

## Widely tunable laser source for gas sensing applications

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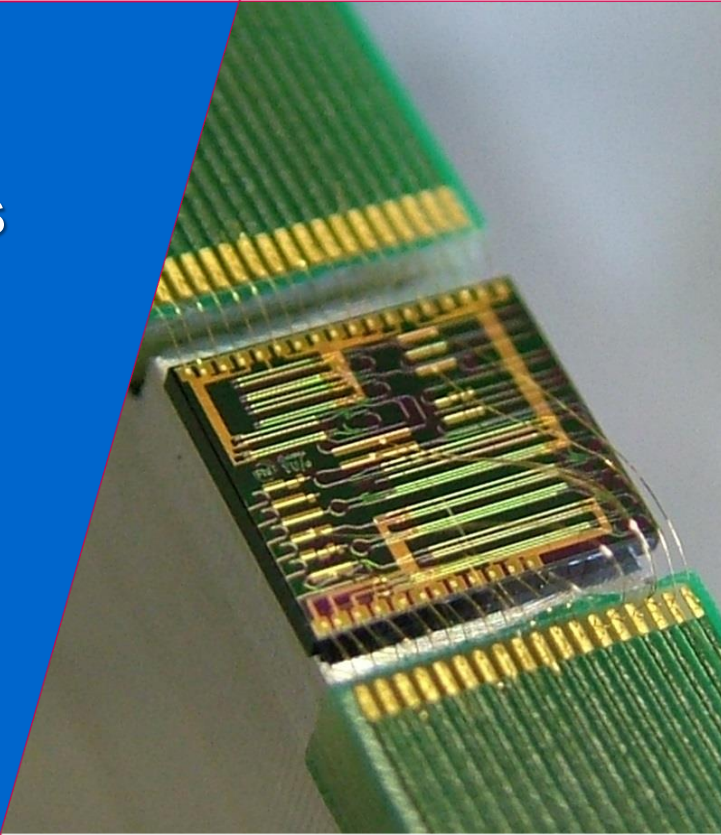
providing details and we will investigate your claim.

# Widely tunable laser source for gas sensing applications

*Sylwester Latkowski, Erwin Bente*

*Photonics Event 2015, Veldhoven*

04 June 2015



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University of Technology

**Where innovation starts**

# Outline

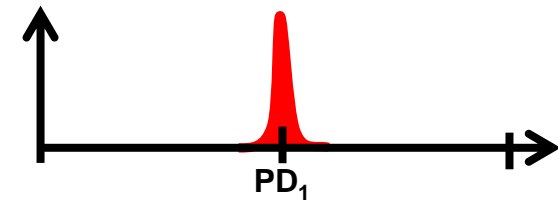
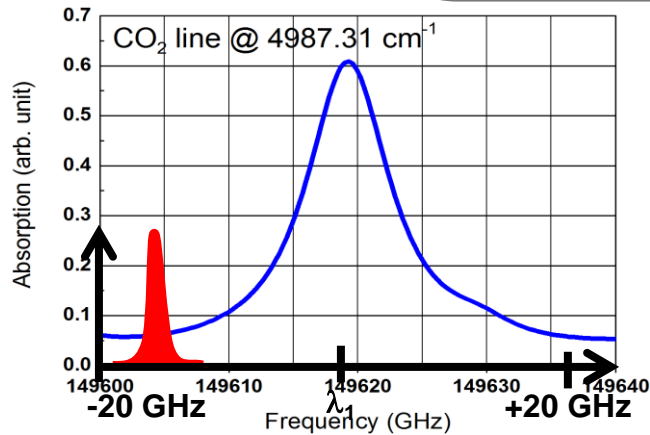
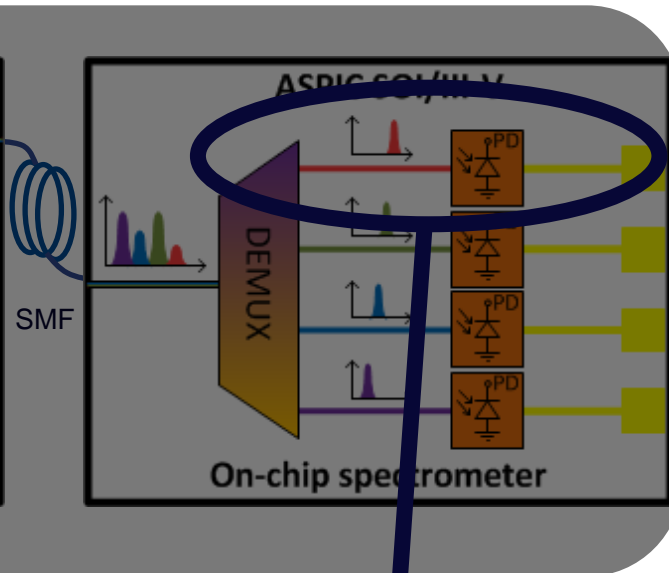
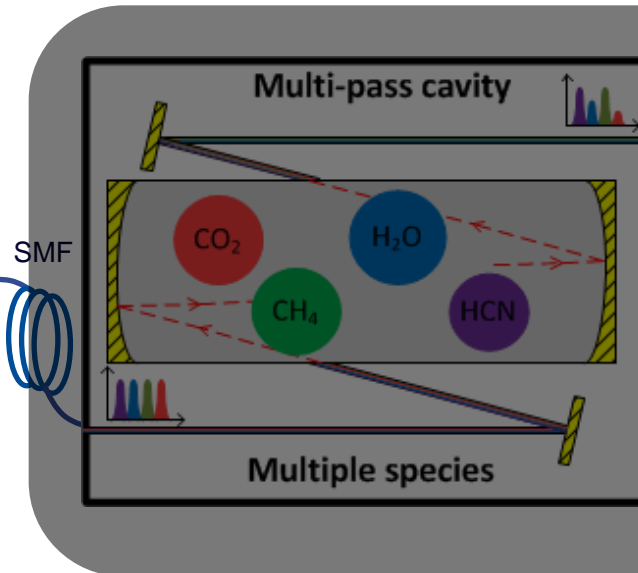
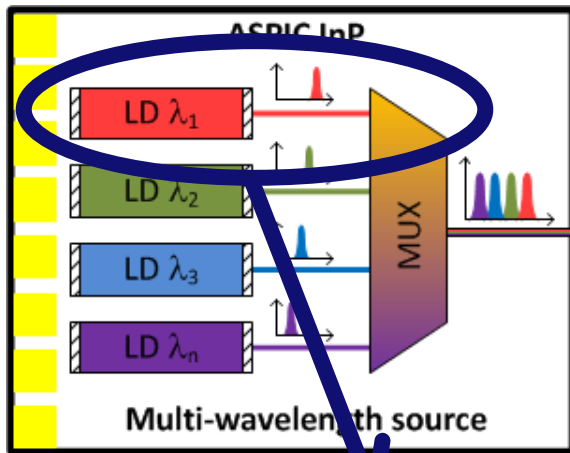
- **Motivation – laser gas detection**
- **Tunable laser - AMZI based  $\lambda$  filter**
- **Simulations**
- **Photonic Integrated Circuits**
- **Experimental results**
- **Summary**

