



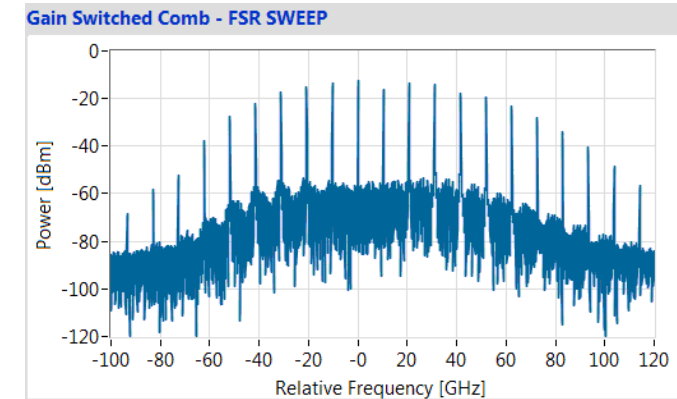
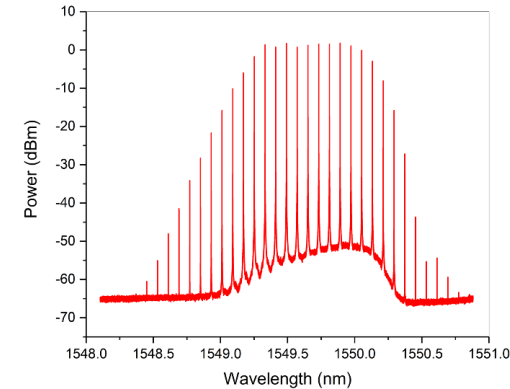
Dual Comb PICs for Optical Sensing

Frank Smyth, Founder and CTO

frank.smyth@pilotphotonics.com

What we do

- Optical combs are lasers that produce multiple coherent frequencies of light simultaneously
- Powerful tool for many photonics applications including fiber sensing and spectroscopy
- Pilot Photonics develops photonic solutions based on patented gain switching approach
 - Flexible, cost effective approach well suited to photonic integration



RF signal sets the comb spacing and can be swept at MHz rates



Comb sources let you see the wood *and* the trees

Typical spectroscopic approaches used today

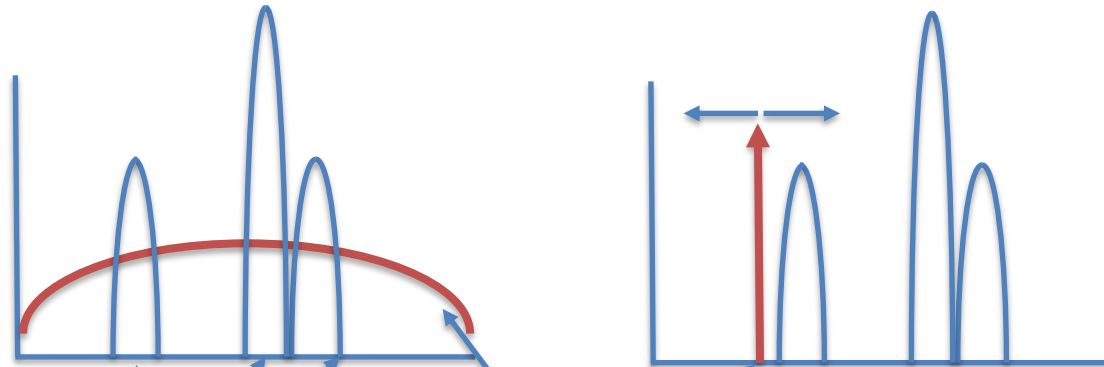
Broadband Light Source

Swept Single Mode Light Source

Optical Comb Source

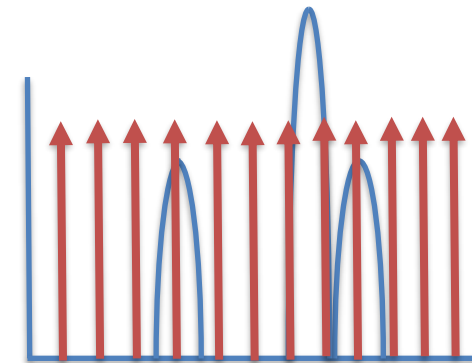
lets you “see the woods”

lets you “see the trees”



