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Low loss integrated optics
Building blocks for optical atomic clocks

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Potential of Photonic Integration

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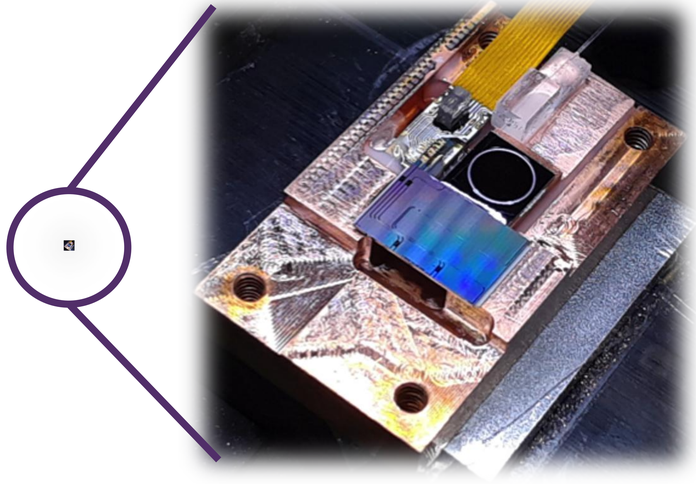
MAX-PLANCK-INSTITUTE OF QUANTUM OPTICS GARCHING MPQ

MenloSystems

CORES
Chip-scale Optical Resonator Enabled Synthesizer



SWaP
- ✓ Size
- ✓ Weight
- ✓ Power
- ✓ Robustness
- ✓ Cost

1998	2008	2019
4 m^3	1 m^3	1 cm^3

Business Model & Offering

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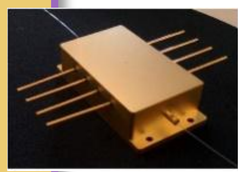
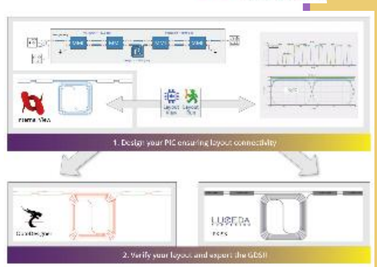
Design → Chip Manufacturing → Packaging → Module → Systems