# Laser gas detection system

## Source

## Gas interaction region

## Detection



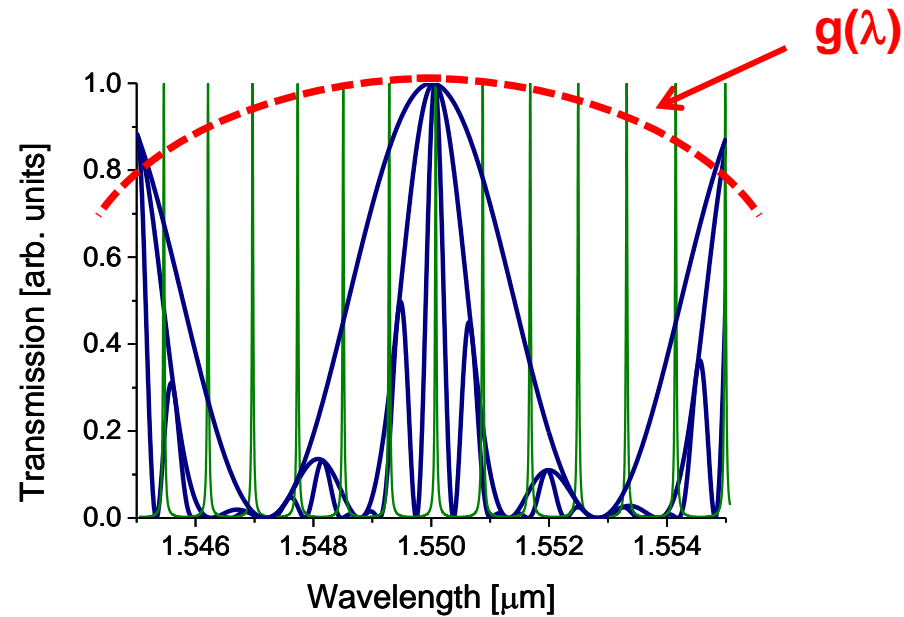
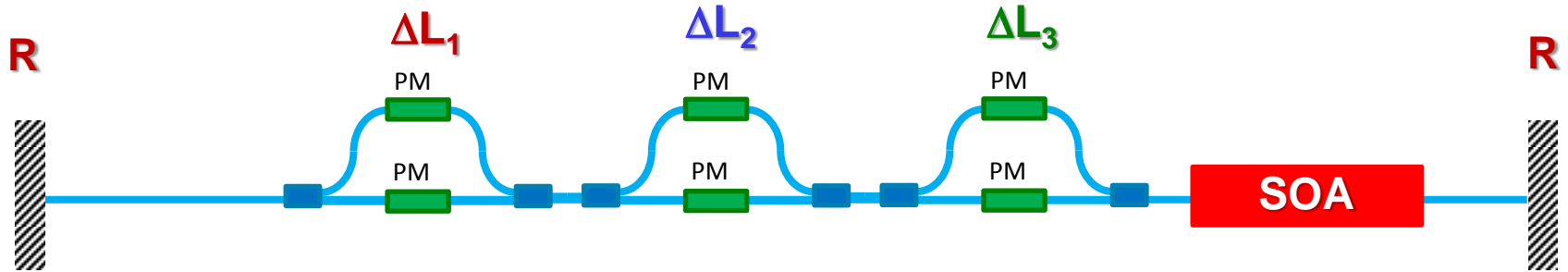
# Laser requirements - gas sensing

- Central frequency/wavelength:  $f_c \pm 100$  of **MHz** ( $\lambda_c \pm 1$  **pm**)
- Swing range **1GHz ~ 30GHz**
- Switching/tuning speed:  **$\mu$ s or less**
- Optical linewidth **~MHz**
- Average optical power  $\geq 1$  **mW** (more -> better)

- **4 tunable lasers on a single PIC chip**
- **Long wavelength laser ~2 $\mu$ m**

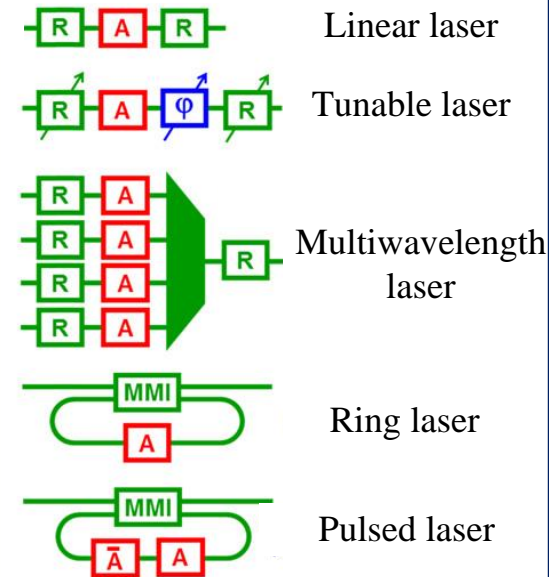
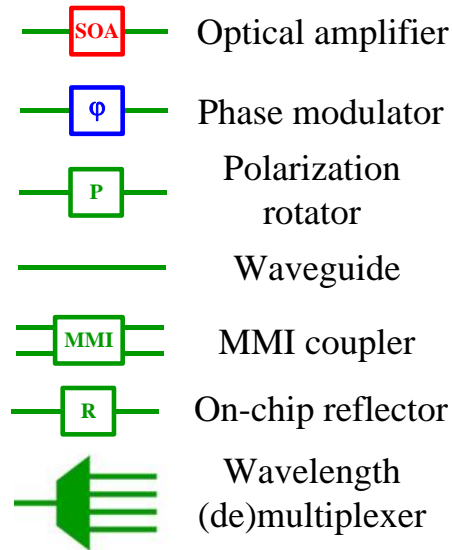
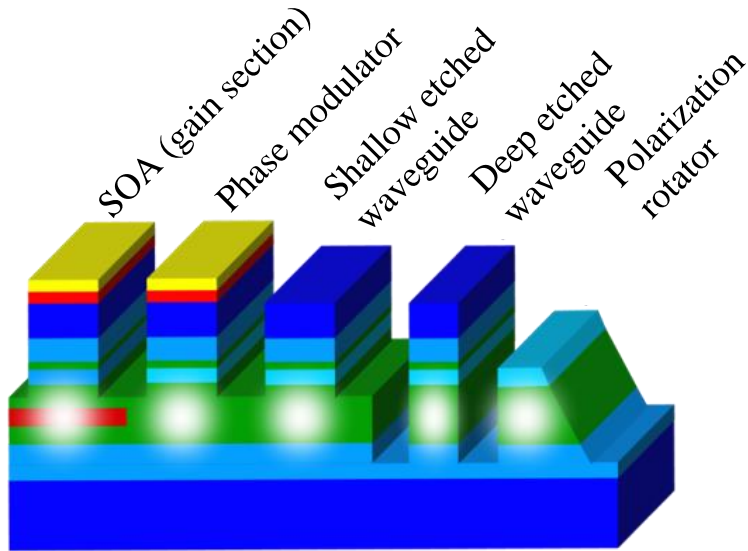
**PIC**

# Intracavity AMZI $\lambda$ filter



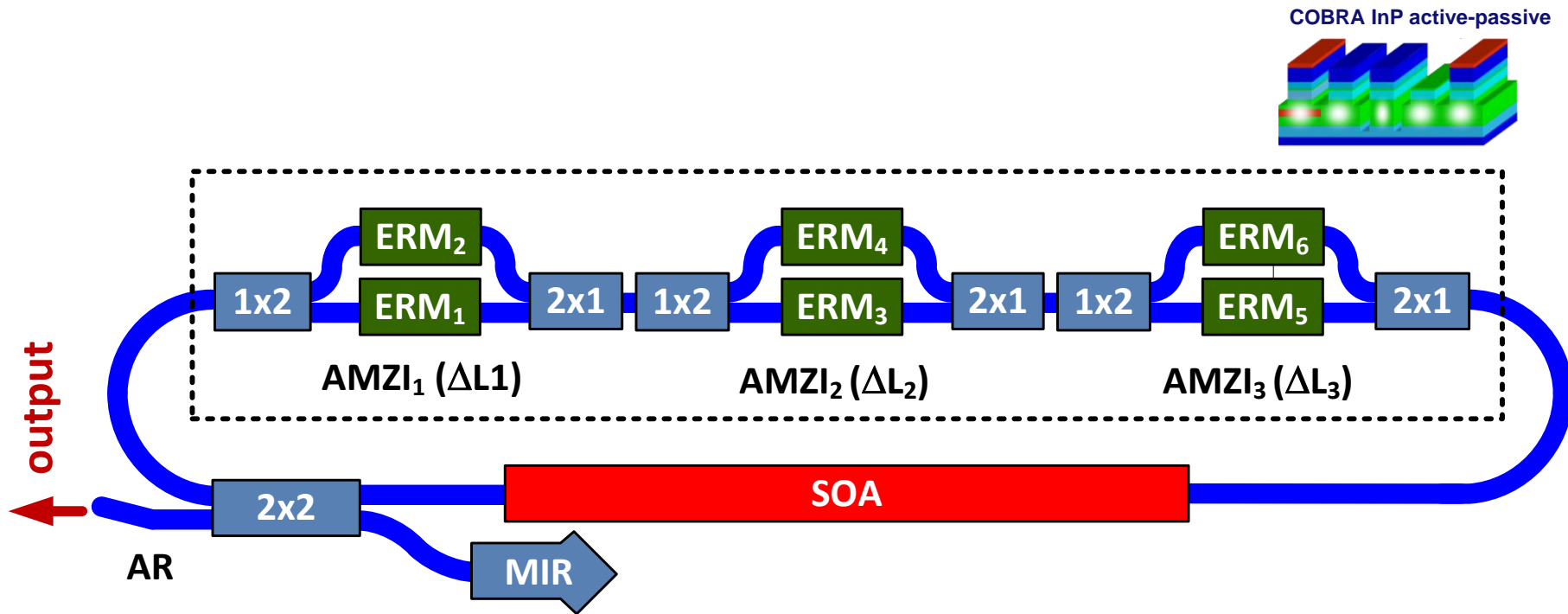
# COBRA active-passive

## InP Generic Photonic Integration Technology



- **M. Smit et al. "An introduction to InP-based generic integration technology," *Semicond. Sci. Technol.*, vol. 29, no. 8, Jun. 2014.**
- **SMART PHOTONICS B.V. <http://www.smartphotonics.nl/>**
- **JePPiX <http://www.jeppix.eu>**

