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Monolithically Integrated Wavelength Tunable Dual Comb Source using Gain Switching

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1. Motivation

Optical frequency combs (OFCs) are devices whose output spectrum consists of a series of discrete, equally spaced frequency lines. This behavior proves useful with many applications, notably spectroscopy as shown in Fig.1. The teeth of OFCs provide fine lines which can be used to identify trace gasses from their absorption spectrum.

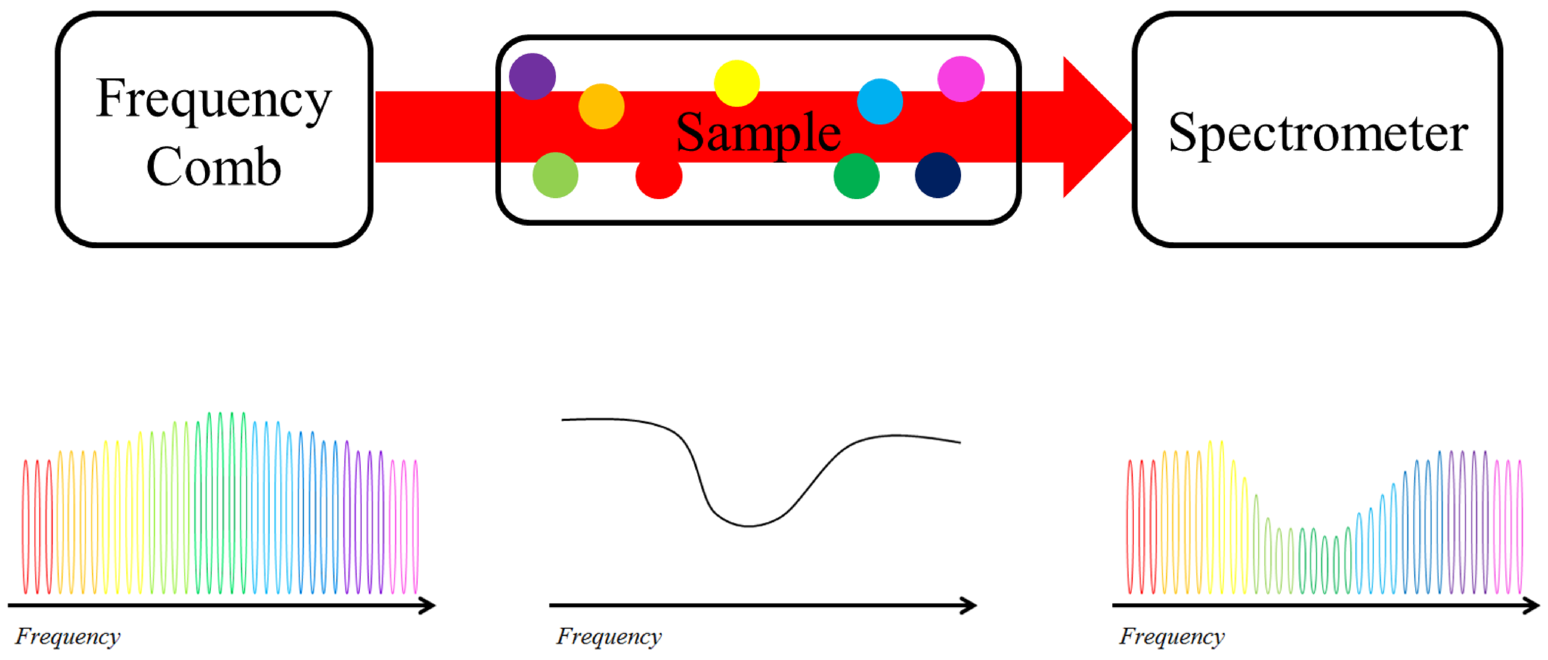

Fig.1. – A view of how an optical frequency comb can be used to measure the absorption lines of a gas sample

Dual optical frequency combs (DFCs) compound the benefits of OFCs noted above. By mixing two coherent combs with repetition rates differing by Δf into a single photo-receiver a new comb structure is generated. In this case, each pair of optical teeth yields a radio frequency (RF) heterodyne signal at a unique frequency. These RF frequencies form an RF comb of spacing Δf . This blending of combs creates a singular comb with greater spectral density than it's constituent components.

