

The Need For More Efficient Electronics

“The Internet will soon have a carbon footprint equivalent to a large industrialized country”

-The Guardian- <https://www.theguardian.com/environment/2010/aug/12/carbon-footprint-internet>

Google's Big Data Center

Information Is Processed with
Photonic Devices



<http://www.pngmart.com/image/58330>

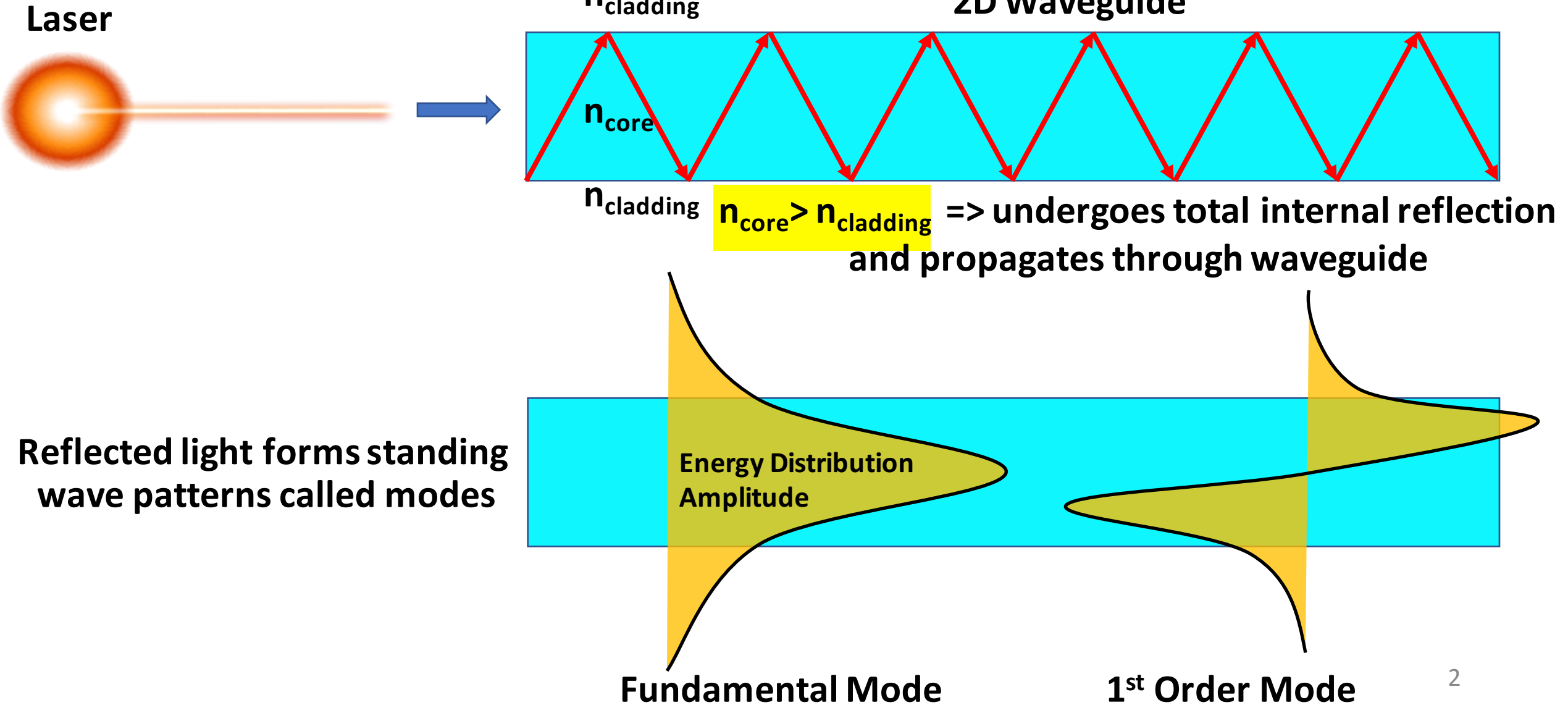
<https://www.merrymesh.com/fiber-optic-cable.html>

Why Photonics?

- Extremely Low Loss at 1.55 μm for Long Distance communications
- Large Bandwidth

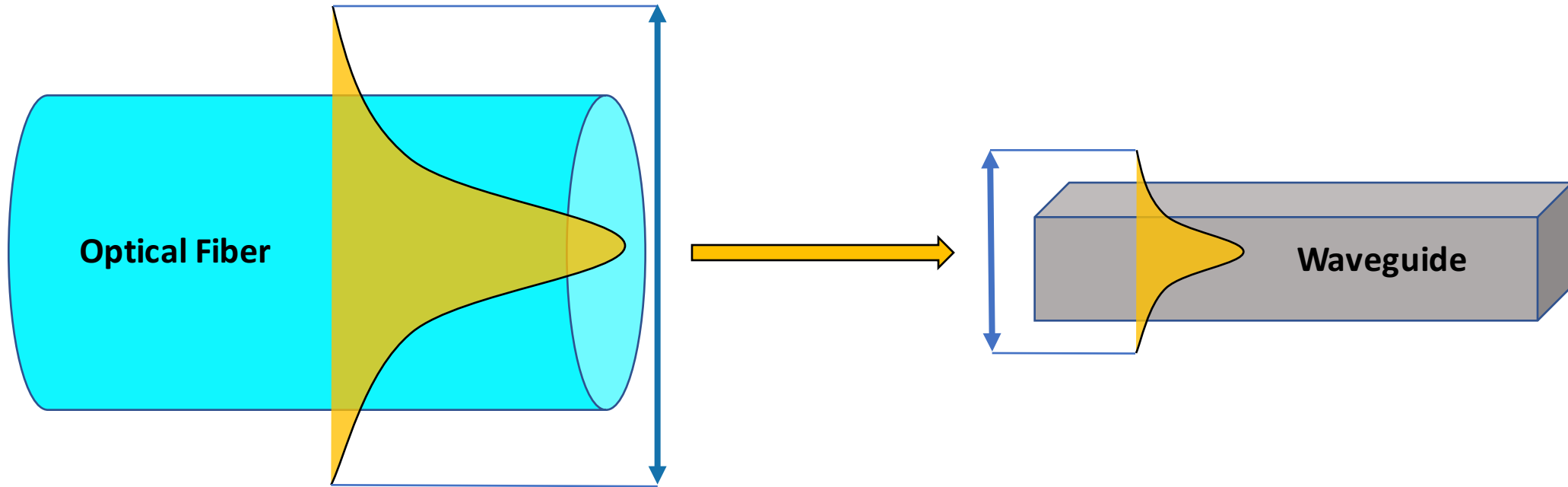
<http://fortune.com/2016/09/30/amazon-google-add-data-centers/>