spectral signature
of gas sample

Optical detection
spectrum

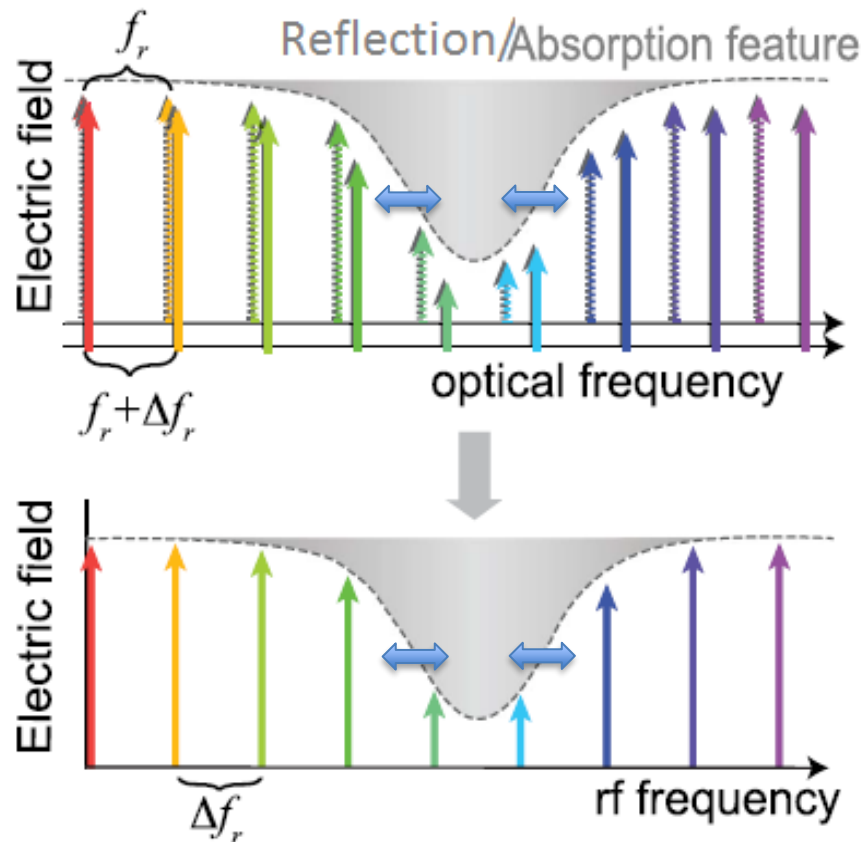


- ✓ High Resolution
- ✓ High Speed
- ✓ Compact
- ✓ Low Cost
- ✓ High Sensitivity

Lets you “see the
woods *and* the trees
at the same time”

One Step Further: Dual Comb PICs to simplify the receiver

Example shown of an FBG sensor optical spectrum as the measured value changes e.g. when a temperature or pressure shift occurs



The transmission spectrum of the fiber bragg grating shifts in the wavelength spectrum in proportion to the applied pressure/temp.

The two laser combs are shifted to create a different delta at each point in the spectrum with hundreds of lines per comb source.