Technology Development → FeOL → Test & Measure





- R&D support in Design & Packaging
- Die Delivery from Prototype to Volume

- Circuit IP stays with customer

Building blocks for optical atomic clocks

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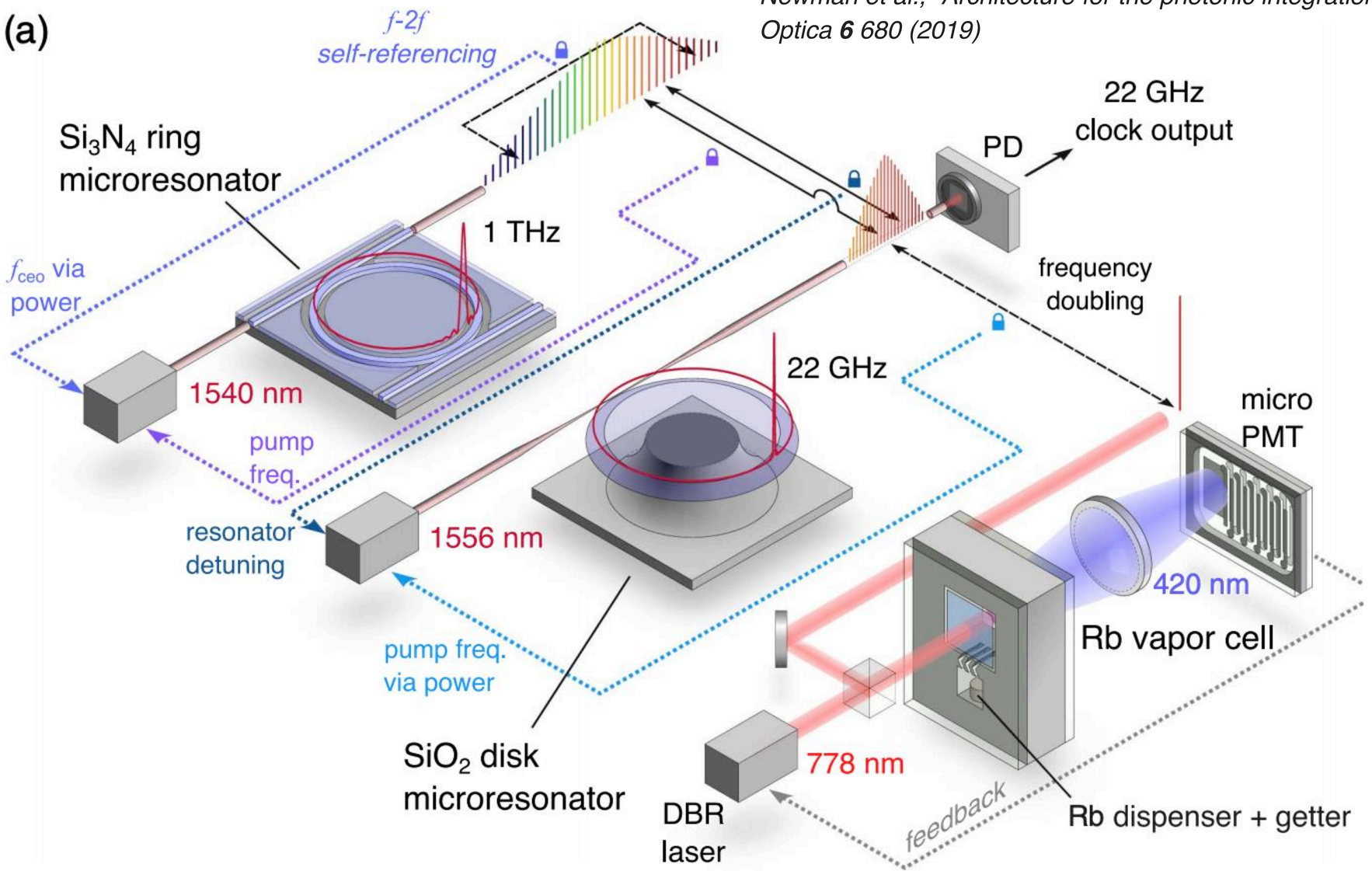
*Newman et al., "Architecture for the photonic integration of an optical atomic clock", Optica **6** 680 (2019)*