Waveguide Fundamentals

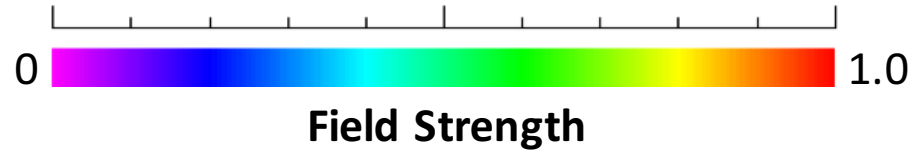


Better Efficiency Solutions

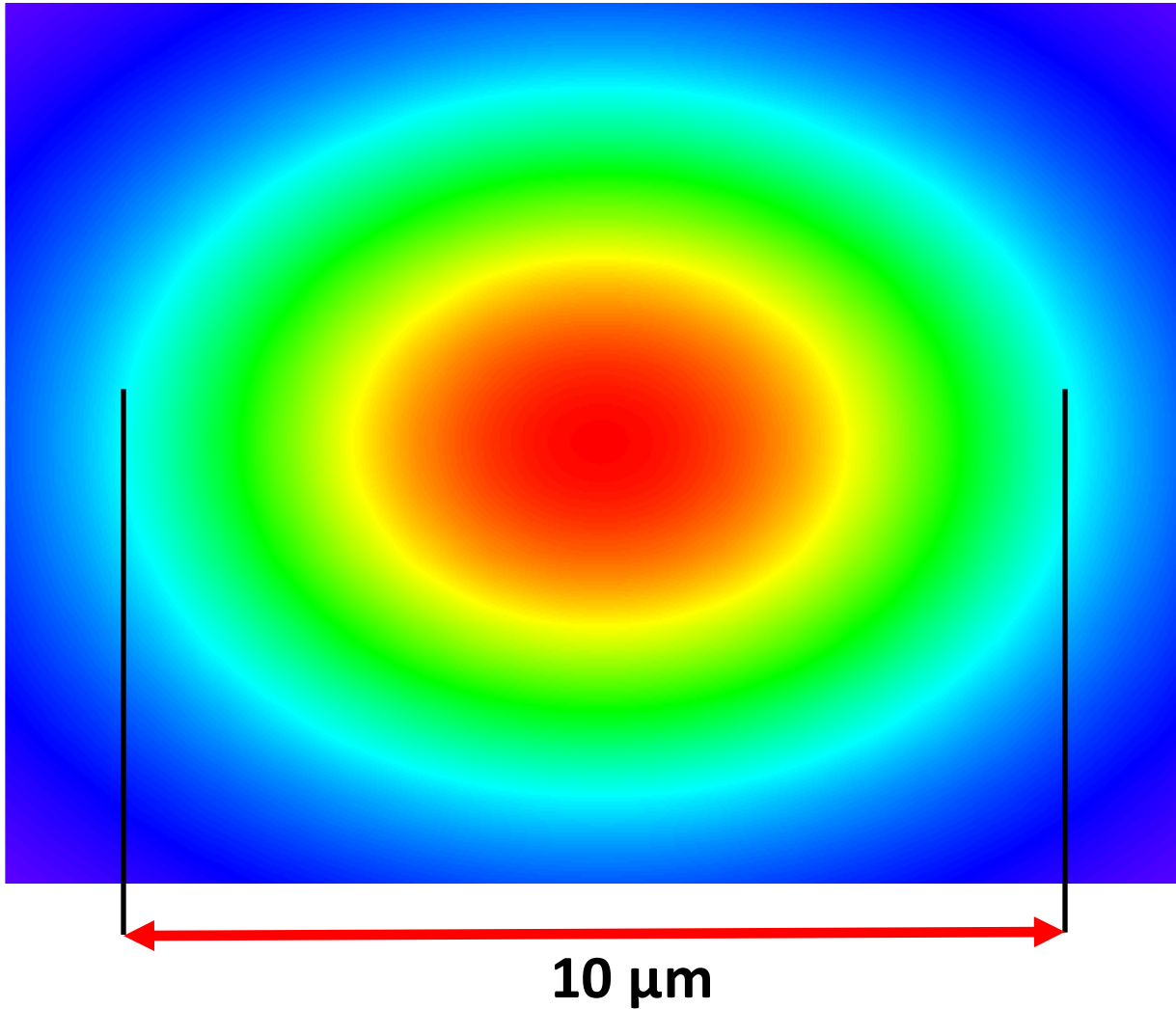
1) Reduction of Modal Size Mismatch



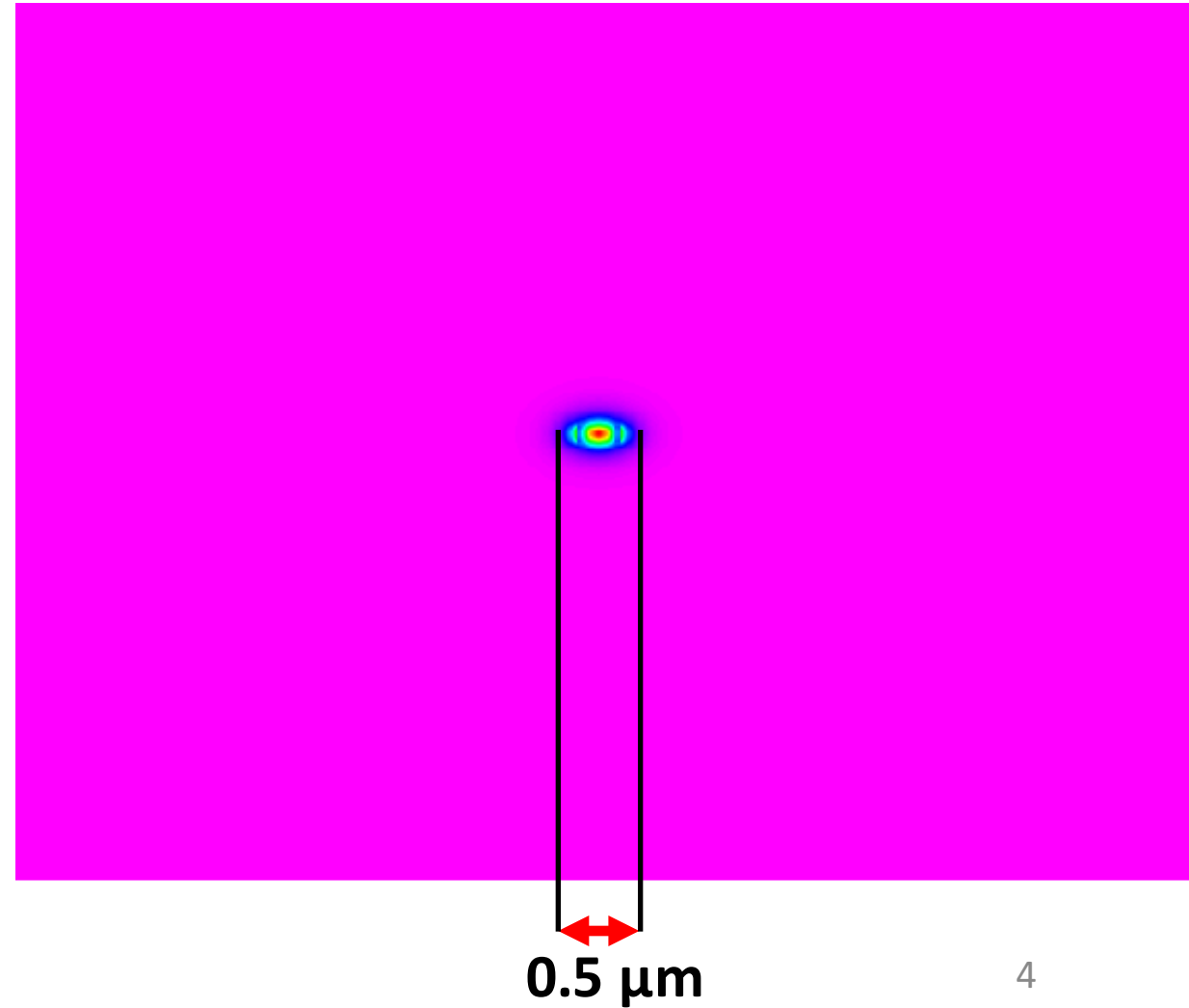
Fiber Vs Semiconductor Waveguide Mode Size



