A novel polishing stop for accurate integration of potassium yttrium double tungstate on silicon dioxide

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RENOS Project

Rare Earth Novel On-chip Sources

Goal: development of high-contrast waveguide fabrication technique in $KY(WO_4)_2$

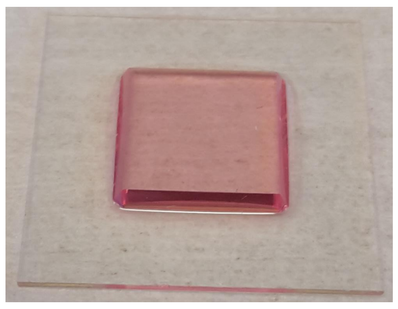
Why?
- High refractive index (n≈2 @ 1550 nm)
- Long inter-ionic distance for RE ions (<d>≈0.5 nm) [1] and high cross-sections for RE ions [2]
- High Raman yield [3]

Challenges
- Impossible to grow on most substrates
- Small waveguide dimensions
- Defect free layers

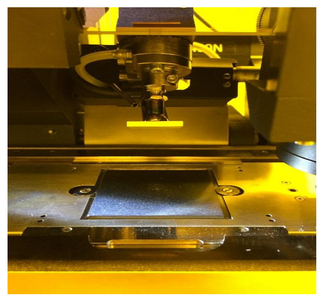
Hybrid integration of $KY(WO_4)_2$

Material
- $KY(WO_4)_2$ crystal 1.0 cm by 1.0 cm, 1.0 mm thick
- SiO_2 substrate 2.0 cm by 2.0 cm, 0.5 mm thick

Goal
- Hybrid integration of $KY(WO_4)_2$ crystal with a final layer thickness of ~1 µm.

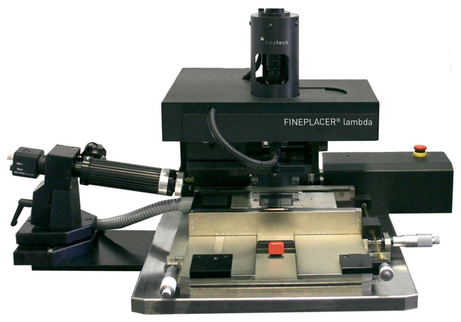


$KY(WO_4)_2$ bonded on a SiO_2 substrate with 6.0 µm wide pillars separated 500.0 µm



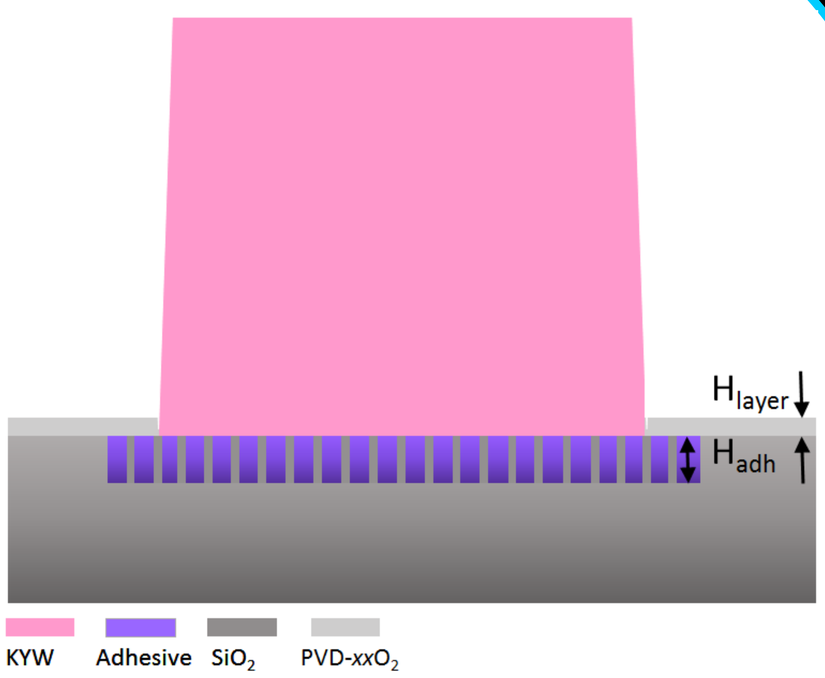
Bonding

Requirements
- Round beveled KYW edges *(to avoid chipping of the edges)*
- Low temperature adhesive
- High precision (± 0.1 µm) z-direction



Finetech Fineplacer Lamda precision flip-chip bonder with 0.5 µm X-Y positioning accuracy.

Polishing stop



Schematic representation of a bonded KYW sample with the polishing stop.

Thinning

Logitech PM5 precision lapping and polishing system

Stage	Material
Grinding	400/ 800/ 1000 SiC paste
Lapping	9/ 3/ 1 µm Al_2O_3 suspension on cast iron disk
Polishing	3 µm CeO_2 / 40 nm SiO_2 on polyurethane disk

Fabrication of polishing stop

Requirements
- Hard material
- Room temperature process *(to minimize stress due to CTE mismatch of the layers)*
- High precision (H_{layer} ≈ 1.0 ± 0.1 µm)

Process

Pulsed laser deposition of e.g. TiO_2, Al_2O_3 at ~25 °C

Results

- Layer as thin as the polishing stop
- Acceptable planarity
- Reduction of polishing speed by 3-4 times
- Higher yield expected

Outlook

- Increase surface quality (RMS < 2.0 nm) for low transmission losses
- Etching of waveguides on thin layer

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[2] Y.-S. Yong, S. Aravazhi, S. A. Vázquez-Córdova, J. J. Carjaval, F. Díaz, J. L. Herek, S. M. García-Blanco, and M. Pollnau, "Temperature-dependent absorption and emission of potassium double tungstates with high ytterbium content," *Opt. Express*, vol. 24, no. 23, p. 26825, Nov. 2016.
[3] A. A. Kaminskii, A. F. Konstantinova, V. P. Orekhova, A. V Butashin, R. F. Klevtsova, and A. A. Pavlyuk, "Optical and nonlinear laser properties of the χ(3)-active monoclinic α-$KY(WO_4)_2$ crystals," *Crystallogr. Reports*, vol. 46, no. 4, pp. 665–672, Jul. 2001.

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