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High Q ring resonator

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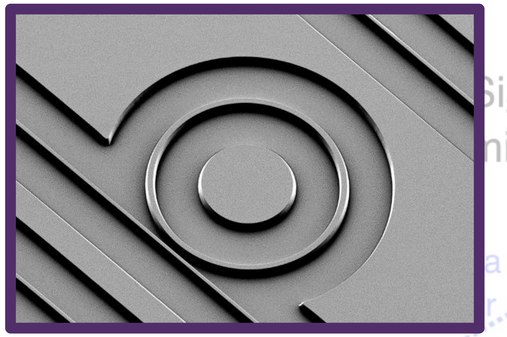
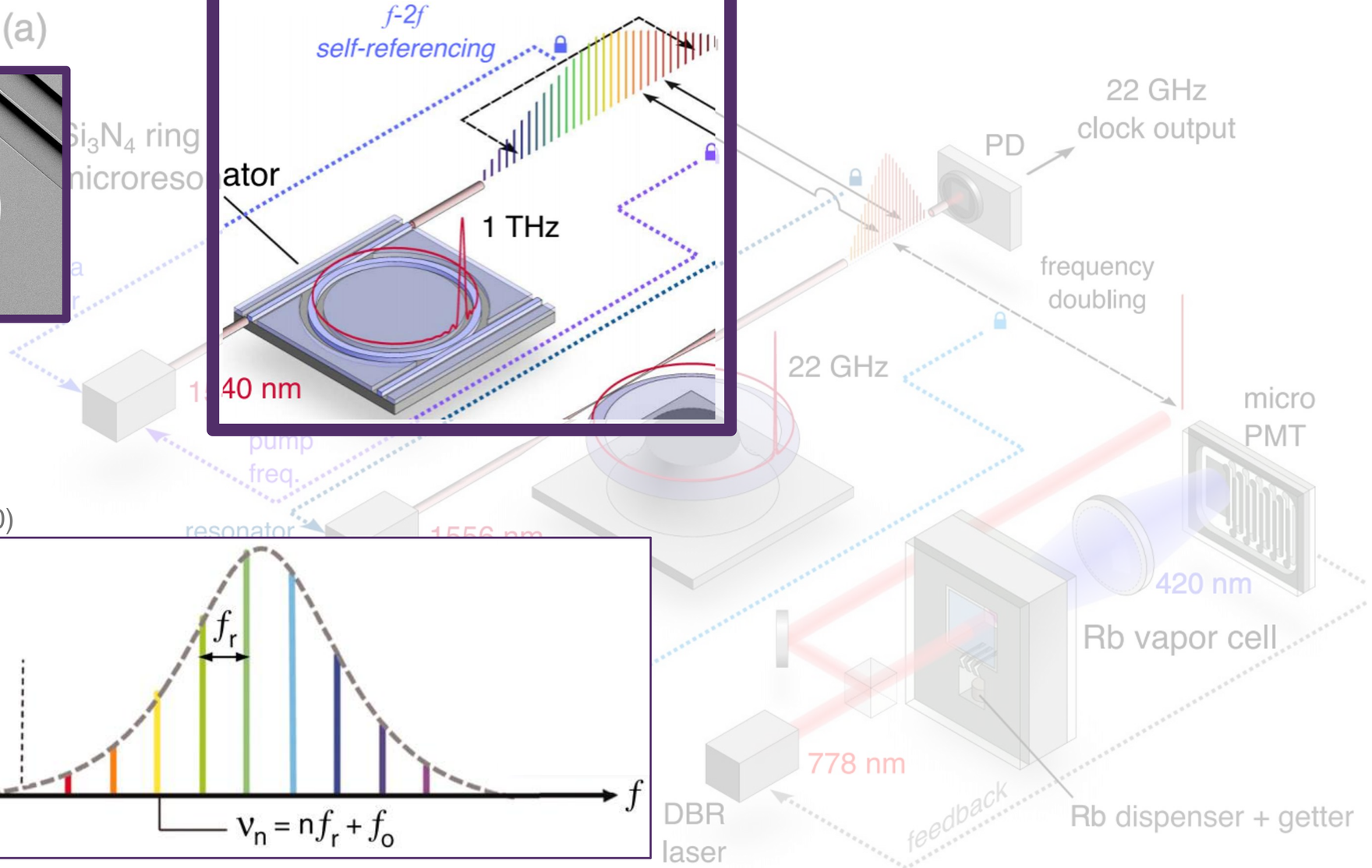
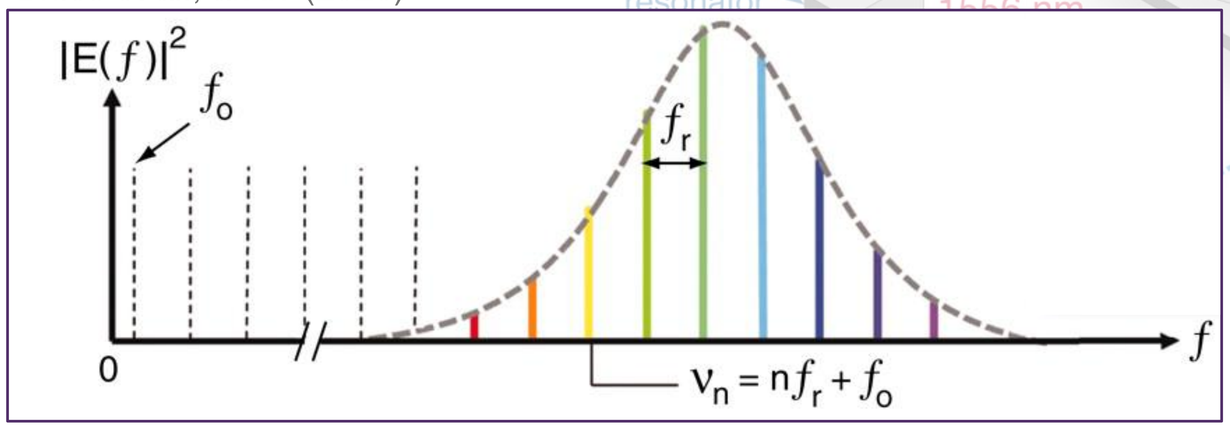




Briles et al., arXiv (2020)



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Edge coupling and fiber coupling