Fiber

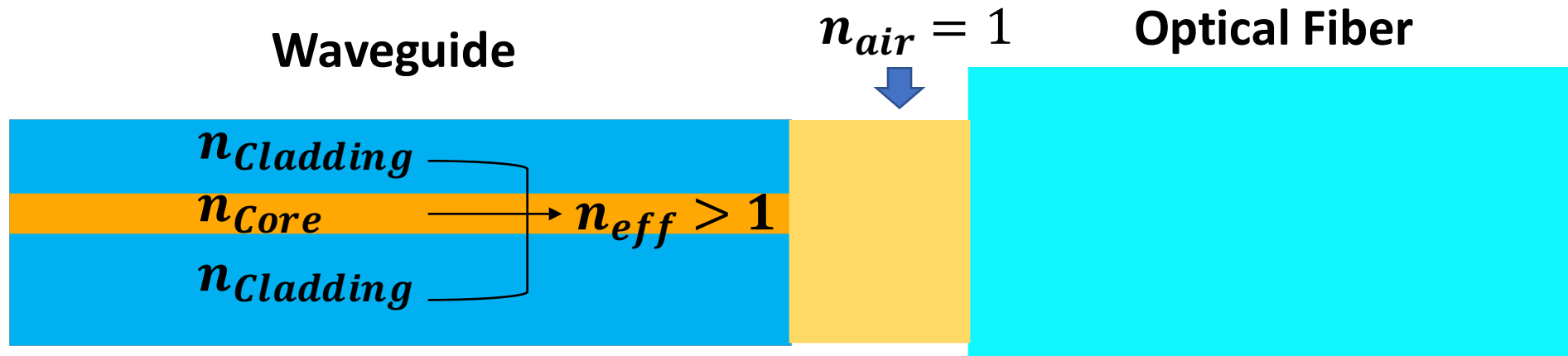


Waveguide



Better Efficiency Solutions

2) Reduce effective index to minimize power reflection



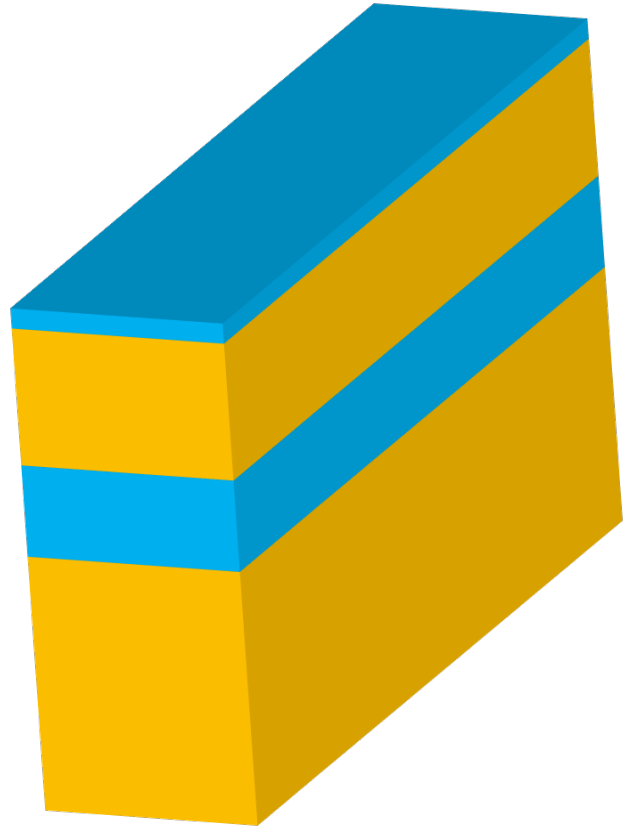
n_{eff} depends upon:

➤ n_{Core} & $n_{Cladding}$ → $n_{Cladding} < n_{eff} < n_{Core}$

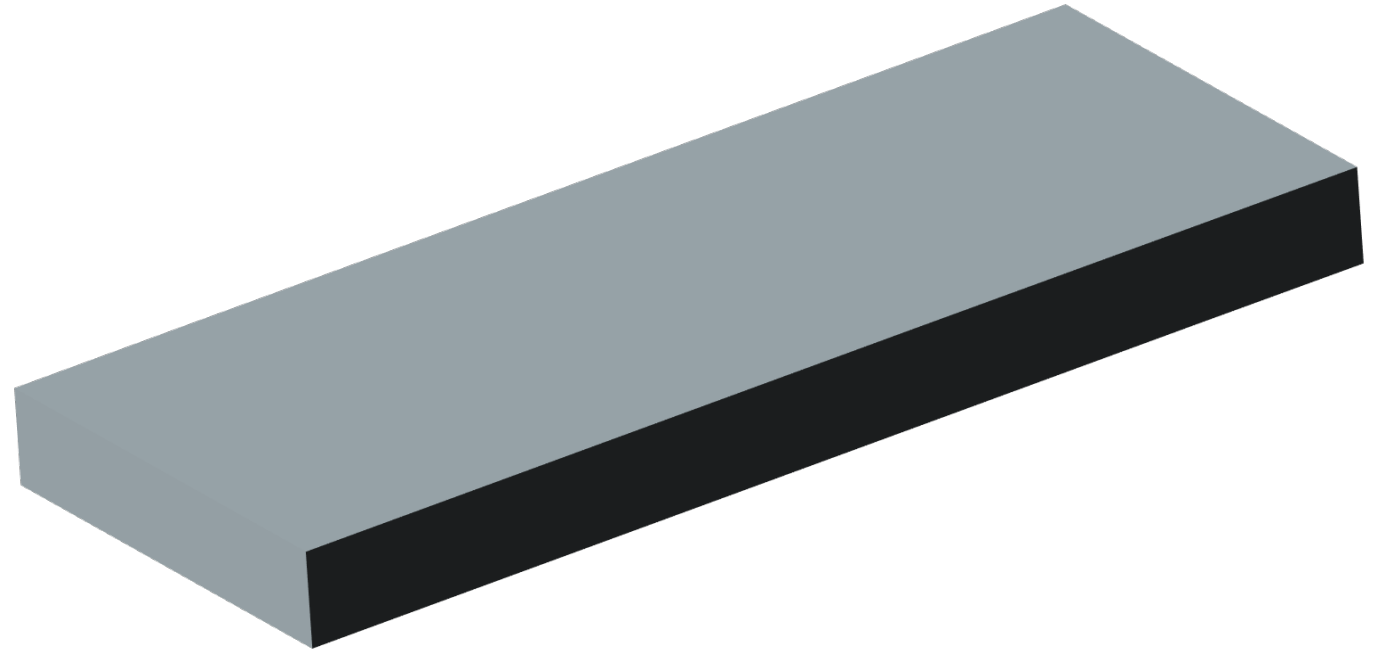
➤ Waveguide geometry

$$\Gamma = \left(\frac{n_{eff} - n_{air}}{n_{eff} + n_{air}} \right)^2$$

Waveguide Design using Rsoft BeamPROP



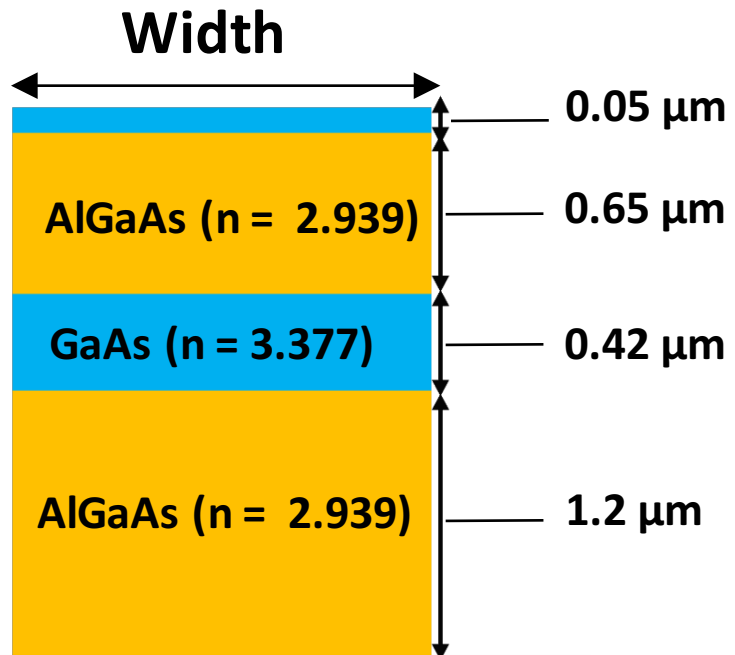
GaAs Waveguide



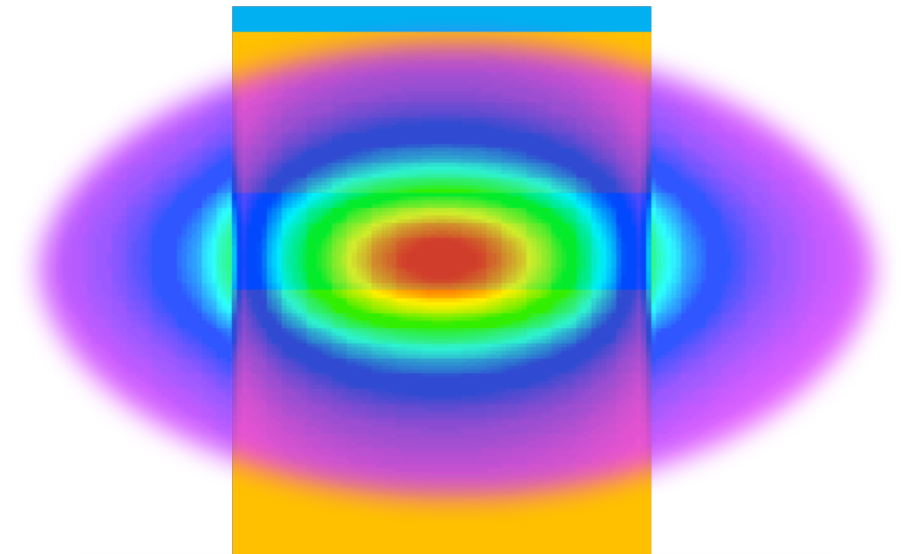
a-Si Waveguide

