Diode Laser Transverse Mode Engineering via Waveguide Structuring

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Pawel Strzebonski[1], Bradley Thompson[1], Katherine Lakomy[1], Paul Leisher[2], and Kent D. Choquette[1]

[1]Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign, Urbana, IL, [2]Freedom Photonics, Santa Barbara, CA

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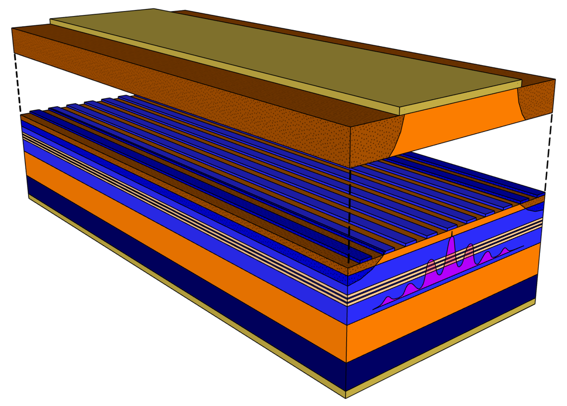
Motivation

Pump lasers require high power and brightness diode lasers. Their performance can be improved by:

- Increased modal discrimination
- Higher spatial brightness
- Higher spectral brightness
- Engineered beam cross-section and properties

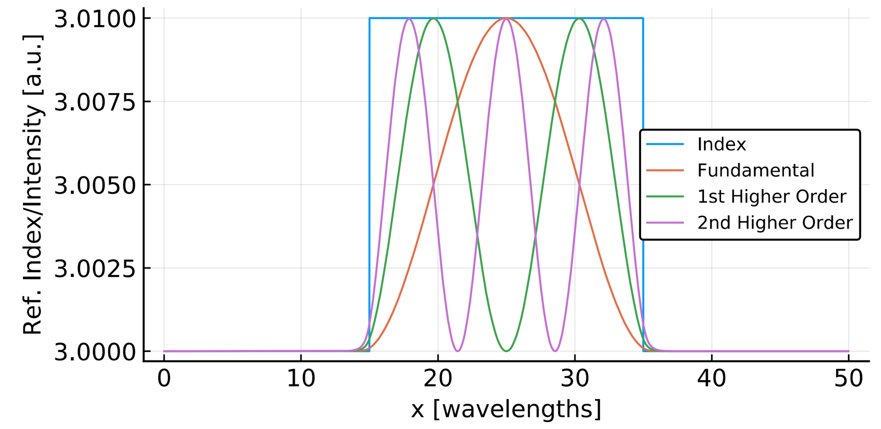


Outline

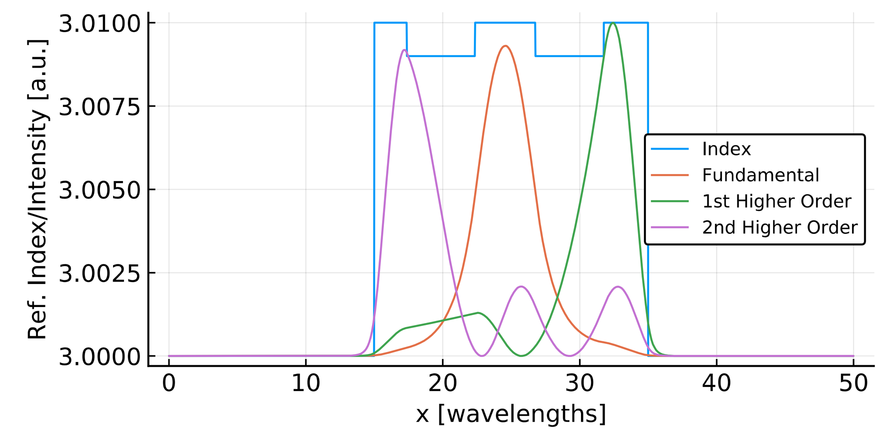
- Show mode selection and discrimination
  - Waveguide modes of standard and engineered dielectric waveguide structures
  - Modal effective indices
  - Modal confinement factors
- Show engineered mode properties
  - Waveguide modes of engineered structure
  - Far-field ‘power in the bucket’ by angle
  - Far-field ‘power in the bucket’ by mode

UIUC is partnering with Freedom Photonics and Teledyne to create better diode pump lasers