# Ring laser with three AMZI filters



$$L_{\text{RING}} = 16\text{mm} \quad (\text{FSR}_{\text{RING}} = 5\text{GHz})$$

$$\Delta L_1 = 1300\mu\text{m} \quad (\sim 88\text{GHz})$$

$$L_{\text{SOA}} = 1\text{mm}$$

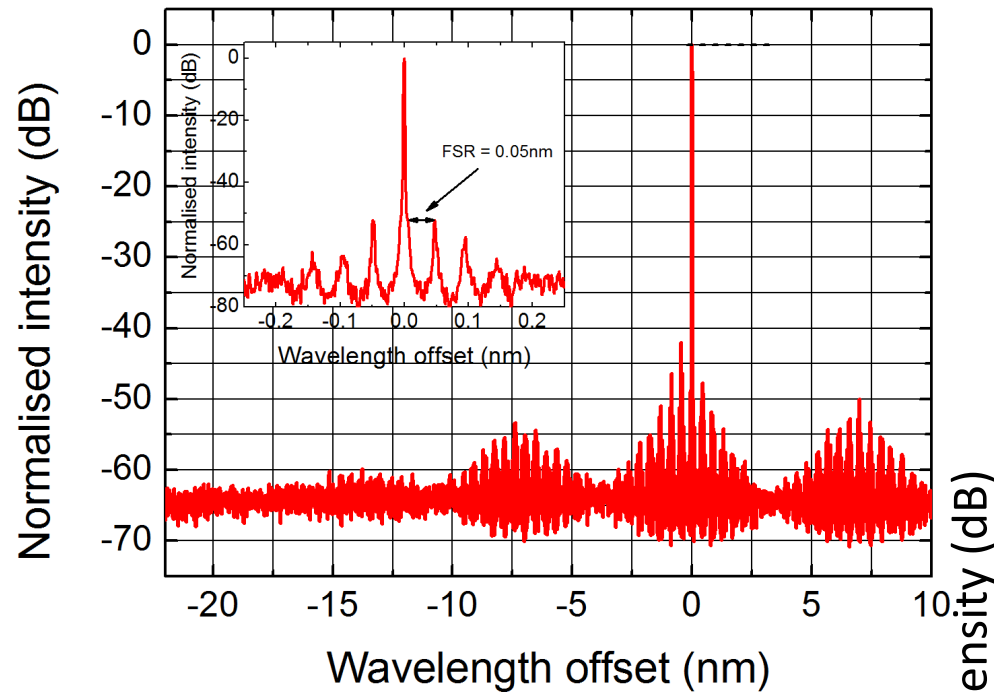
$$\Delta L_2 = 89\mu\text{m} \quad (\sim 1\text{THz})$$

$$L_{\phi} = 2\text{mm} \quad (V_{2\pi} = 12\text{ Volt})$$

$$\Delta L_3 = 9\mu\text{m} \quad (\sim 9\text{THz})$$

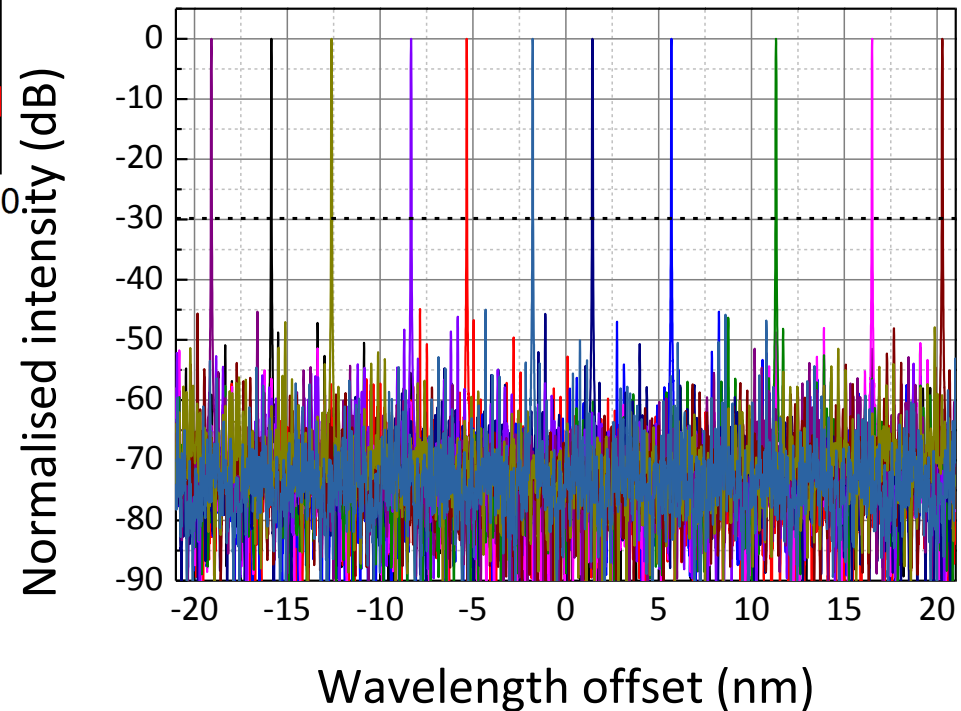


# Ring laser with AMZI filter – simulations



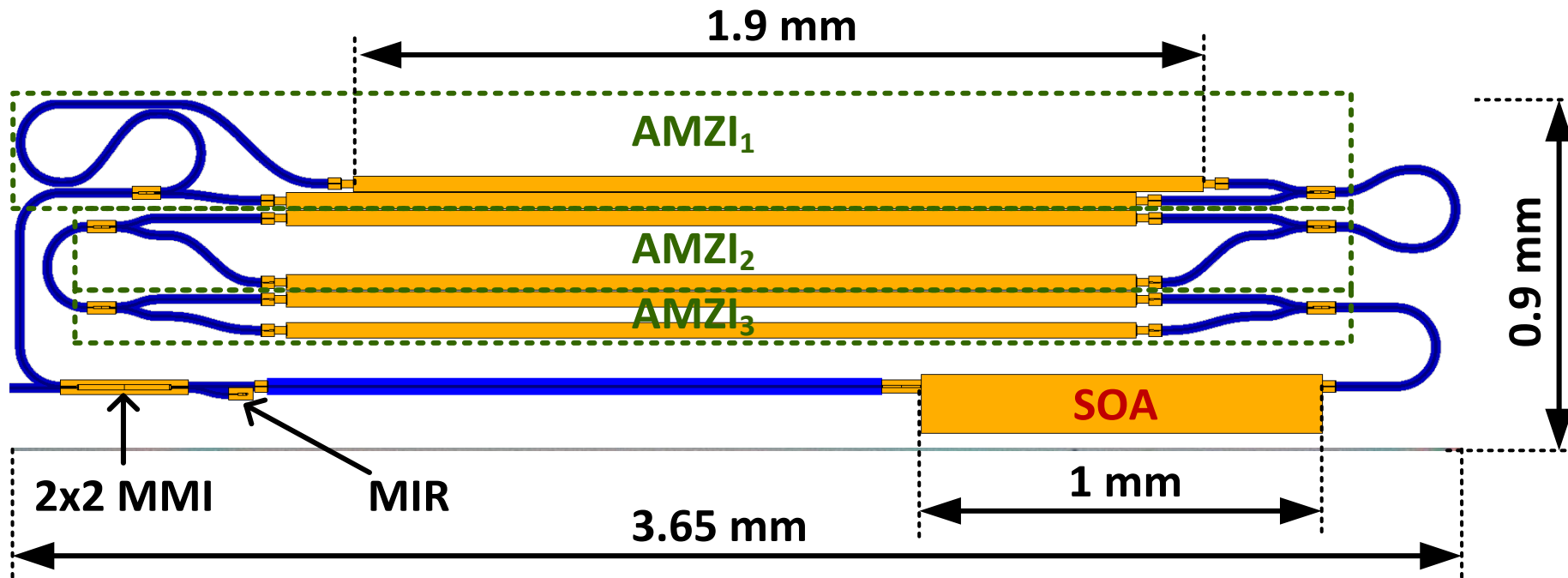
**Simulation results**  
(PicWave)