GaAs Waveguide

Cross-Sectional View

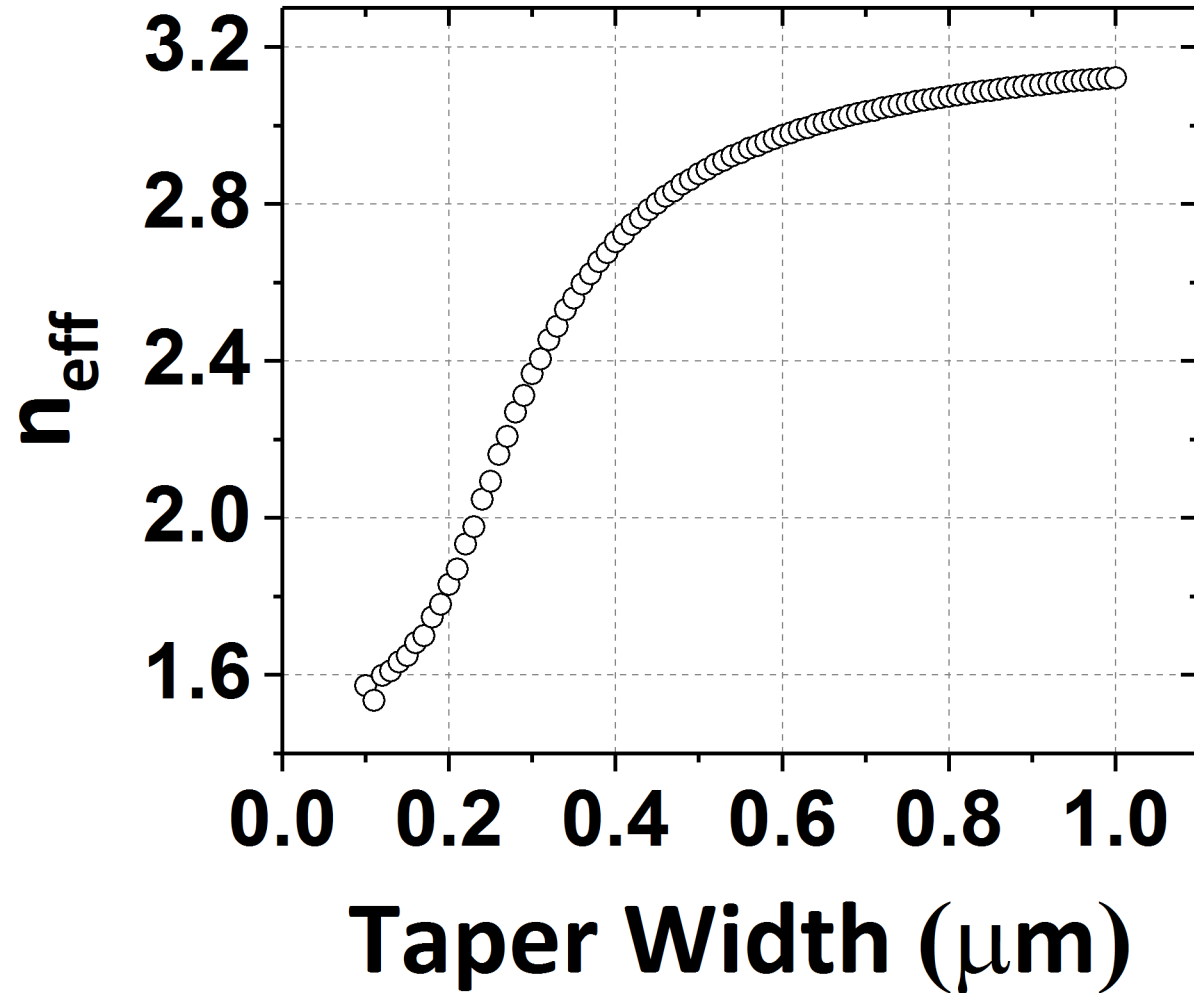


Mode Profile

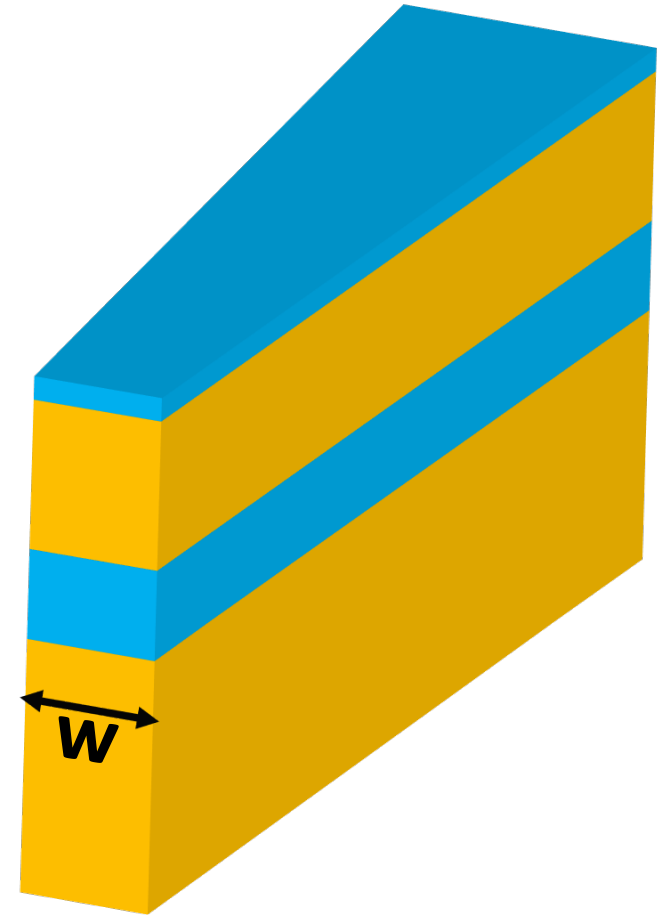


GaAs Waveguide

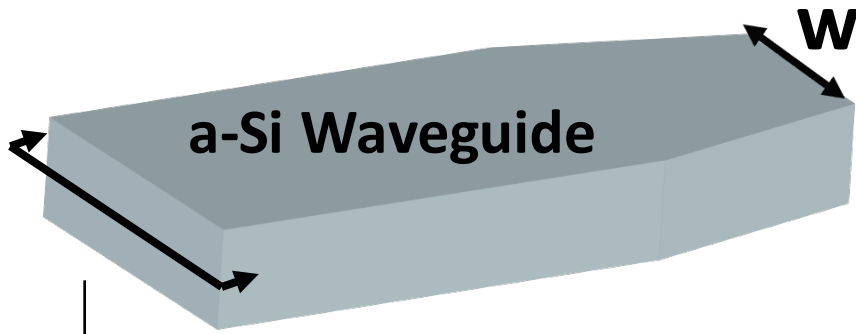
Taper designed to reduce effective index



$$n_{eff} \propto w$$

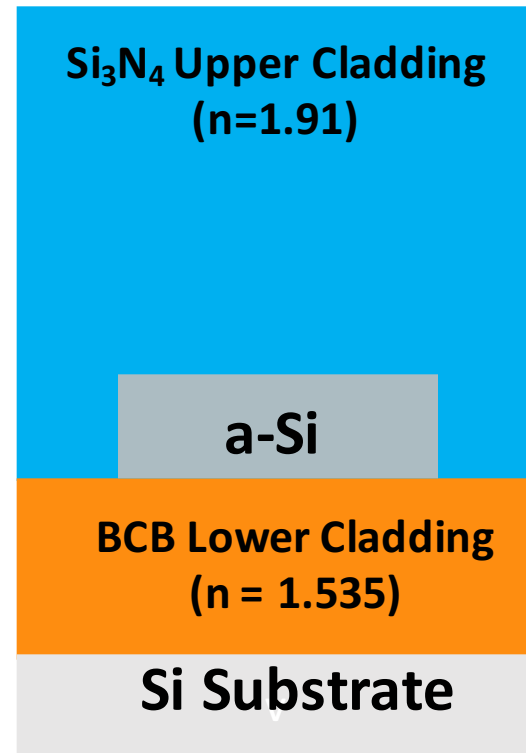
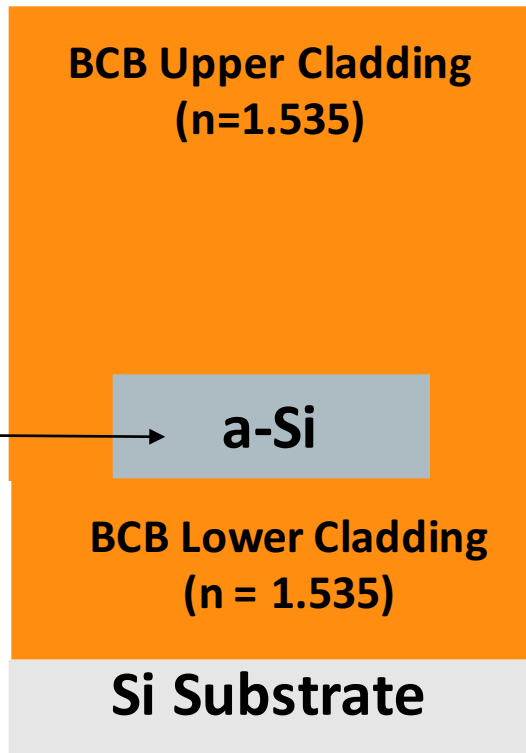