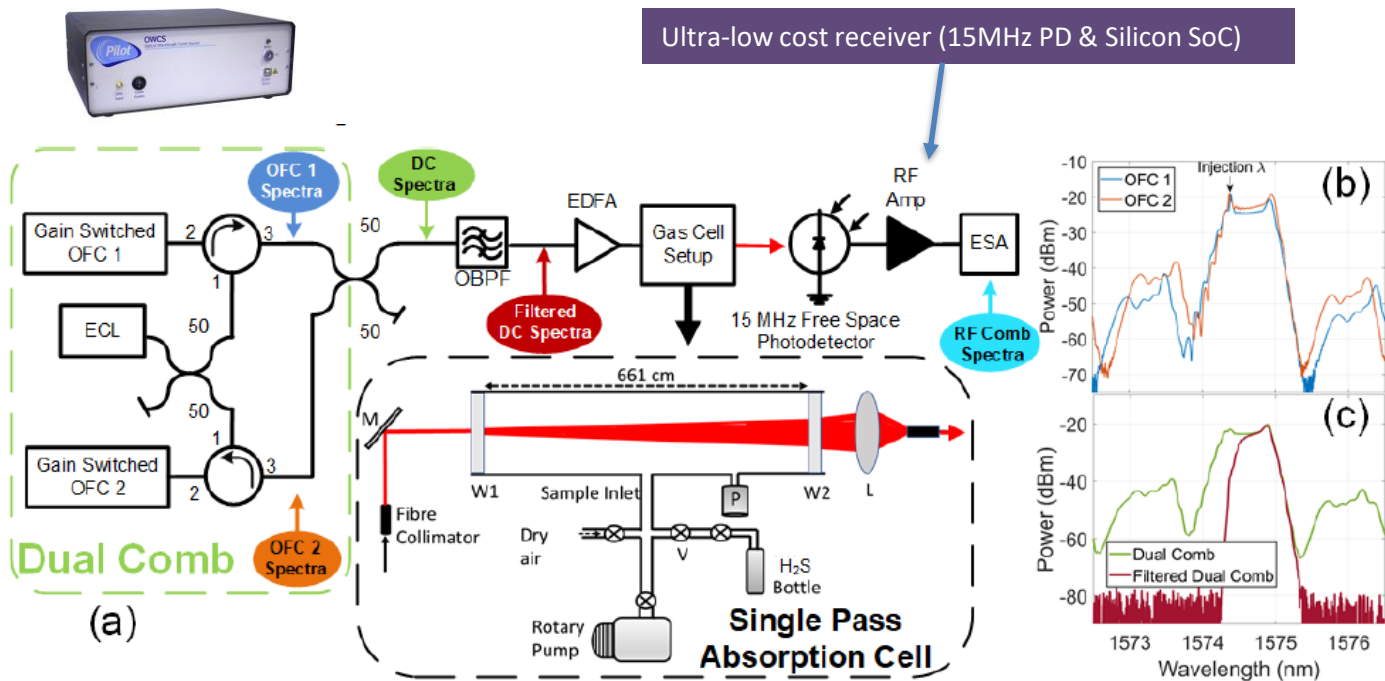
When mixed in the receive photodiode, the frequency component for each delta f_r is recovered as a down-mixed electrical spectral shape equivalent to the original transmission spectrum.

Eliminates the need for an optical spectrometer by transposing the measurement to the low-frequency RF domain

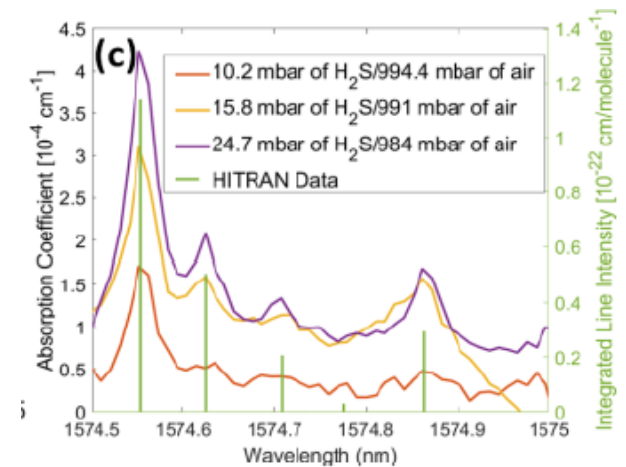
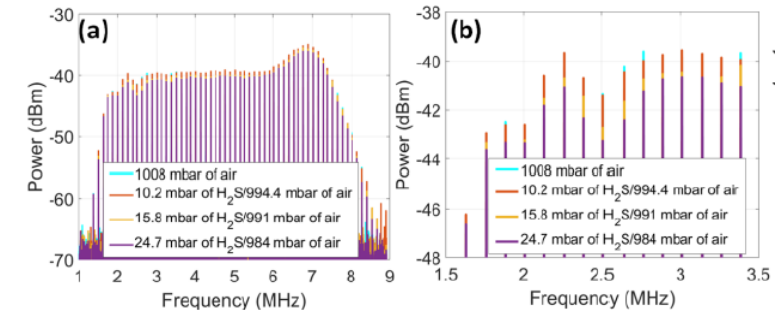
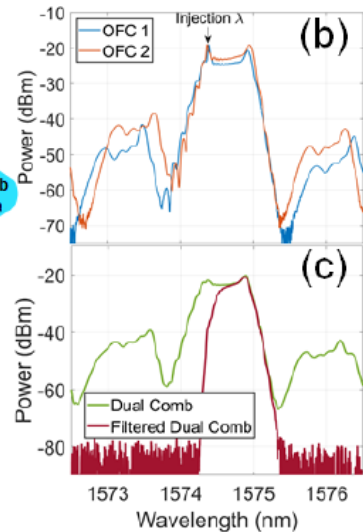
Image adapted from I. Coddington, et al, "Dual Comb Spectroscopy", Optica, Vol. 3, Iss. 4, April 2016