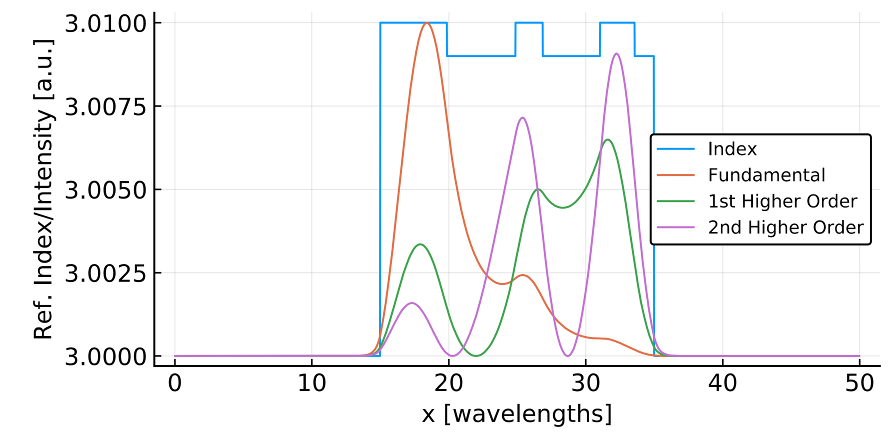
Waveguide Structures and Their 3 Lowest-Order Modes



WG0



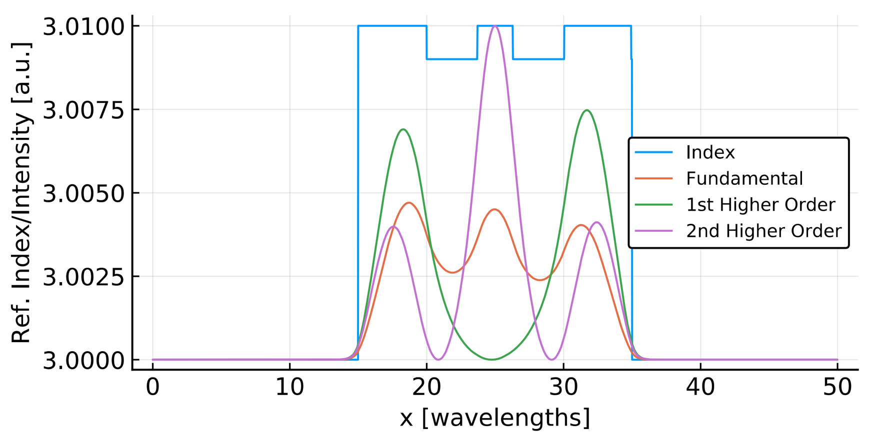
WG1



WG2

We present 3 waveguide (WG) structures. WG0 is a simple, standard dielectric waveguide structure. Using index perturbations, we engineer waveguide WG1 for improved modal discrimination (defined here by the modal confinement factor) in favor of the fundamental mode. While the first two waveguides, WG0 and WG1, favor the fundamental mode, we can engineer a waveguide, as in WG2 to produce a higher order mode that has the highest modal confinement factor.

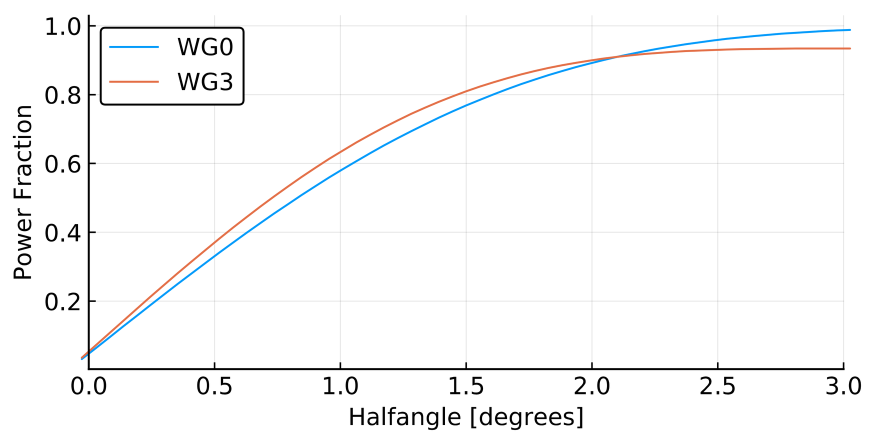
Waveguide Structure and Its 3 Lowest-Order Modes



