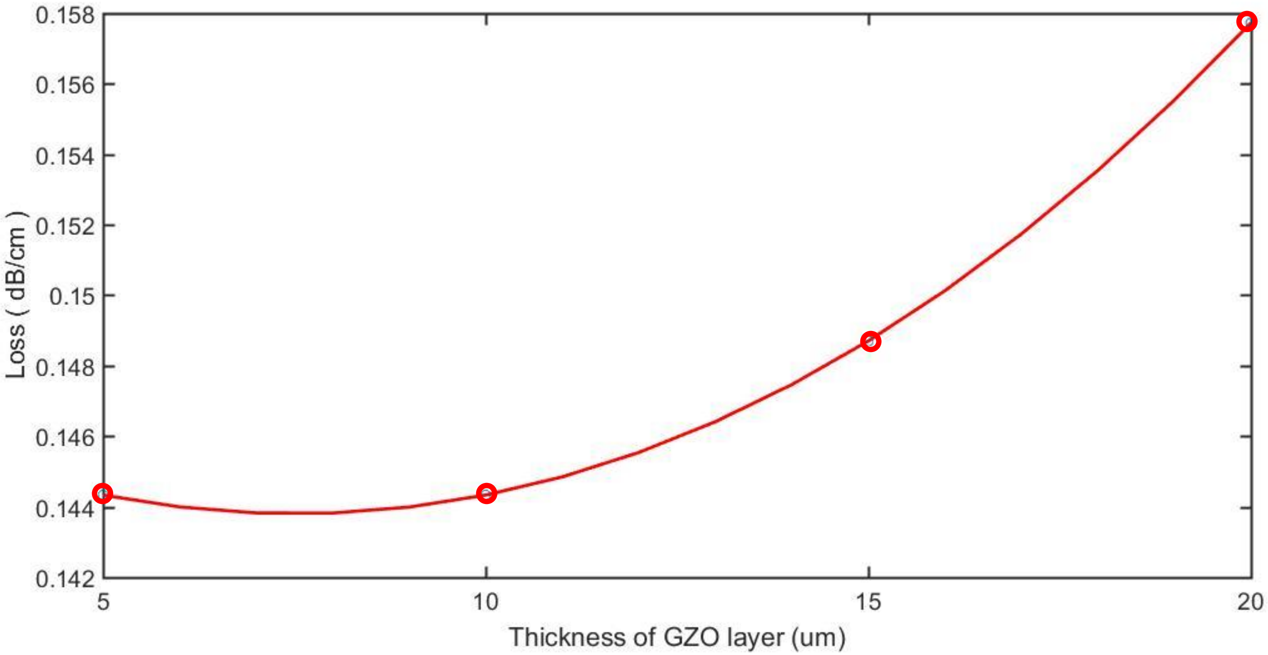


Fig. 7 Plot of loss for different thickness of GZO layer at 1 THz

Conclusions and Future Work

- The simulated structure is able to produce core-confined mode up to 2.25 THz.
- The thicknesses were optimized and hence the structure possesses minimal fabrication complexity.
- The waveguide can be used for THz applications such as probe for THz sensing and imaging.
- The structure can be simulated with different set of interface layers to further reduce the loss.
- The operating bandwidth can be improved by adding more interface layers.
- In future, the structure will be fabricated and characterized by obtaining other losses such as scattering loss, dispersion and coupling loss using THz time domain spectroscopy.

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