Dual-comb Gas Spectroscopy

- Dual-comb spectroscopy greatly simplifies the receiver by transposing the measurement to the RF domain
- Continuous, high resolution, real time measurement of a gas sample without laser sweeping



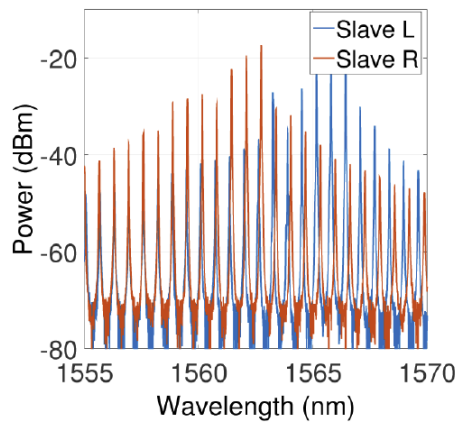
Ultra-low cost receiver (15MHz PD & Silicon SoC)



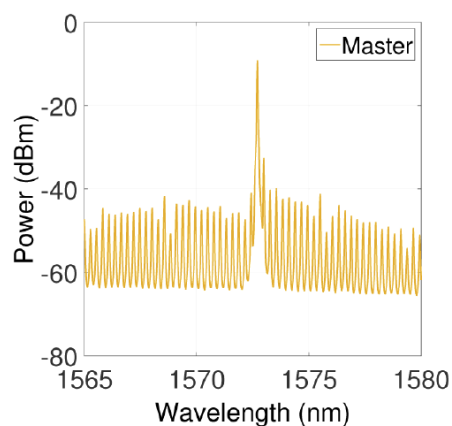
E. P. Martin, et al, "Mutually Injection Locked Gain Switched Optical Frequency Combs for Dual Comb Spectroscopy of H₂S," in *CLEO 2020*

Dual-comb PIC

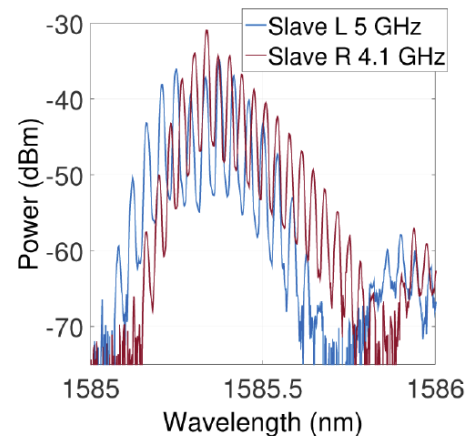
- A PIC version of the dual-comb based on gain switching has now been developed to target dramatic cost reduction
- Ultra low-cost system becomes deployable at very large volumes
- Regrowth free, monolithic InP fabrication at Tyndall