WG3

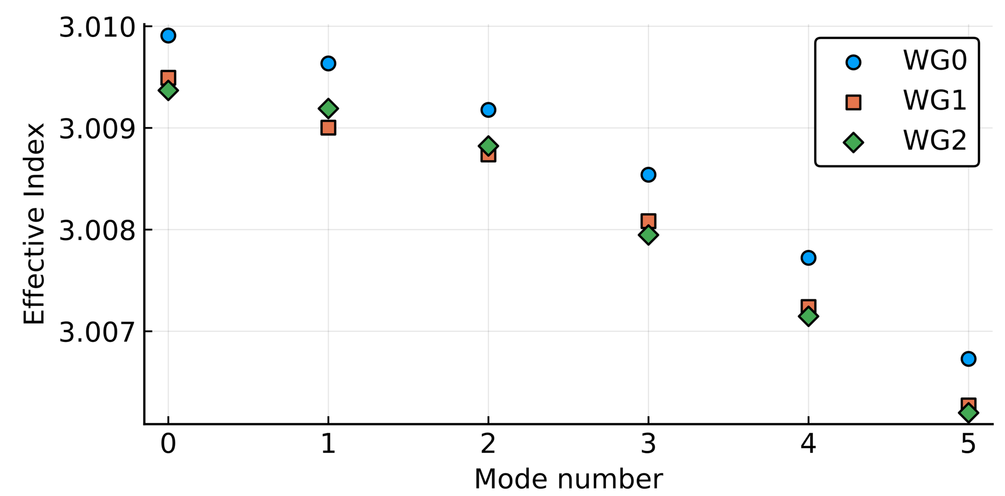
Waveguide structuring not only allows engineering the modal selection and discrimination, but the mode profile and properties as well. WG3 is engineered to have a fundamental mode with improved far-field characteristics.

‘Power in the Bucket’ by Angle



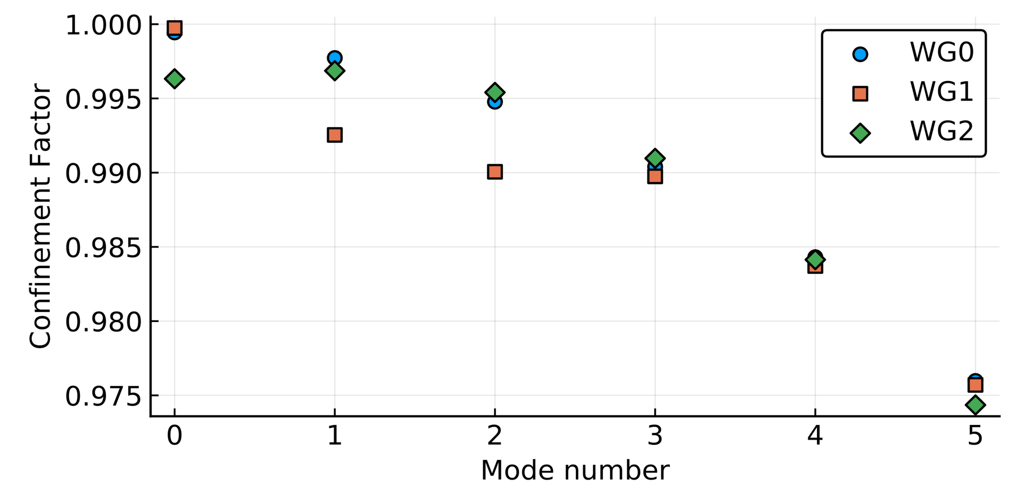
Comparing the ‘power in the bucket’ (the fraction of the far-field power that is contained within a certain angle) for the fundamental modes of WG0 and WG3, we find that the engineered mode performs better for half-angle values of about 2°.