a-Si Waveguide

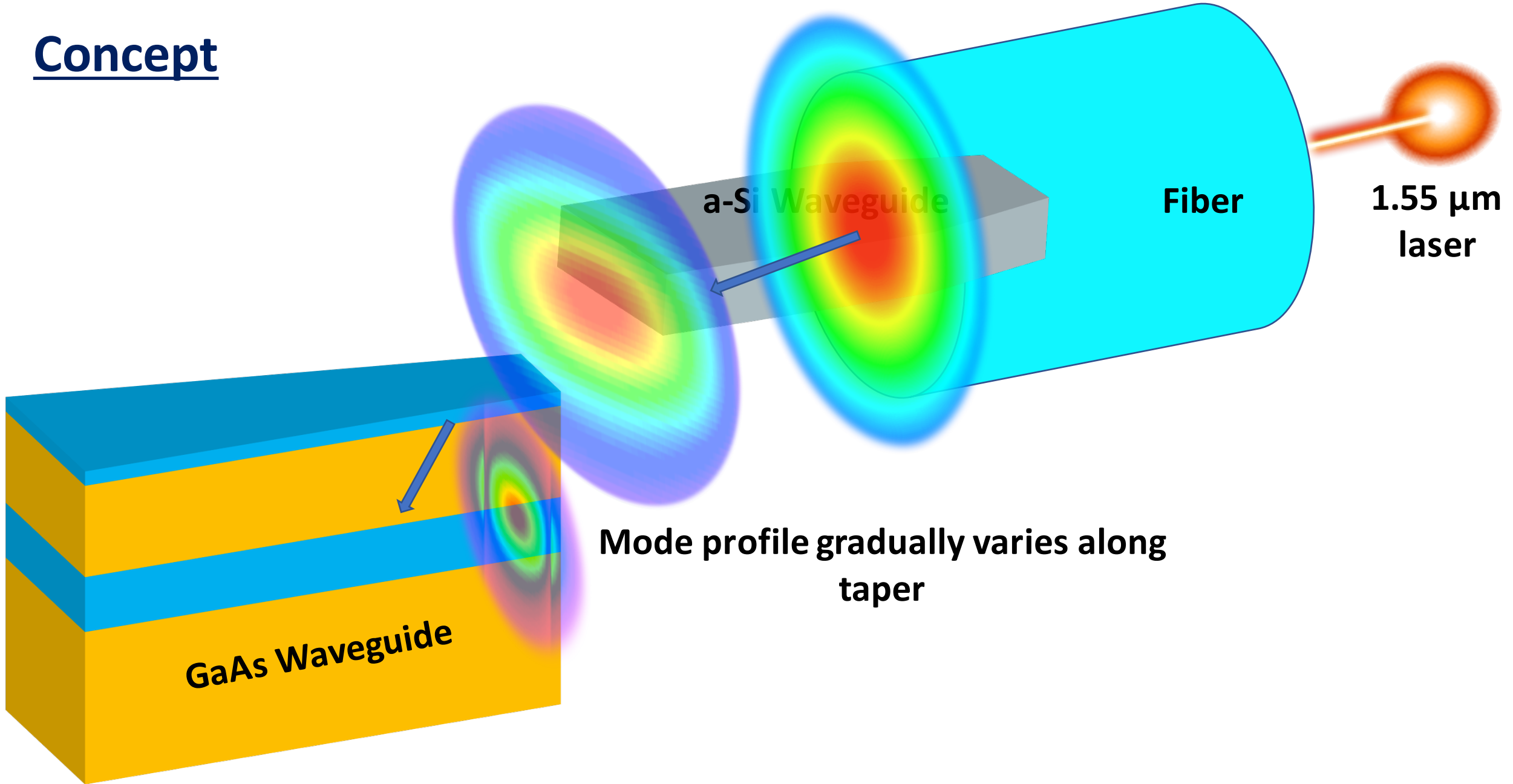


$$n_{eff} \propto W$$

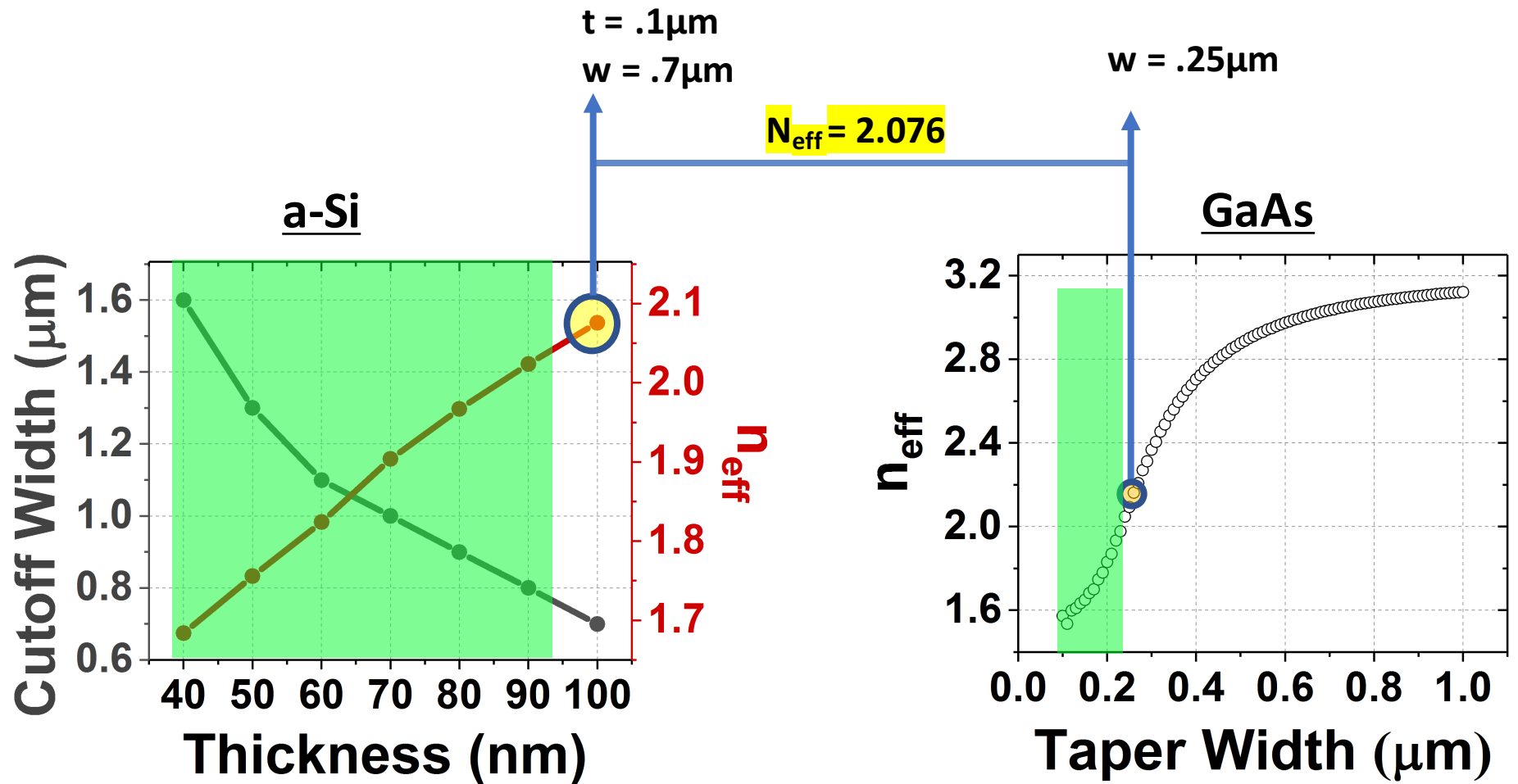
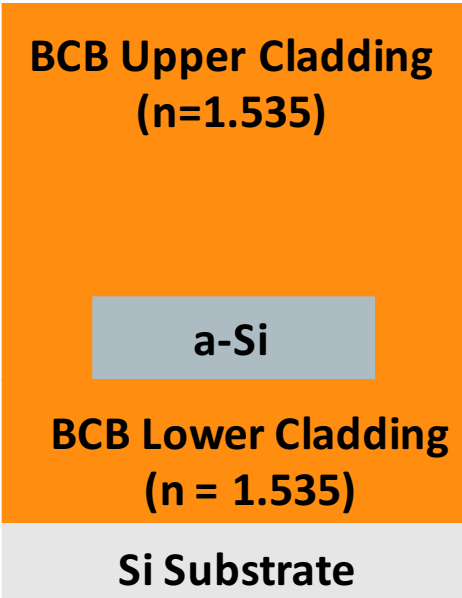
Cover Material Options