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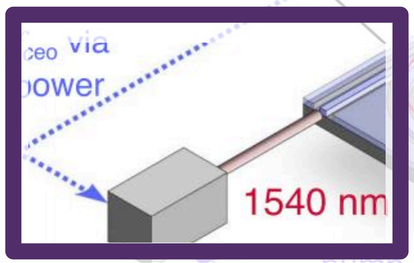
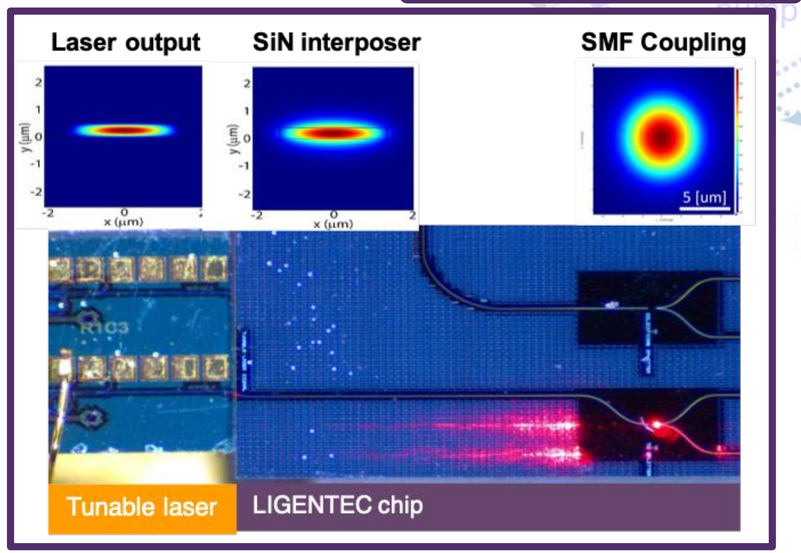
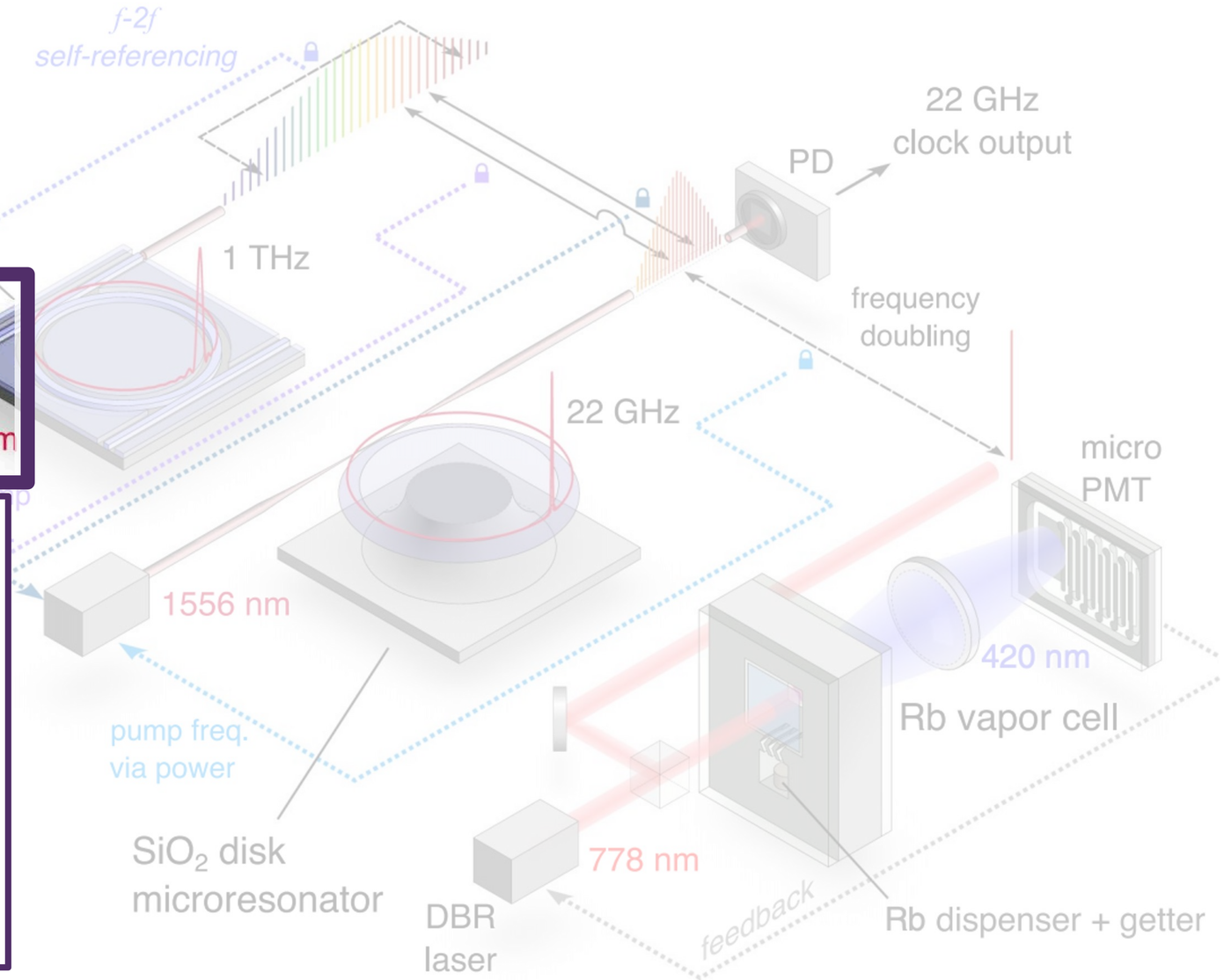
Stroganov et al., ECIO (2019)