- Photonic circuit simulator PICwave
- Time domain – travelling wave
- SOA gain data from experiment

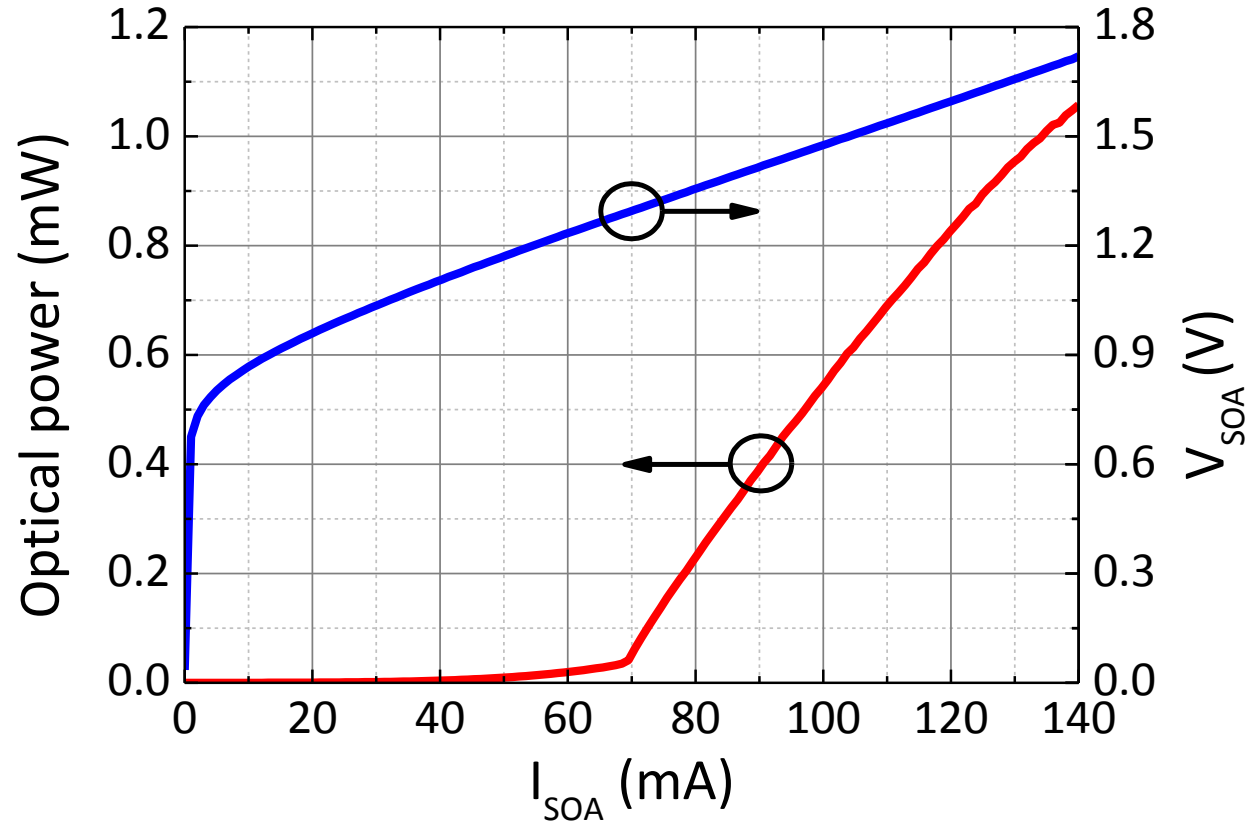
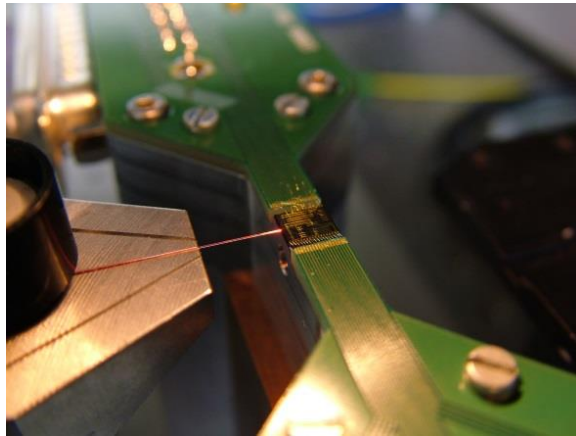
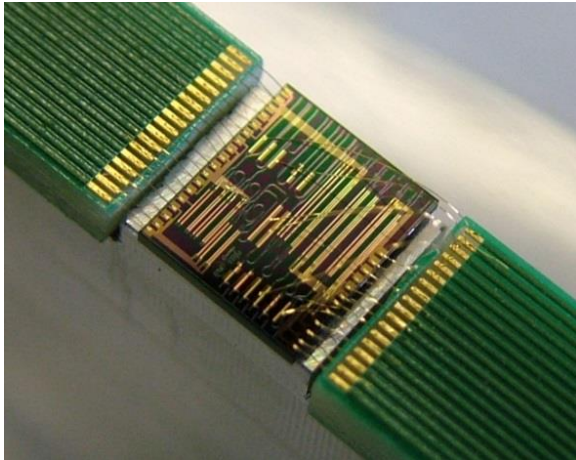