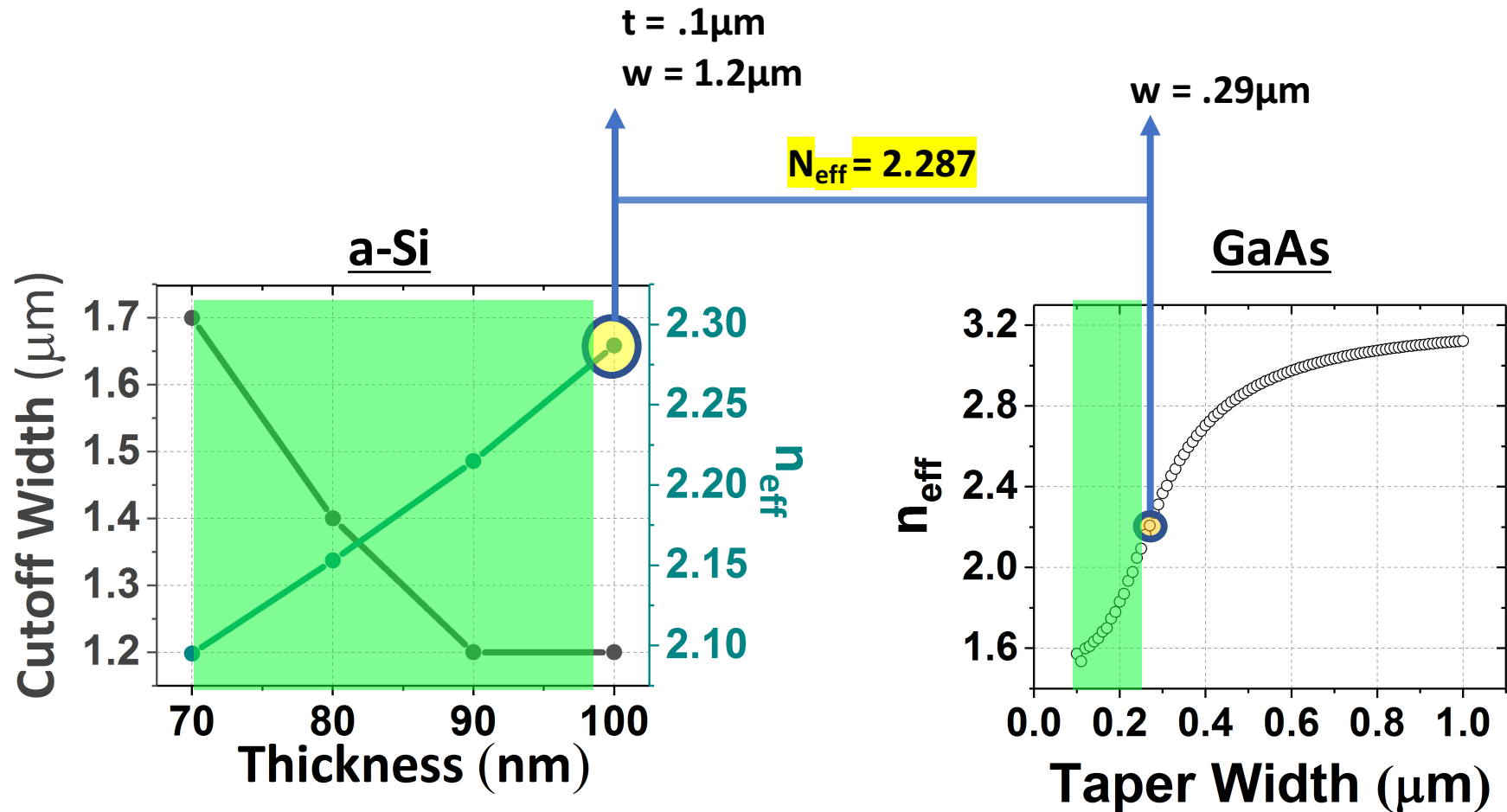
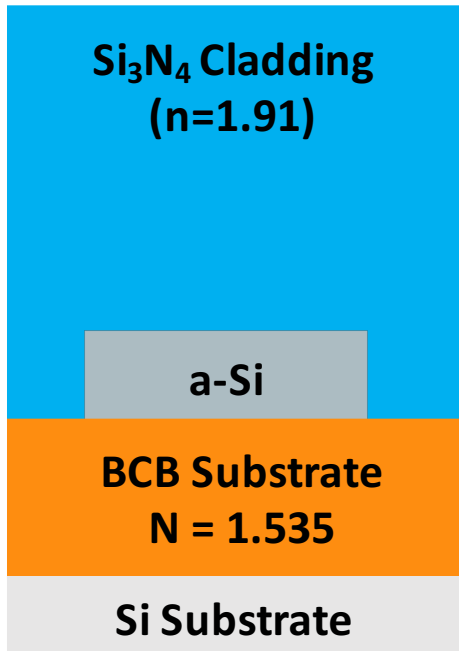
Concept