Building blocks for optical atomic clocks
Bonding window opening

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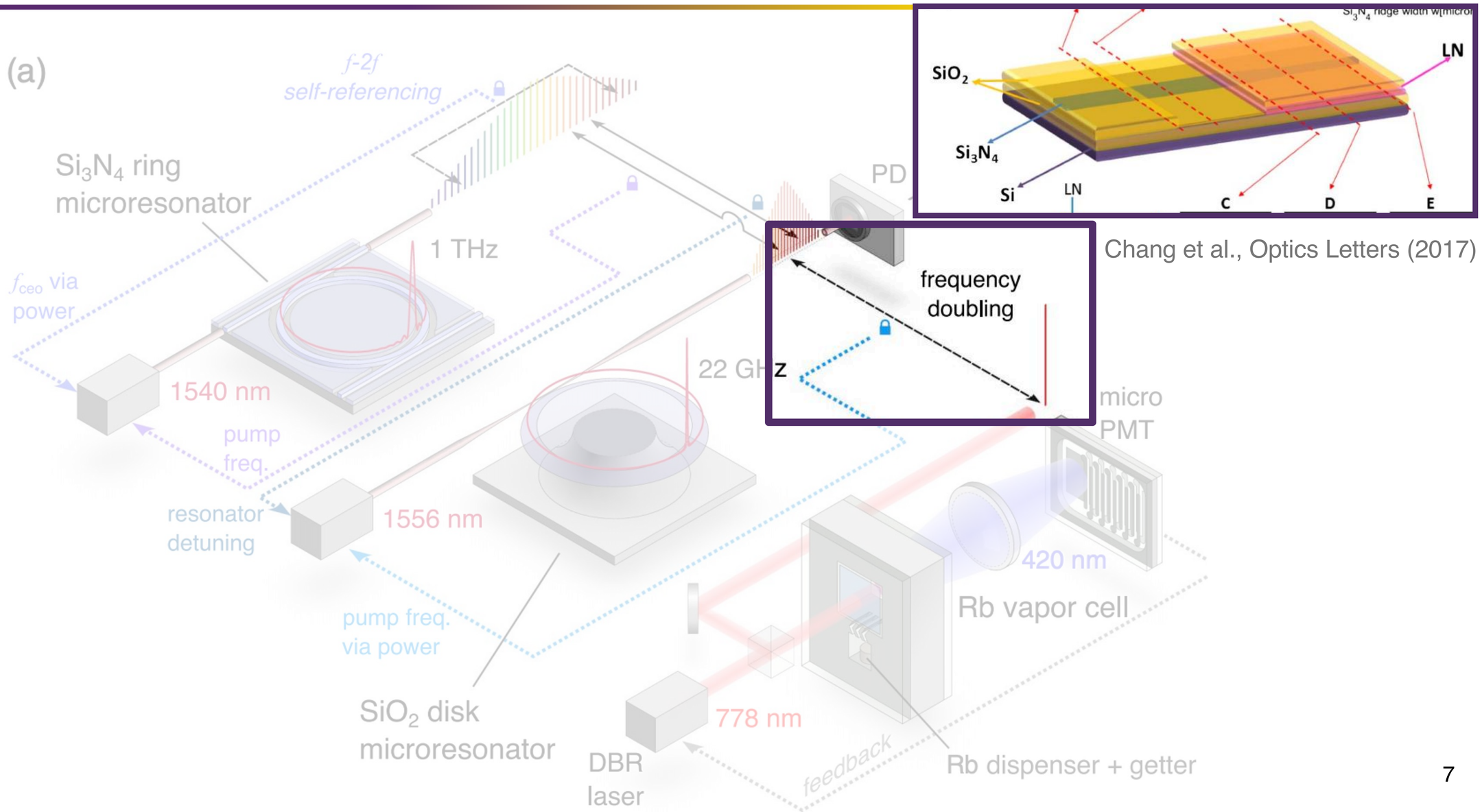