# Tunable ring laser – chip

## SMART MPW 09



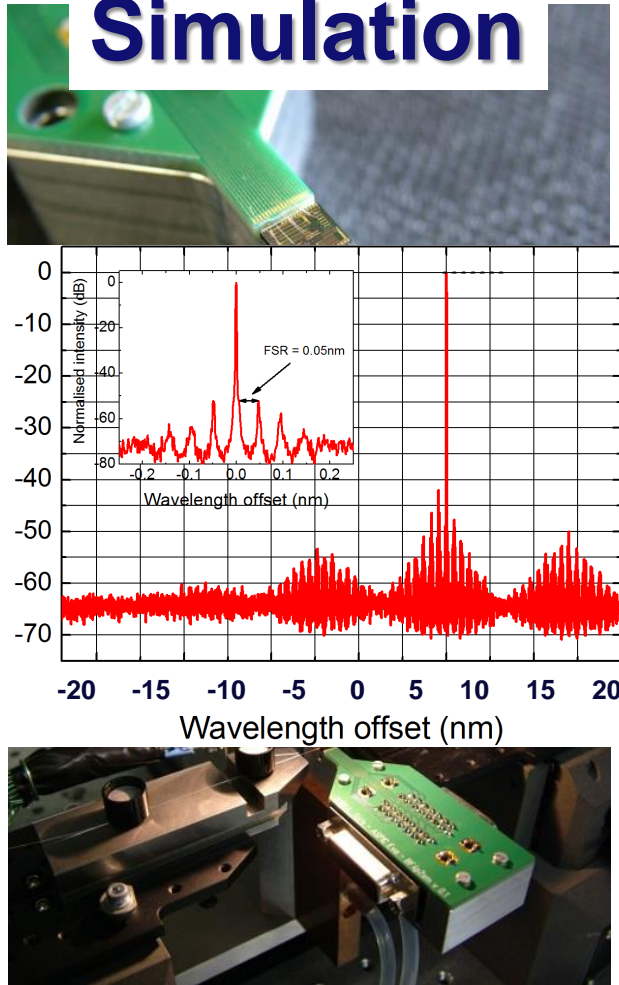
# LI – curve



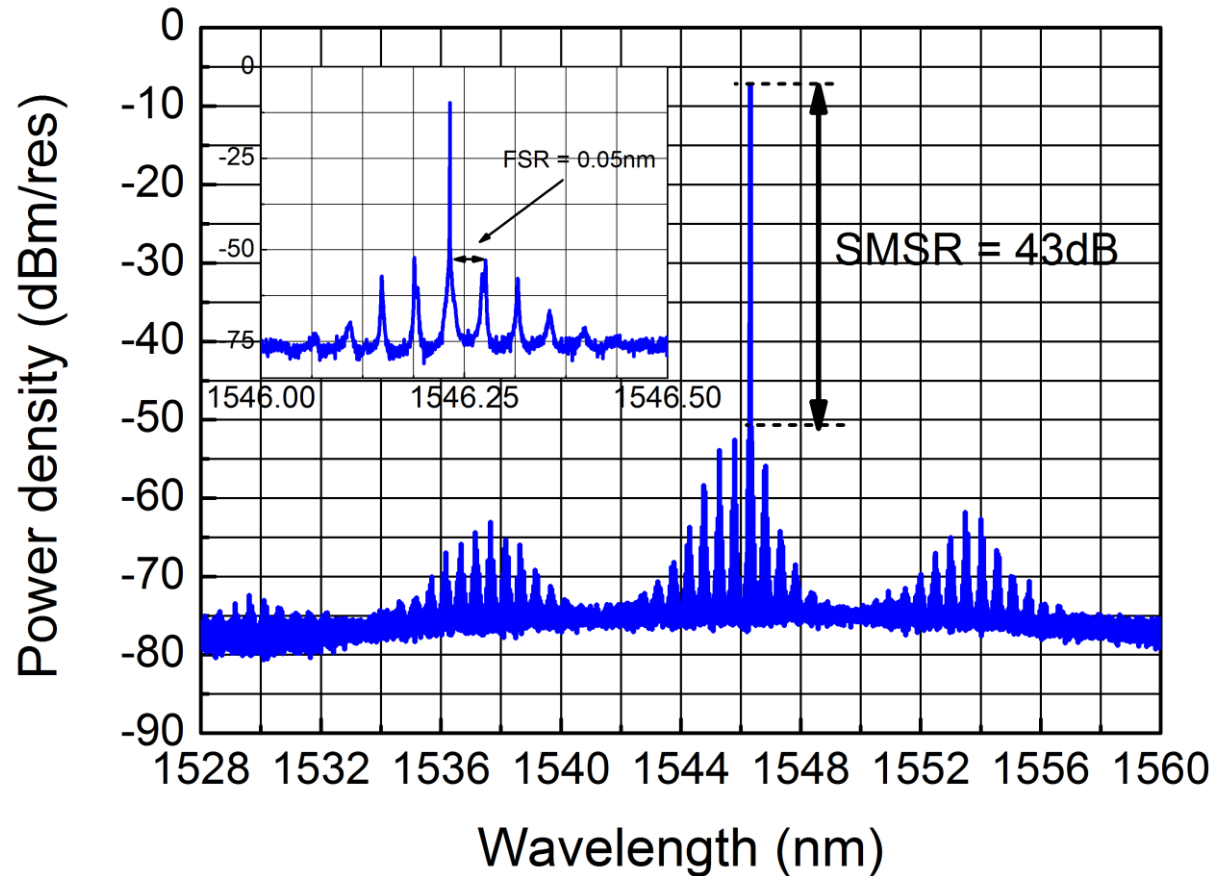
$I_{TH}=68\text{mA}$  ( $J_{TH}=2.8\text{kA/cm}$ ) @  $18^\circ\text{C}$

