Towards High Contrast Potassium Double Tungstate Rib Waveguides For Laser Applications

C.I. van Emmerik, S.M. Martinussen, J. Mu, M.A. Sefünç, M. Dijkstra, S.M. García-Blanco
Optical Sciences group, MESA+ Institute for Nanotechnology, University of Twente
P.O. Box 217, 7500 AE Enschede, The Netherlands
c.i.vanemmerik@utwente.nl

Objective

The main objective of the **RENOS project** (Rare Earth doped Novel On-chip Sources) is to develop very compact, power efficient, tunable lasers that operate in a wide frequency range.

These lasers will be beneficial in applications in optical sensing, spectroscopy, metrology and telecommunications.

Material

The devices will be made from **rare-earth doped potassium double tungstate** (RE:KY$(WO_4)_2$ or KYW) because it possesses:

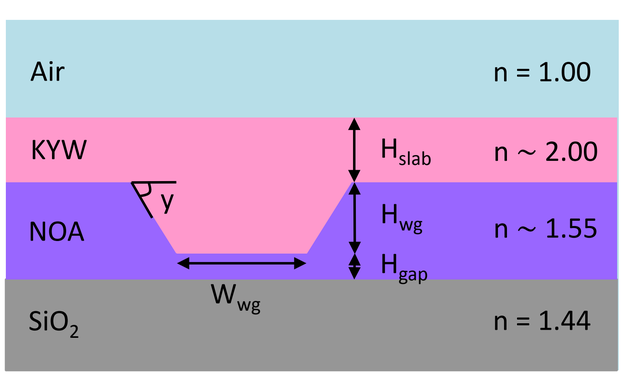
- High refractive index (n ~ 2.00 @ 1550 nm)
- High allowed dopant concentration
- High emission and absorption cross-section for rare-earth ions

Those characteristics will make it possible to obtain:

- Highly confined waveguides
- Ring resonators with large FSR
- Ring resonators with high Q-factor
- Efficient four-wave mixing and Raman scattering

Simulation

Numerical analyses for single mode condition of the high-contrast waveguides are performed using the software Lumerical MODE. The calculated optimal parameters for the structure shown in the figure are listed in the table.



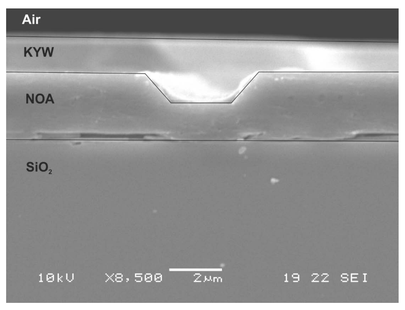
Structure	Size (µm)
W_{wg}	1.60 – 2.40
H_{wg}	1.30 – 1.50
H_{gap}	~ 0.60
y	~ 55°
H_{slab}	≥ 1.70 – 2.80*

*Limit for single mode conditions for smallest and largest rib configuration

Fabrication

Fabrication flow:

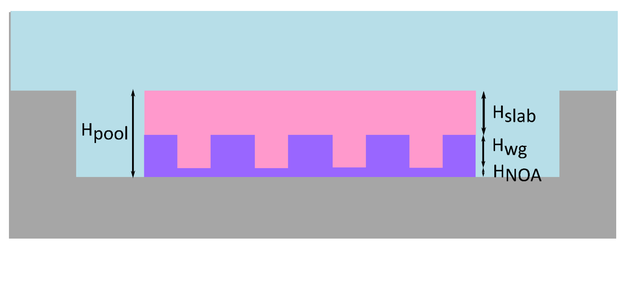
1) The patterned sample is flip-chip bonded onto a SiO_2 carrier with Norland Optical Adhesive NOA 81.
2) The sample is mounted with wax on a thick glass plate.
3) Coarse lapping with 9 µm Al_2O_3 particles on an iron disk (Logitech LP50), lapping speed 4-5 µm/min, to a total height of 50 µm.
4) Fine lapping with 1 µm Al_2O_3 particles on an iron disk, lapping speed 1-2 µm/min to a total height of 7 µm.
5) Polishing with 40 nm SiO_2 particles on a polyurethane disk, polishing speed ~1 µm/hour to desired height (or until polishing stop).



20% Er:KYW single mode waveguides. Fabricated with technology proposed by M.A. Sefünç [1] (fabrication flow without 4th step). Structure dimensions, W_{wg} = 2.3 µm, H_{wg} = 1.1 µm, H_{gap} = 1.5 µm, H_{slab} = 1.5 µm, y = 54°.

Polishing stop

A **polishing stop** has been designed and fabricated in order to improve thickness control. The polishing stop is created by etching a 12x12 mm^2 pool in the SiO_2. The KYW sample (10x10 mm^2) is bonded inside it before lapping. Upon reaching the pool edge, the increase in surface area slows down the polishing to 10-30%.



Schematic representation of the KYW substrate with waveguides after polishing.

Challenges:

- Fabrication tolerance of:
  - SiO_2 pool < 100 nm
  - H_{wg} of KYW < 100 nm
- Well defined glue thickness

MESA+ INSTITUTE FOR NANOTECHNOLOGY

UNIVERSITY OF TWENTE.

References

[1] M.A. Sefünç, PhD-thesis, University of Twente, 2015