Modal Effective Index



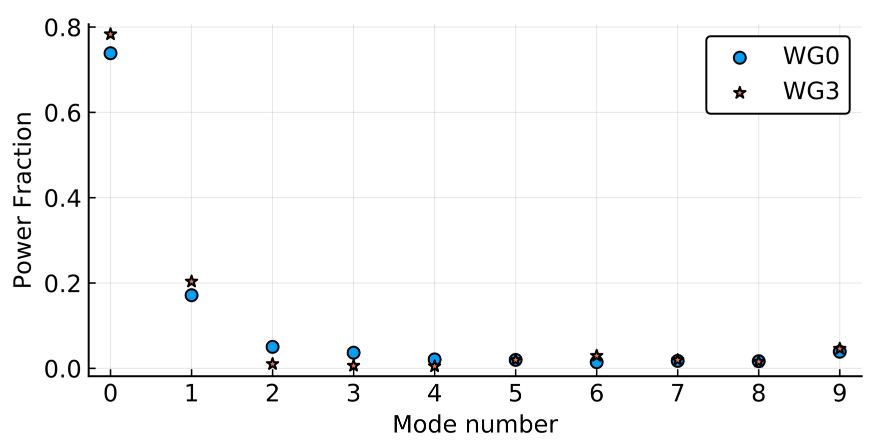
Introducing the low index perturbations generally lowers the modal effective indices. However, it can increase the difference in modal effective indices. WG1 has a modal effective index difference between the 2 lowest order modes that is 78% higher than the difference between the 2 lowest order modes of WG0.

Modal Confinement Factor



The confinement factor for the fundamental mode is only slightly increased in WG1, relative to WG0, but the difference between the modal confinement factors of the first 2 modes is increased by over 300%. For WG2, the modal confinement factor of the 1st higher order mode is actually higher than that of the other modes.

‘Power in the Bucket’ by Mode



We calculate our ‘power in the bucket’ for a ‘bucket’ of 1.5° within normal. The engineered fundamental mode of WG3 puts more than 78% of the far-field power within this target, more than the fundamental mode of WG0.

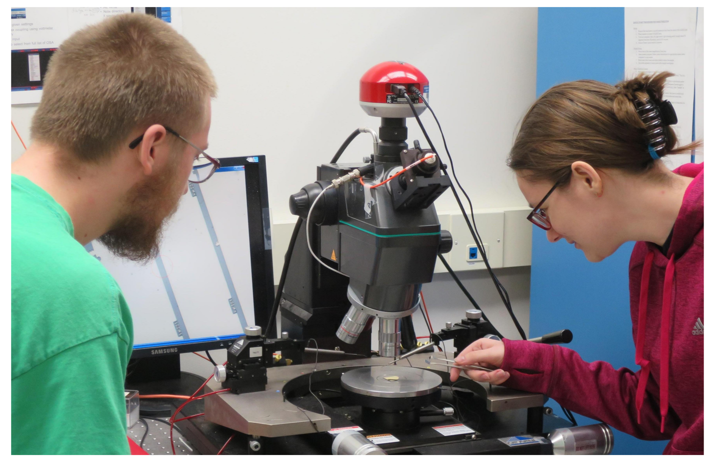
Conclusion

Simulation of dielectric waveguide index structures show that index structuring is able to:

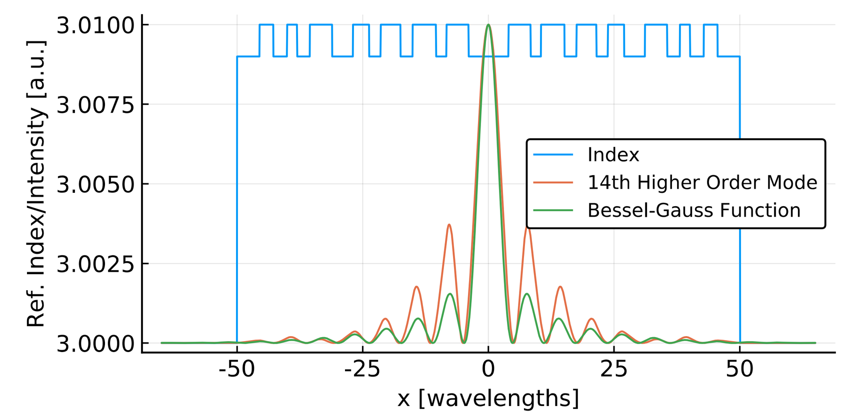
- Improve modal discrimination
- Impart modal selection
- Engineer the transverse modes and their properties

Future Work and Research

- Implement waveguide index structure
- Fabrication and characterization
- Combine waveguide mode engineering with other mode selection techniques



Future of Mode Engineering?



Waveguide index structuring, in combination with other mode selection techniques, could enable engineering diode lasers with many novel beam shapes and properties. For example, a larger waveguide structure can produce a higher mode that roughly approximates a Bessel-Gauss function.