# Single-mode operation

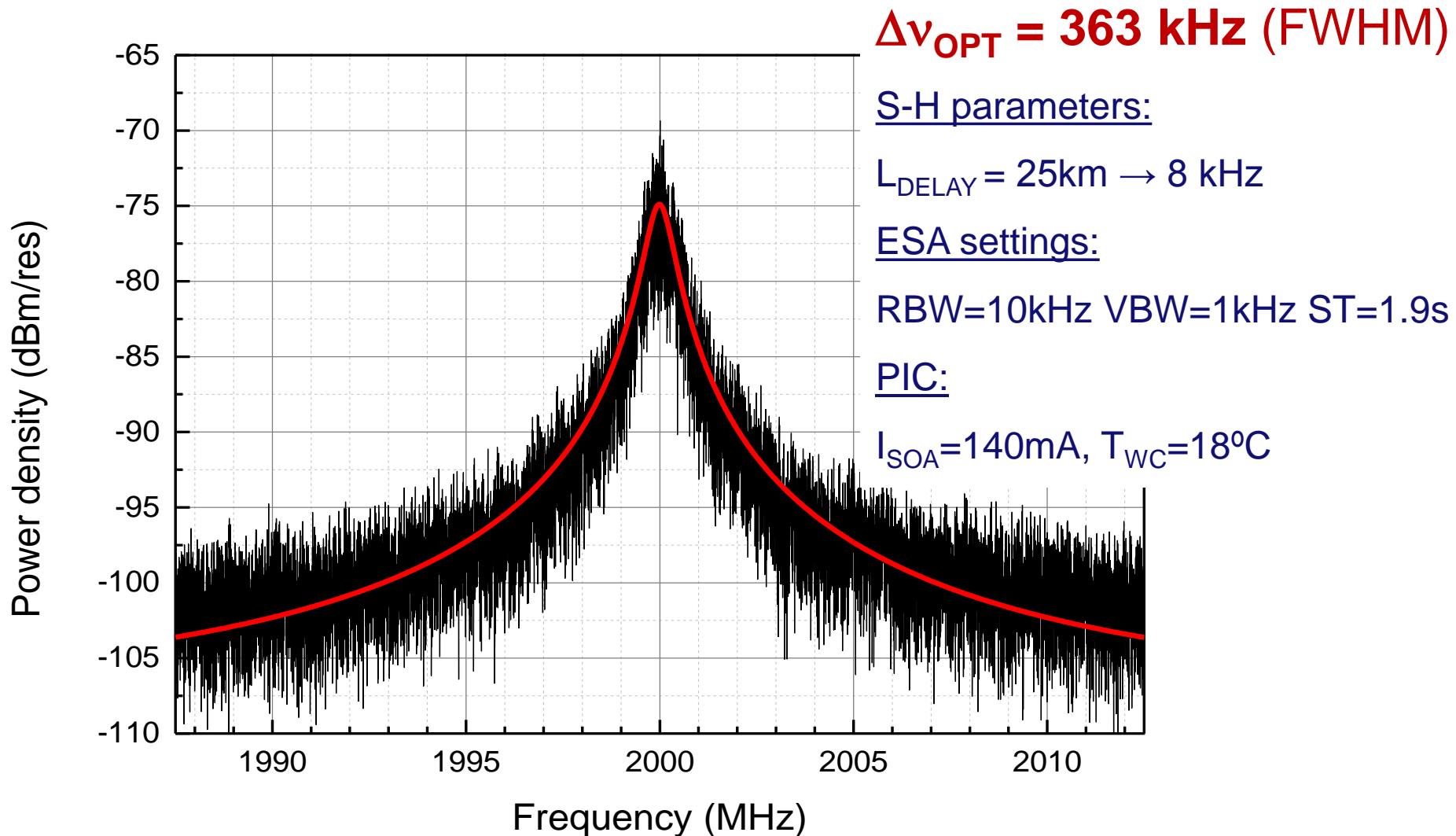
## Simulation



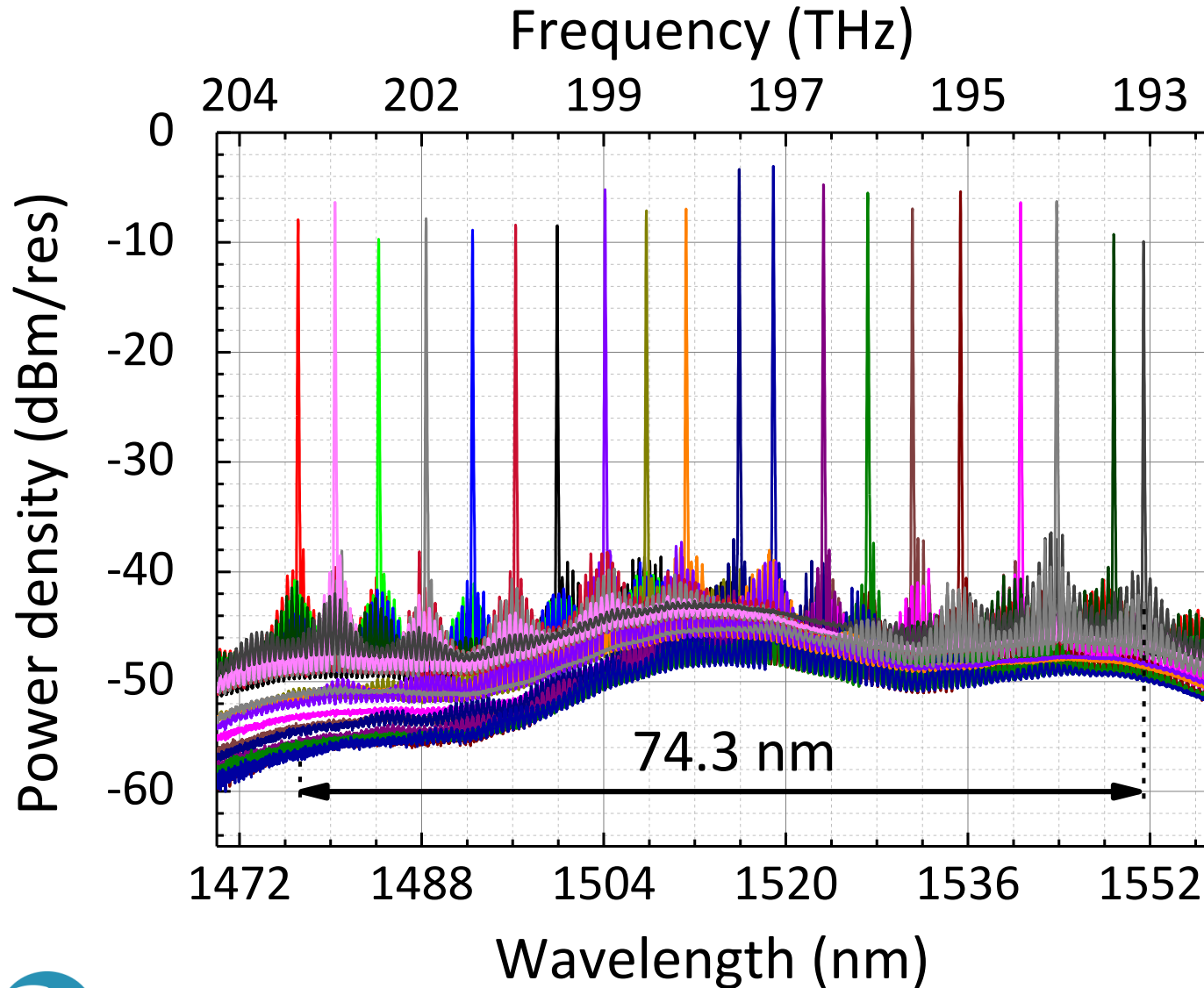
## Measurement



# Laser linewidth – self heterodyne



# Tuning range



$$\Delta\lambda = 74.3 \text{ nm}$$

$$\Delta f = 9.4 \text{ THz}$$

OSA settings:

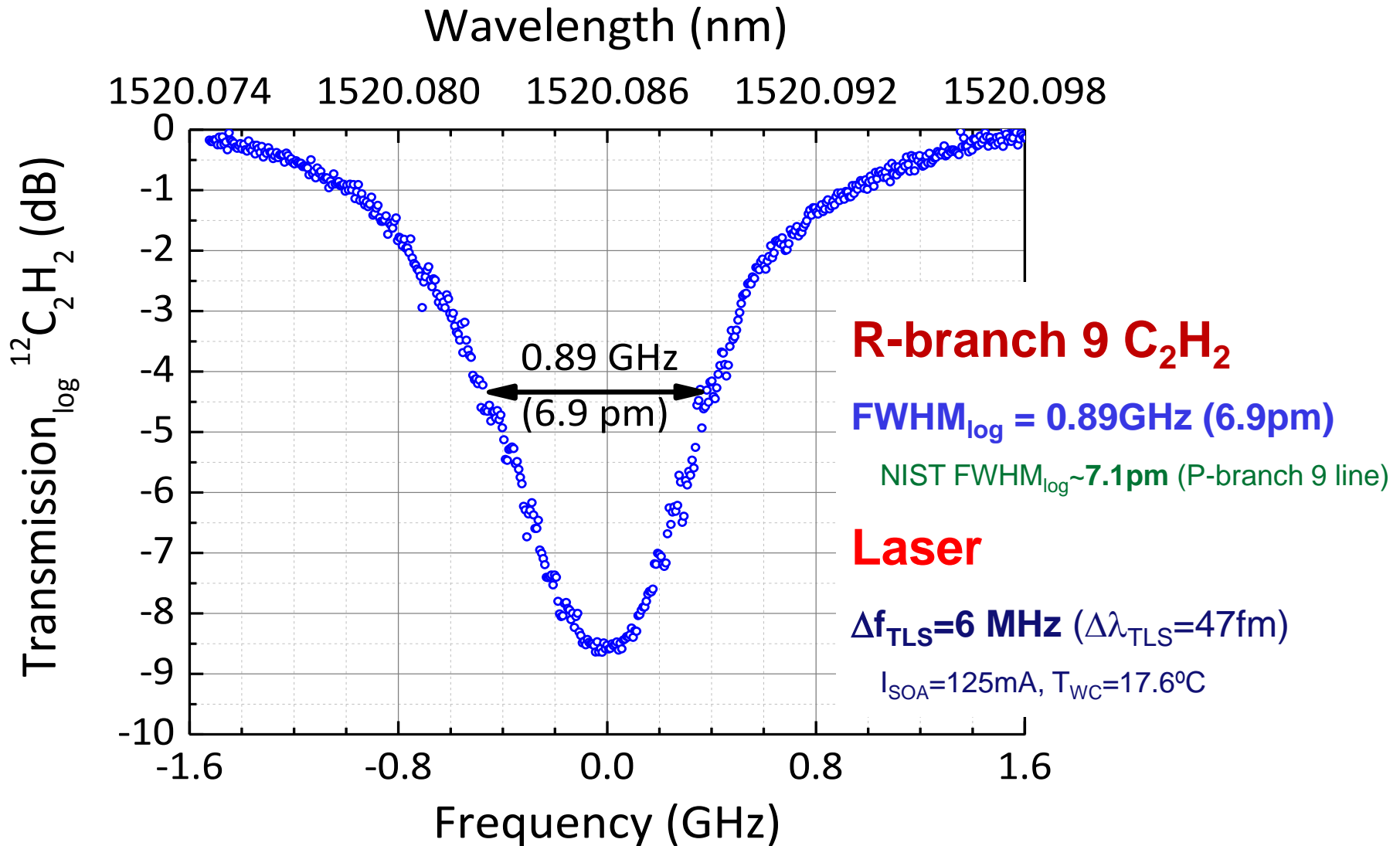
Res = 0.1nm (12.5GHz)

PIC:

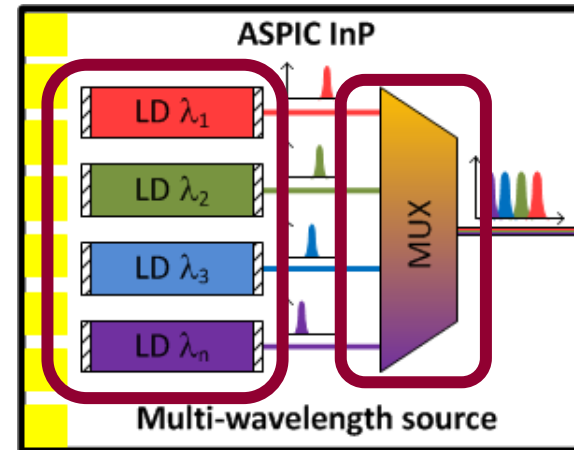
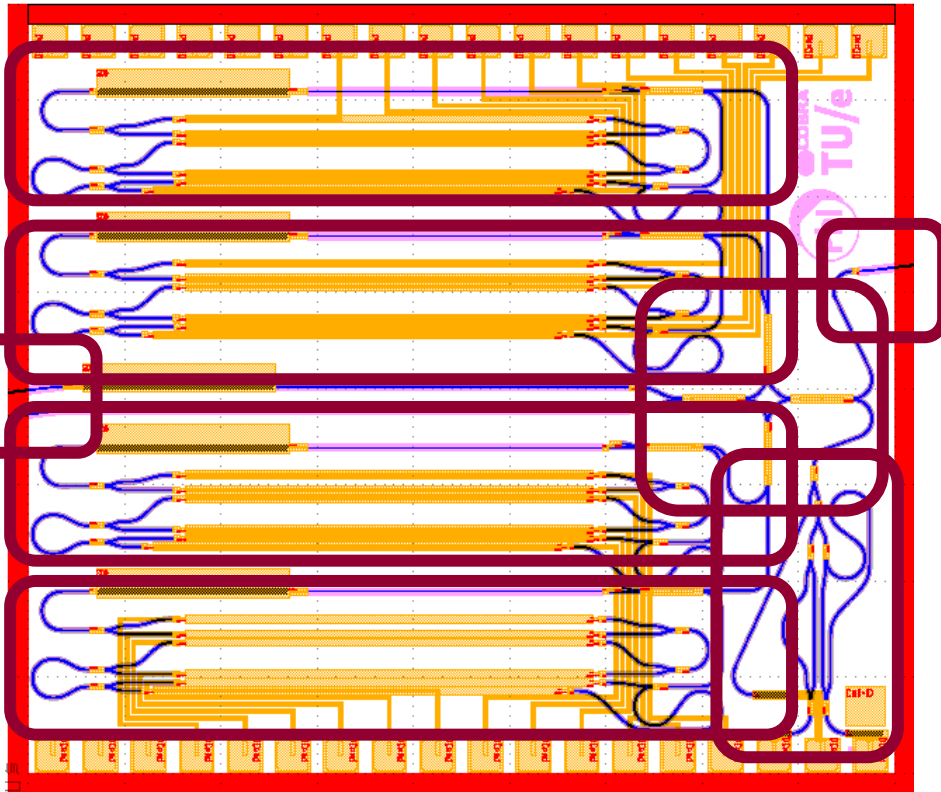
$I_{\text{SOA}}=140\text{mA}$

