Fabrication of Photonic LPCVD Silicon Nitride Waveguides

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Project Objectives

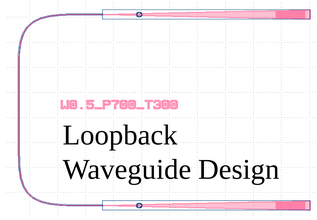
Goal: Create working Nitride Waveguides using the tools available through the RIT SMFL Cleanroom

- Demonstrate Loopback and Ring Resonator Waveguide Designs
- Qualify Nitride Waveguides against similar designs
- Lay the groundwork for future research

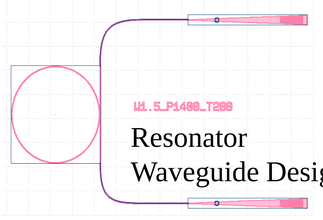
Motivation

- Nothing is faster than the speed of light
- Photonics uses less power than traditional electronics but requires more space
- Integrating photonics into microelectronics is necessary to continue making our technology better
- Nitride is ideally a low loss material making it better than amorphous silicon

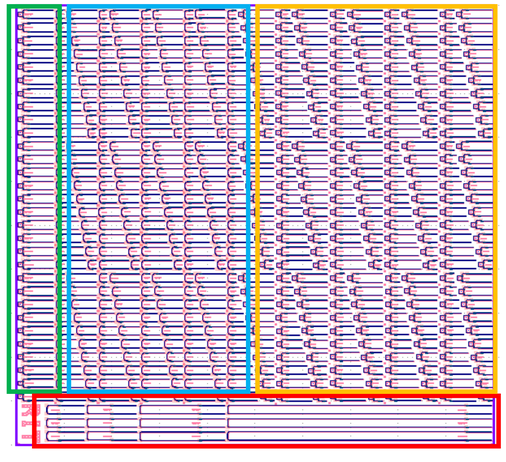
Mask Design



Loopback Waveguide Design



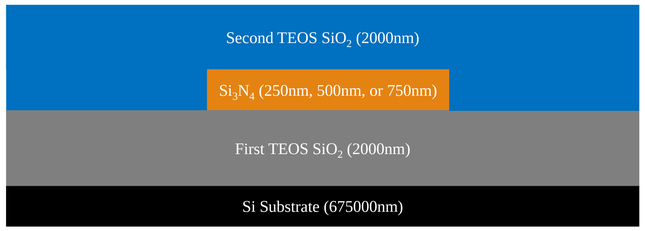
Resonator Waveguide Design



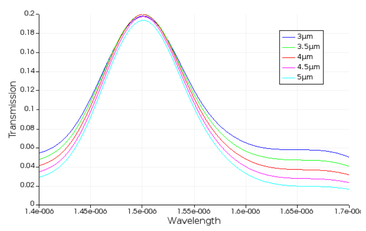
Design Variations:
- Loopback Waveguide □
  - Varied Coupler Taper
  - Varied Coupler Pitch
  - Varied Waveguide Length □
- Ring Resonator Waveguide □
  - Varied Coupler Taper
  - Varied Coupler Pitch
  - Varied Resonator Gap □

Process Flow

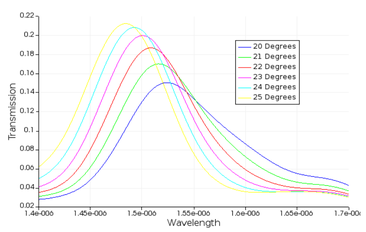
1. RCA Clean
2. TEOS Oxide Deposition
3. Silicon-Nitride Deposition
4. Waveguide Pattern
5. Nitride Etch
6. TEOS Oxide Cladding Deposition



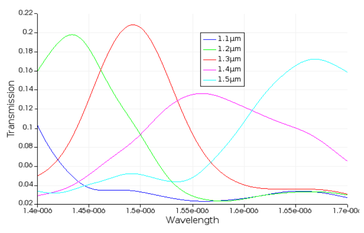
Simulation Results



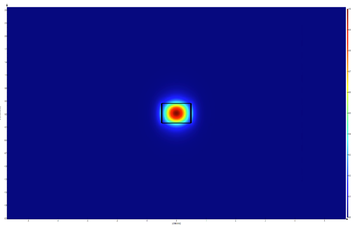
Test Head Position Variation to optimize transmission through grading coupler



Test Head Angle Variation to optimize transmission through grading coupler



Grading Coupler Pitch Variation to optimize transmission through grading coupler

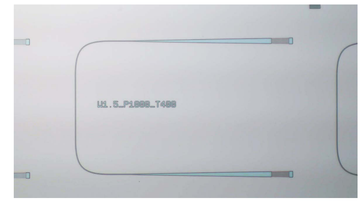


Eigenmode Solution for 450nm thick, 1000nm wide Nitride Waveguide

References

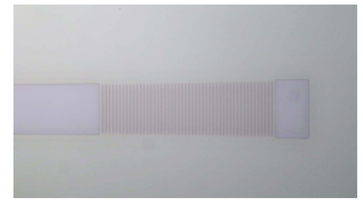
[1] P. Cadareanu, "Silicon Photonic Devices Manufactured Using Double Patterned i Line Lithography," rep.
[2] Venkatesh Deenadayalan, Unpublished.

Fabrication Results



Fabricated Loopback Waveguide with 1.5µm width, 1µm coupler pitch, and 400µm coupler taper

Fabricated Resonator Waveguide with 0.5µm width, 1µm coupler pitch, and 300µm coupler taper



Close up of grading coupler showing 0.5µm line and space resolution

Close up of resonator gap showing 0.3µm space between waveguide and ring

Conclusions

Successfully fabricated waveguides at RIT.
Found simulated best design to be: 1000nm wide waveguide with 450nm thickness with Test Head Angle of 24 degrees and Grading Coupler Pitch of 1300nm.

Future Work

- Improve process to get smaller features
- Compare results for different LPCVD Nitride recipes
- Compare the results from PECVD Nitride Deposition
- Create dynamic waveguides by incorporating heater/PIN junction
- Simulate each waveguide to compare results

Acknowledgements

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