Chang et al., Optics Letters (2017)

Building blocks for optical atomic clocks
Bonding window opening

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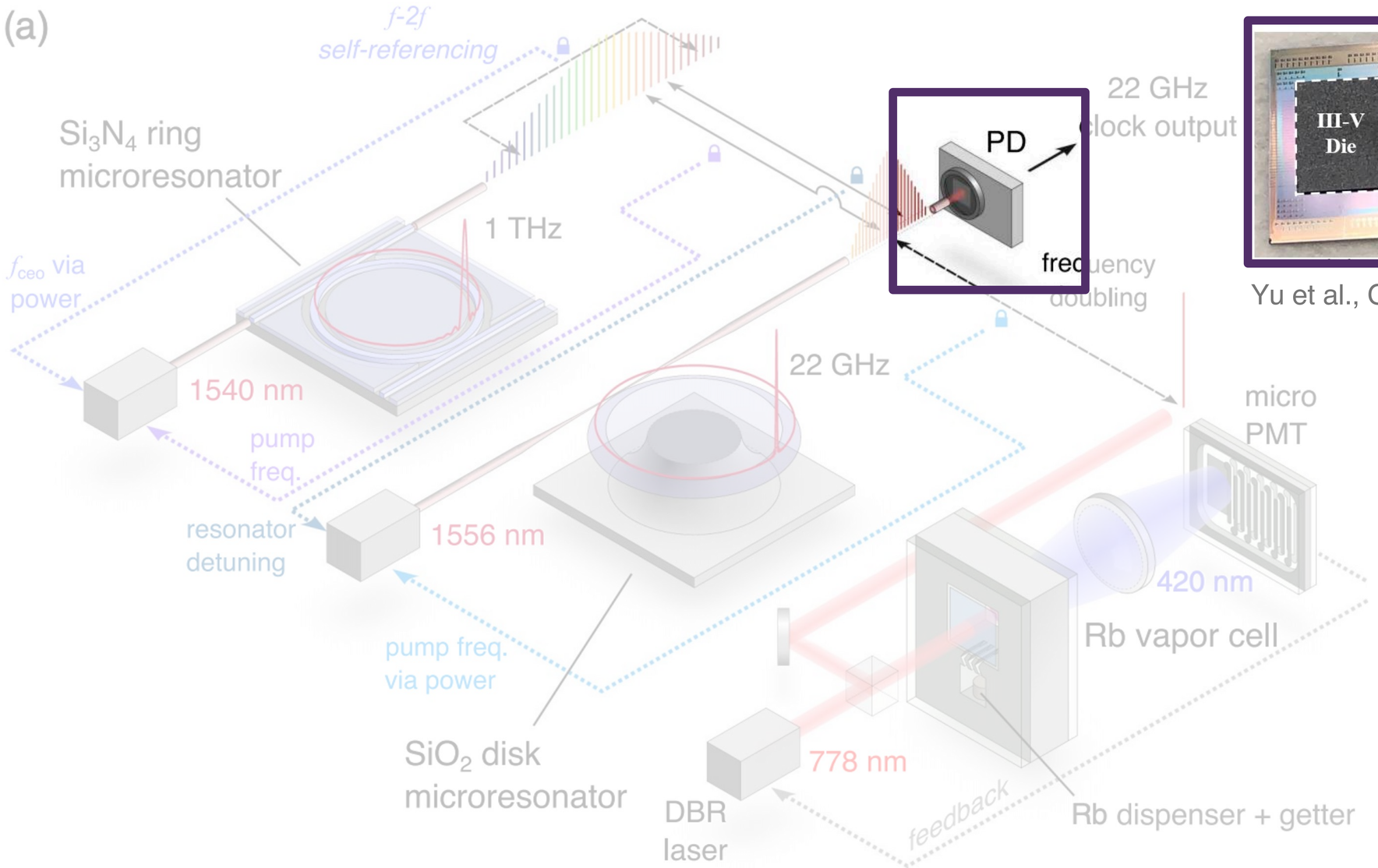