$T_{\text{WC}}=18^\circ\text{C}$

# Fine tuning – $^{12}\text{C}_2\text{H}_2$ R-9 absorption line



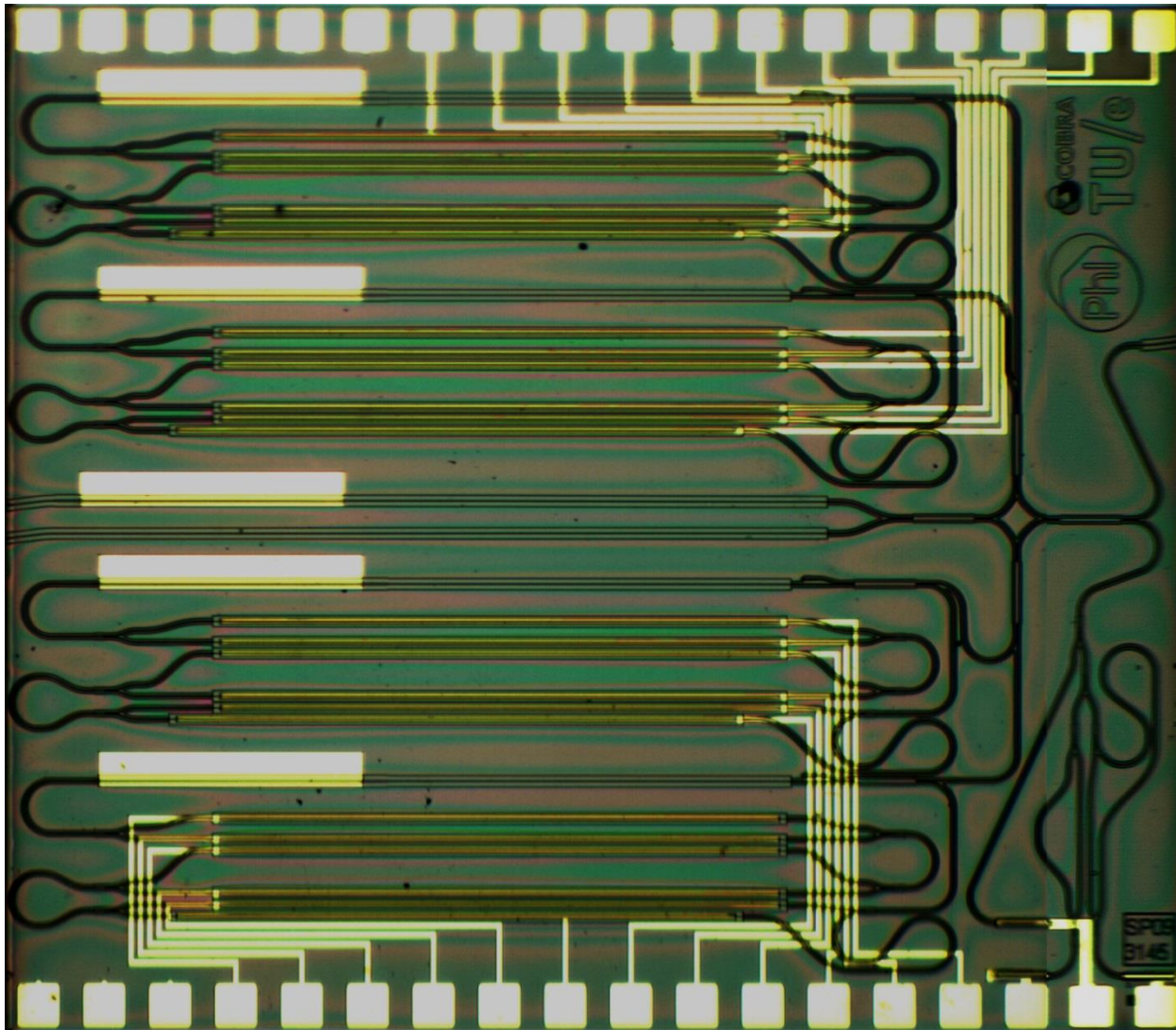
# 4 x Tunable laser at 1.5 $\mu\text{m}$



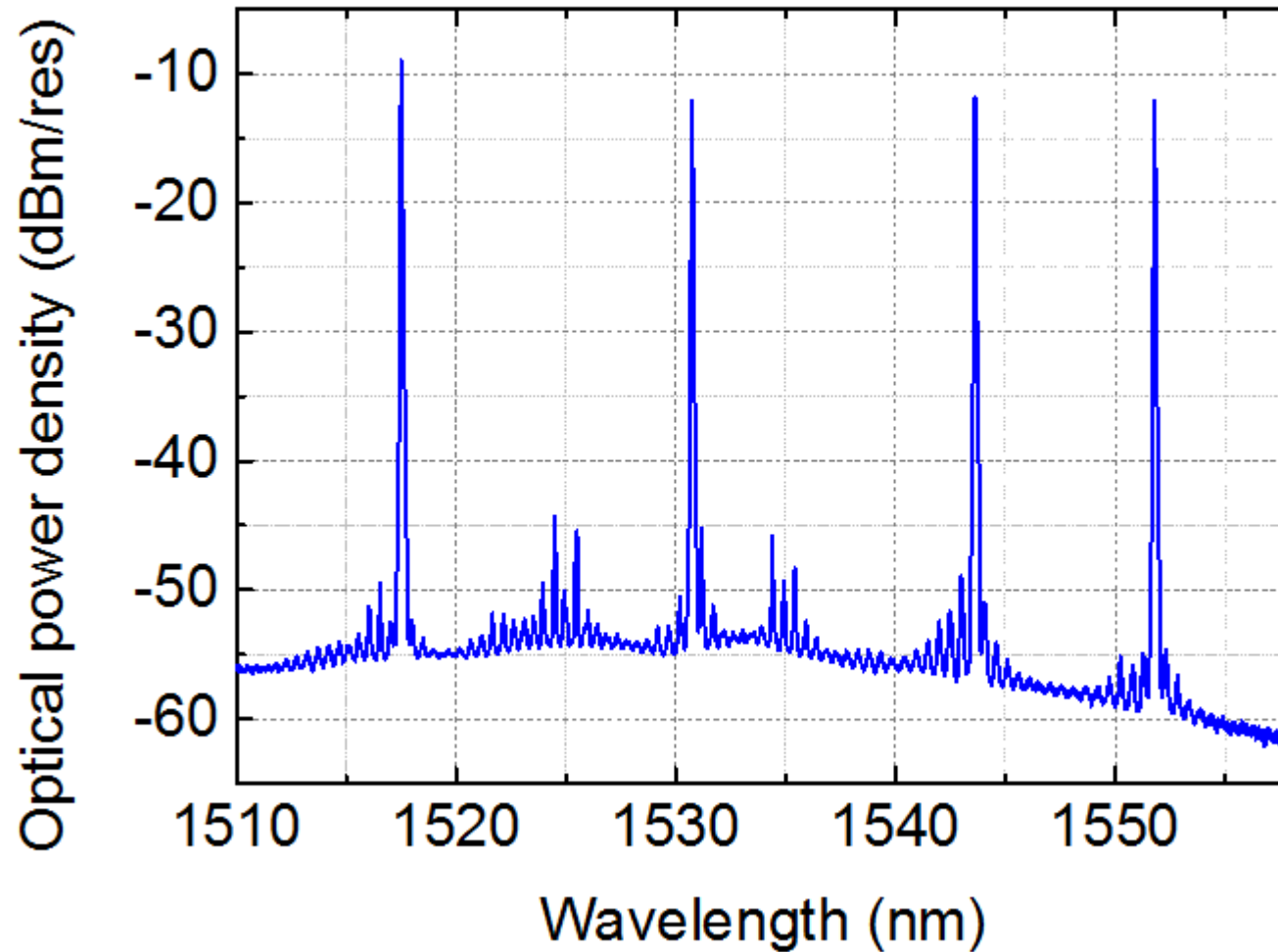
- Four independent lasers
- MMI based combiner
- Three outputs
- On-chip wavelength tracking