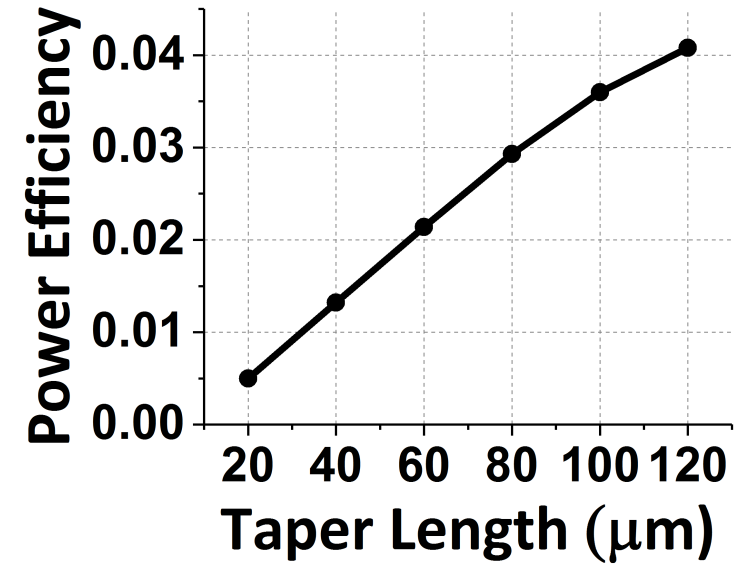
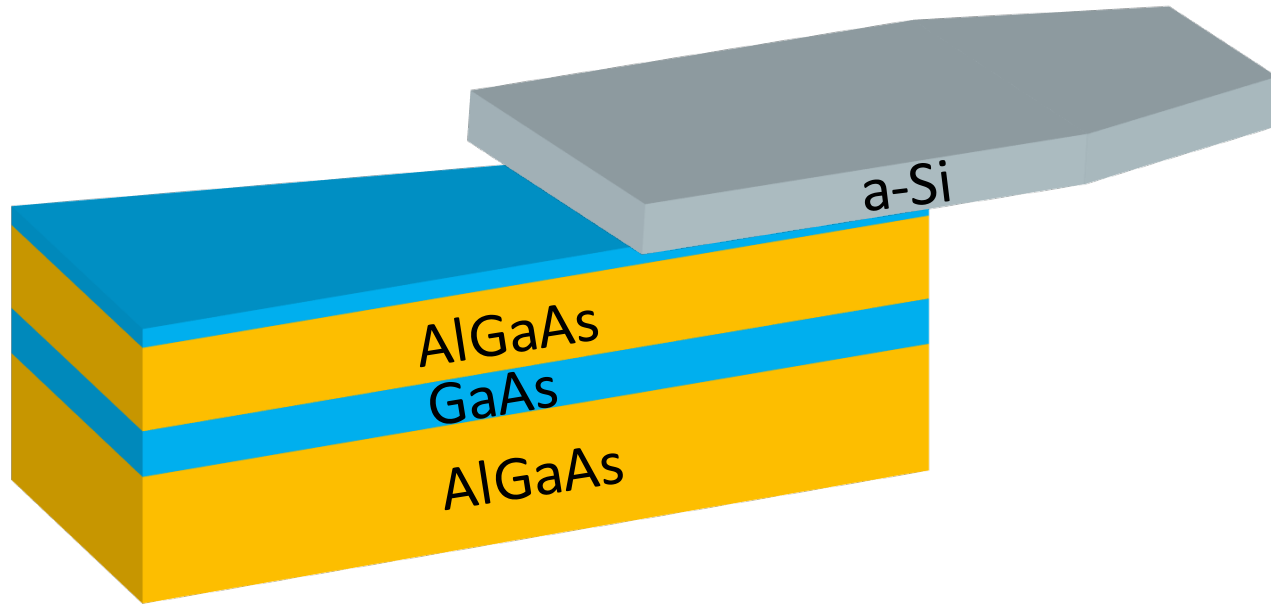
a-Si with BCB Cladding Index Matching Results



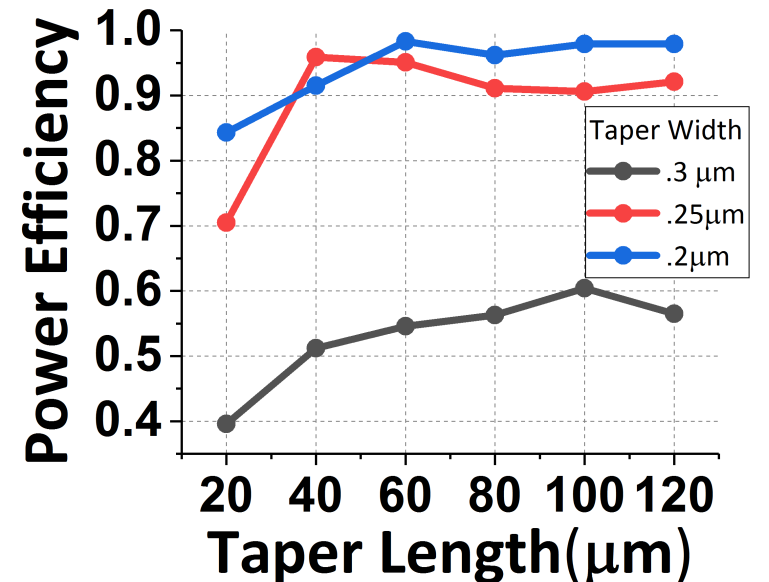
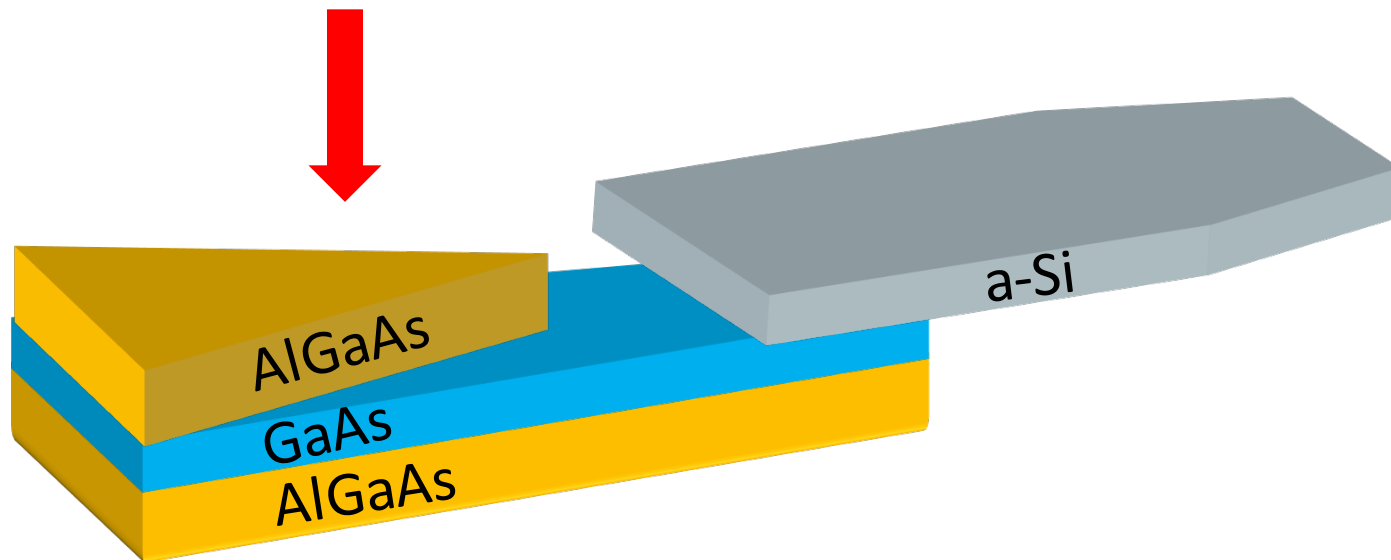
a-Si with SiN₄ Cladding Index Matching Results



Power Efficiency GaAs a-Si



Removing top two layers of structure



Conclusions and Future Work

In general, III-V waveguides have tightly confined modes which are undesired. By introducing the tapered design, I have demonstrated a low loss passive coupling interface with a larger mode profile.

I have also simulated the coupling loss into the Si waveguide – approximately 3.9dB per coupling interface. By reducing the Si waveguide width further, we can reduce this loss.

Acknowledgements

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