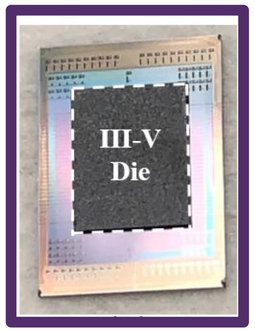

Yu et al., OFC (2020)

SUB-Hz LASER WITH INTEGRATED PHOTONICS

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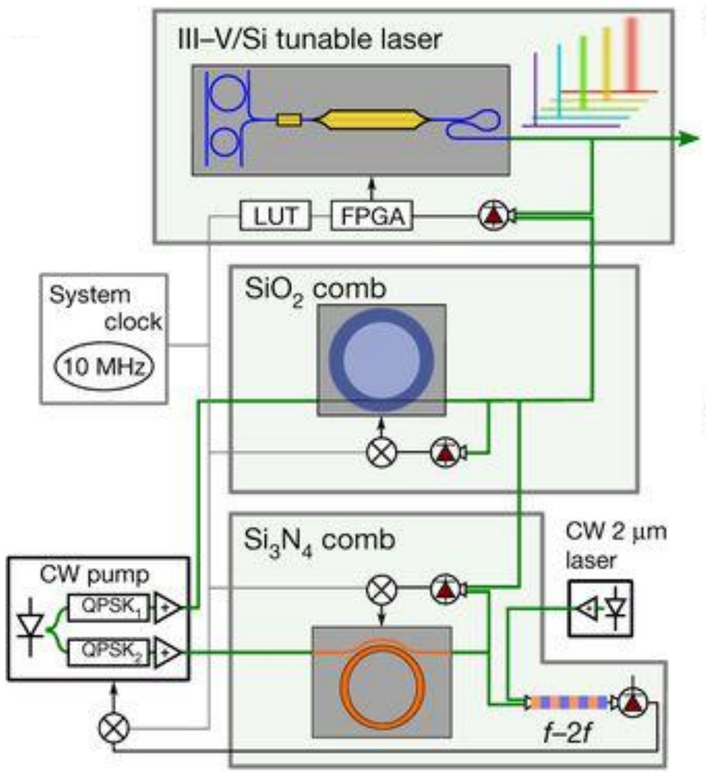
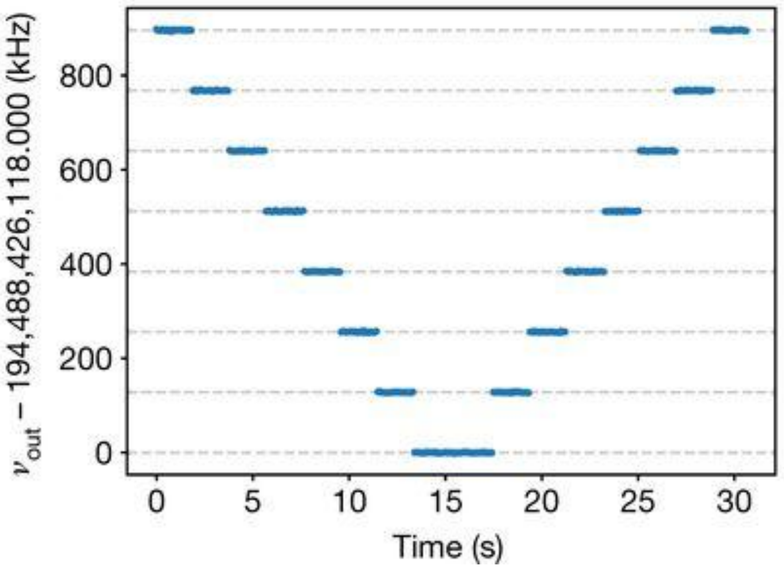
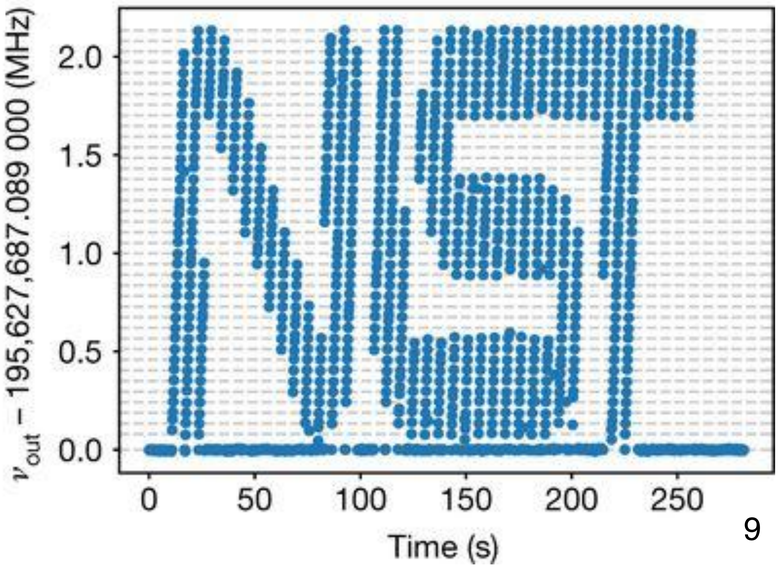