FP Spectra of dual-comb lasers



Single Master Laser to lock and synchronise the combs



Dual coherent gain switched combs at different FSR

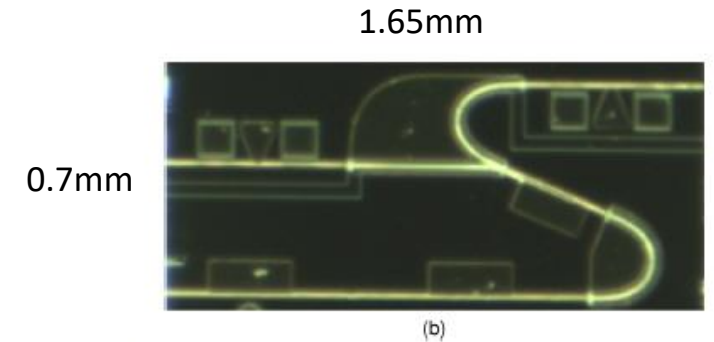
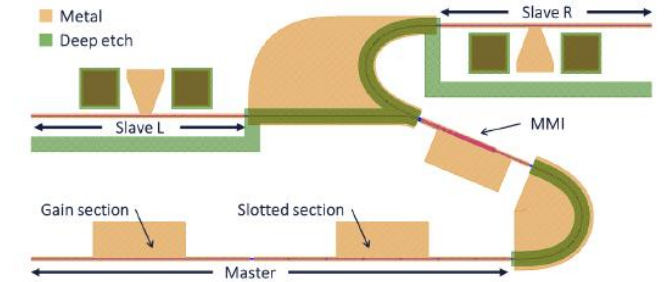
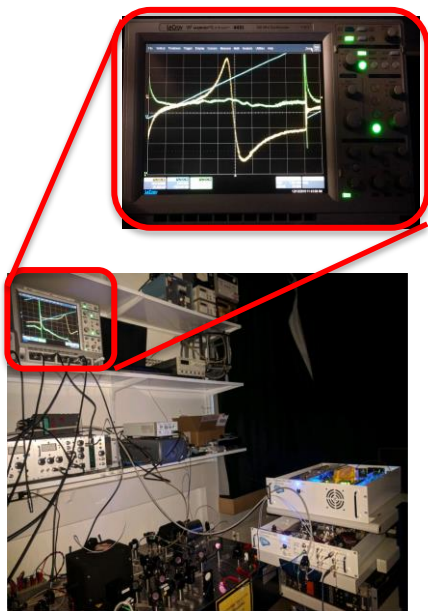


Fig. 1. (a) Schematic of fabricated devices with sections labelled. (b) Microscope image of fabricated devices. The PIC size is $1650\mu\text{m}$ long and $700\mu\text{m}$ wide.

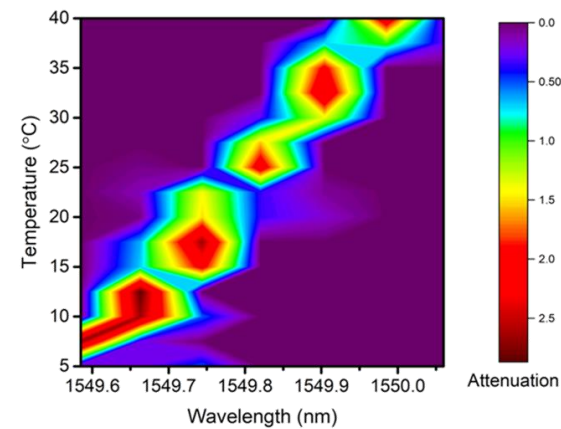


Other Related Applications

Rubidium Spectroscopy for CPT Atomic Clock Generation

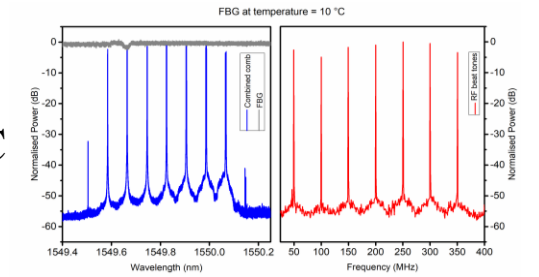


Fiber Bragg Grating (FBG) Based Temperature Sensing



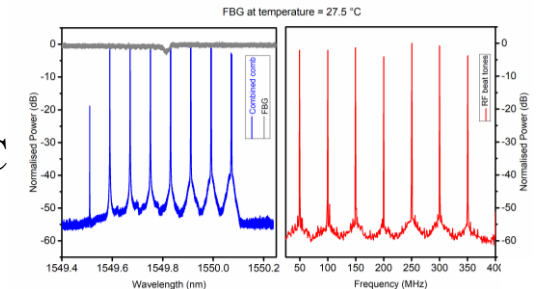
10°C

27.5°C



(a) Optical Spectrum

(b) Electrical Spectrum



(a) Optical Spectrum

(b) Electrical Spectrum





Conclusion

■ What you do?

- We apply our innovative PIC comb source technology to deliver bespoke photonic solutions for applications in data transmission, sensing and metrology.

■ What you offer?

- Low cost approach to optical sensing using PIC based dual-comb spectroscopy
- Product supply or technology license for high volume markets

■ What you need?

- We want to partner with optical sensing companies to bring the technology to market
- We need innovative optical packaging and product manufacturing to maintain the cost advantage of the PIC solution

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