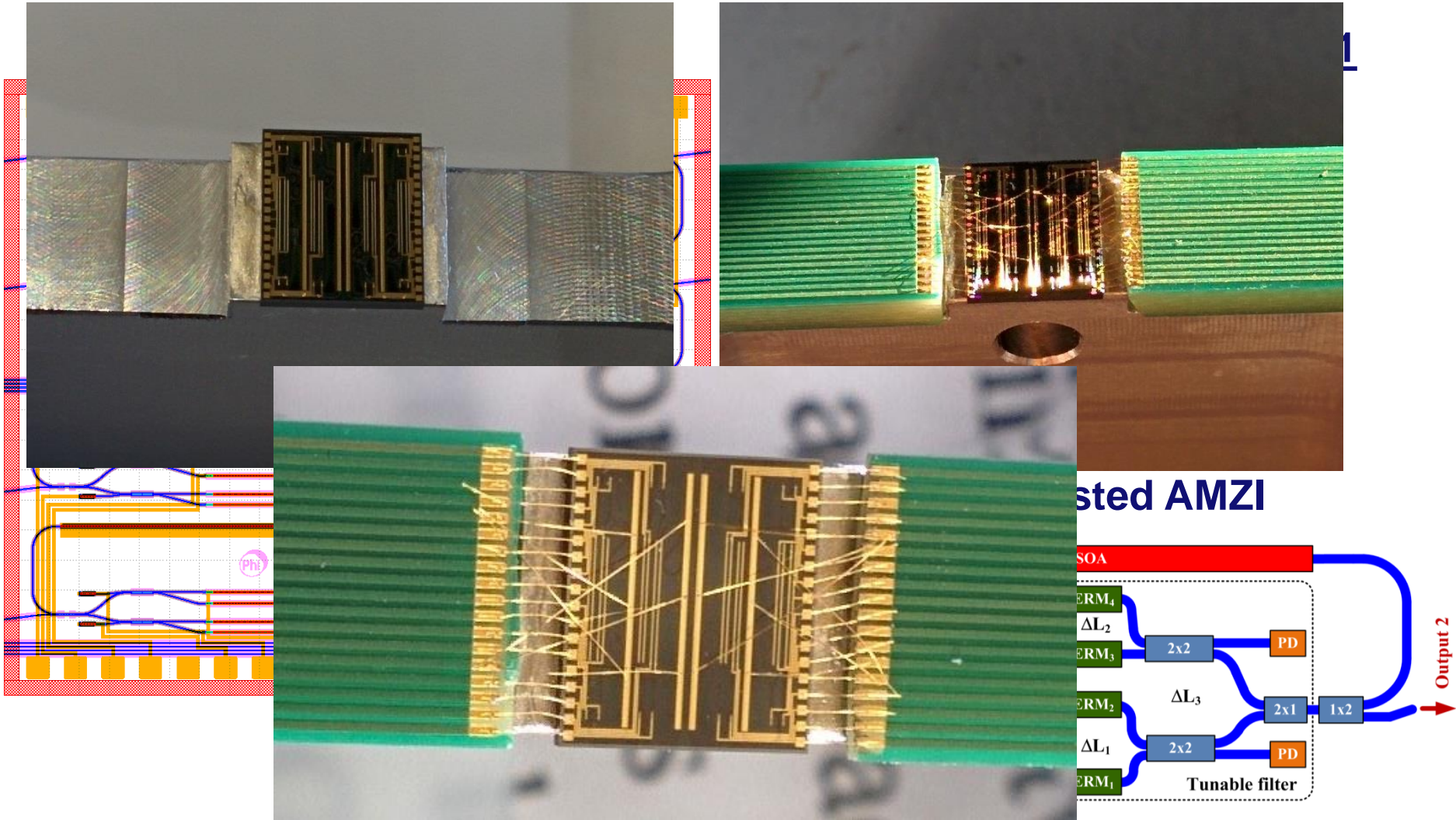
# Quad RsAMZI laser PIC – SMART MPW 09



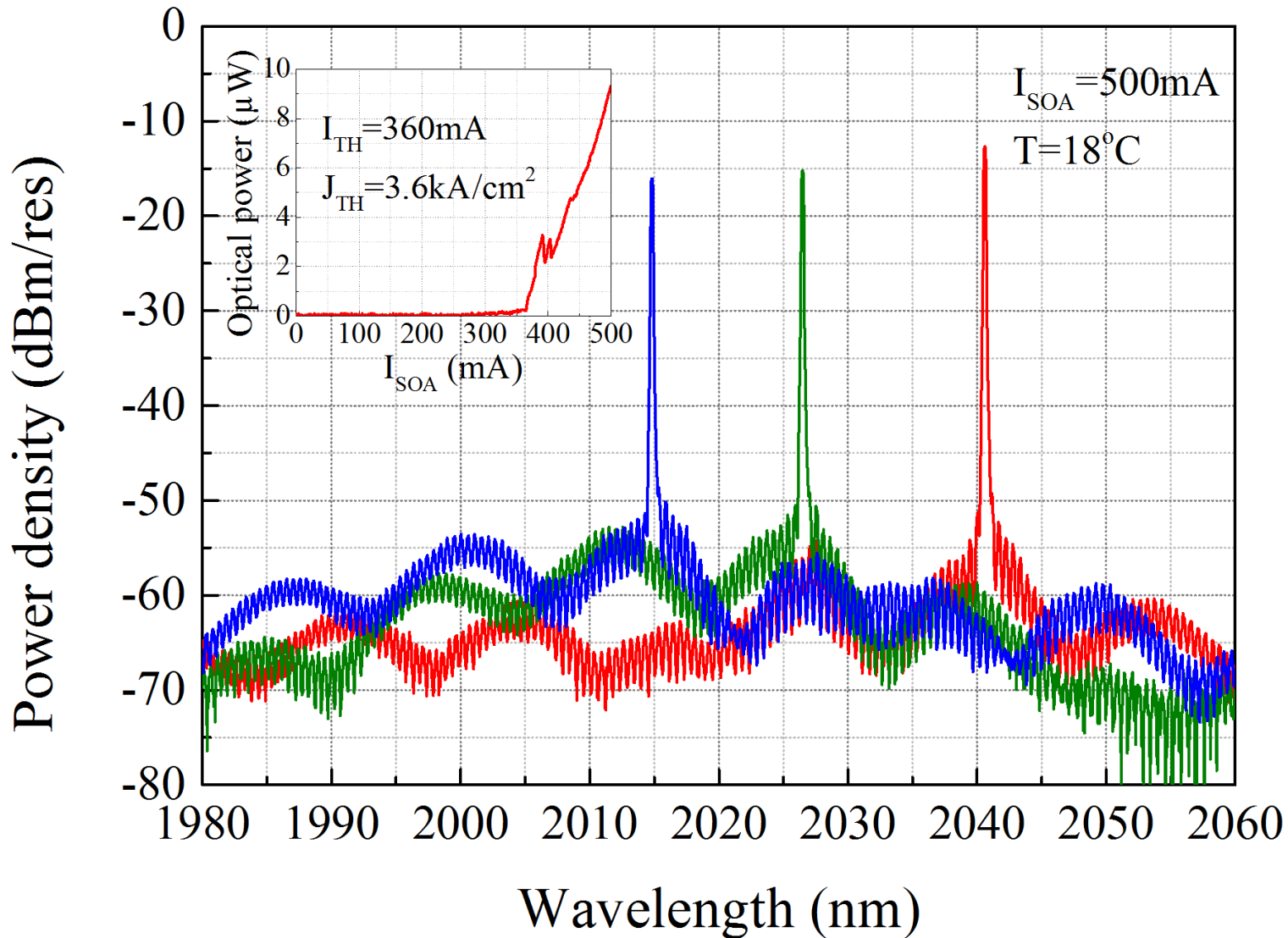
# Four lasers to one output - OSA



# Tunable laser at 2 $\mu\text{m}$ - COBRA LW MPW 01



# Tunable laser at 2 $\mu\text{m}$ - works!



# Summary

- New concept of widely tunable laser
  - PIC at **1.5 $\mu$ m**
  - Record tuning range of **74nm**
  - Gas detection suitable
- 4 sources on one chip at **1.5 $\mu$ m**
  - PIC fully functional
- Fully functional PIC laser at **2 $\mu$ m**
  - Long-wavelength COBRA active-passive
  - Tuning range of **25 nm**

# STW - LWAVE-TECH



Dutch  
Metrology  
Institute



Phoenix Software  
Solutions for Micro and Nano Technologies

The End

**Thank You!!!**  
Questions?