Spencer et al., Nature (2018)

- Small volume and small power consumption
- Thick SiN to do integrated nonlinear optics
- Thick SiN to have small resonators
- Low loss SiN to get best Q factors for low power operation
- Interposer to connect other integrated optics





Low Loss SiN - Platform Overview

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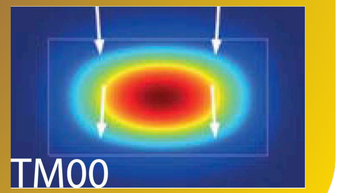
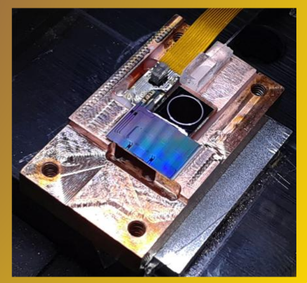
The Basics

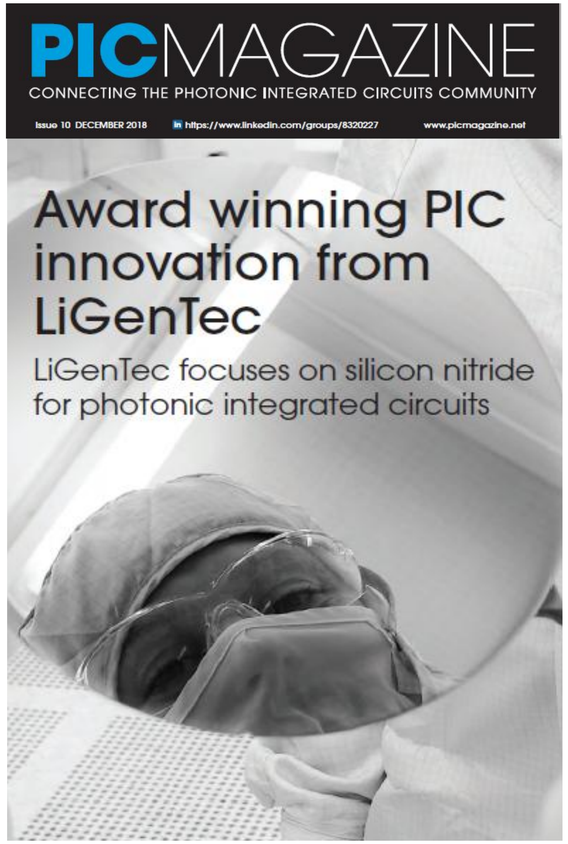
- ✓ High Mode Confinement
- ✓ Low Loss
- ✓ Small Footprint
- ✓ High Power



Actives

- ✓ Electrical Tuning
- ✓ Modulators
- ✓ Lasers
- ✓ Detectors

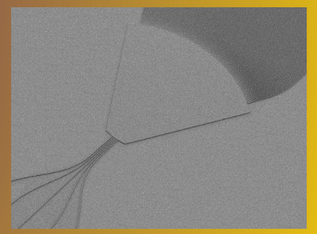


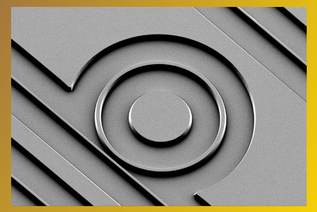


Full Creativity

- ✓ Couplers
- ✓ Mux / DeMux
- ✓ MZIs / DLIs
- ✓ Resonators

many more





World Connections

- ✓ Edge Coupling / U Grooves
- ✓ Spot Size Converter
- ✓ Grating Couplers
- ✓ Arbitrary Die Shape
- ✓ Bond pads