Comb generation for the monolithically integrated DFC presented is based on gain-switched injection-locked lasers. Gain switching facilitates tunable line spacing, while injection locking leads to the gain switched laser retaining the lower linewidth of the master laser. Injection locking also reduces the phase noise in the higher speed Fabry Pérot slave lasers.

2. Device Design

The dual comb device consists of two slave Fabry Pérot lasers, referred to in Fig.2 as slave 1 and slave 2, and a master laser composed of three electrically isolated sections labeled Pit 1, Pit 2, and Gain. Pit 1 and Pit 2 act as single mode reflectors for Gain; the gain section of the laser. To produce single mode lasing, Pit 1 and Pit 2 are populated with small circular perturbations etched through the waveguide as shown in the scanning electron microscope (SEM) image on the right in Fig.2.

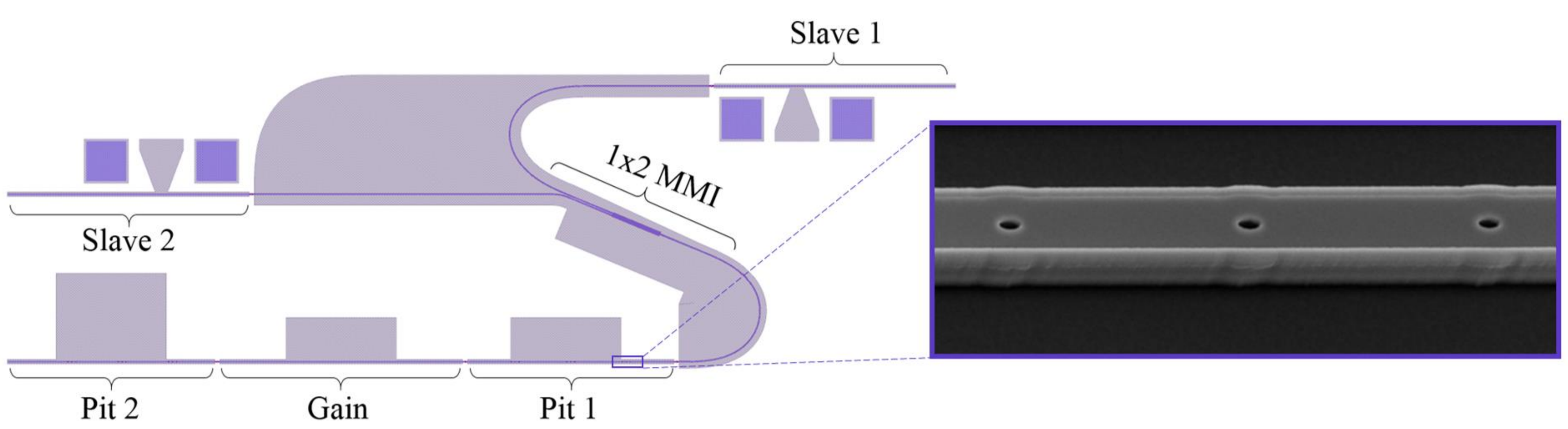

Fig.2 – On the left, a schematic view of the device design. Pit 1 and Pit 2 consist of clusters of three deeply etched pits as shown in the SEM image.

3. DC Characterization

Generation of the optical combs required gain switching of the slave sections, which were injection locked to the master to generate single mode lasing. A tuning map of the peak wavelength and corresponding SMSR of the master laser was obtained to map where single mode wavelengths could be obtained.

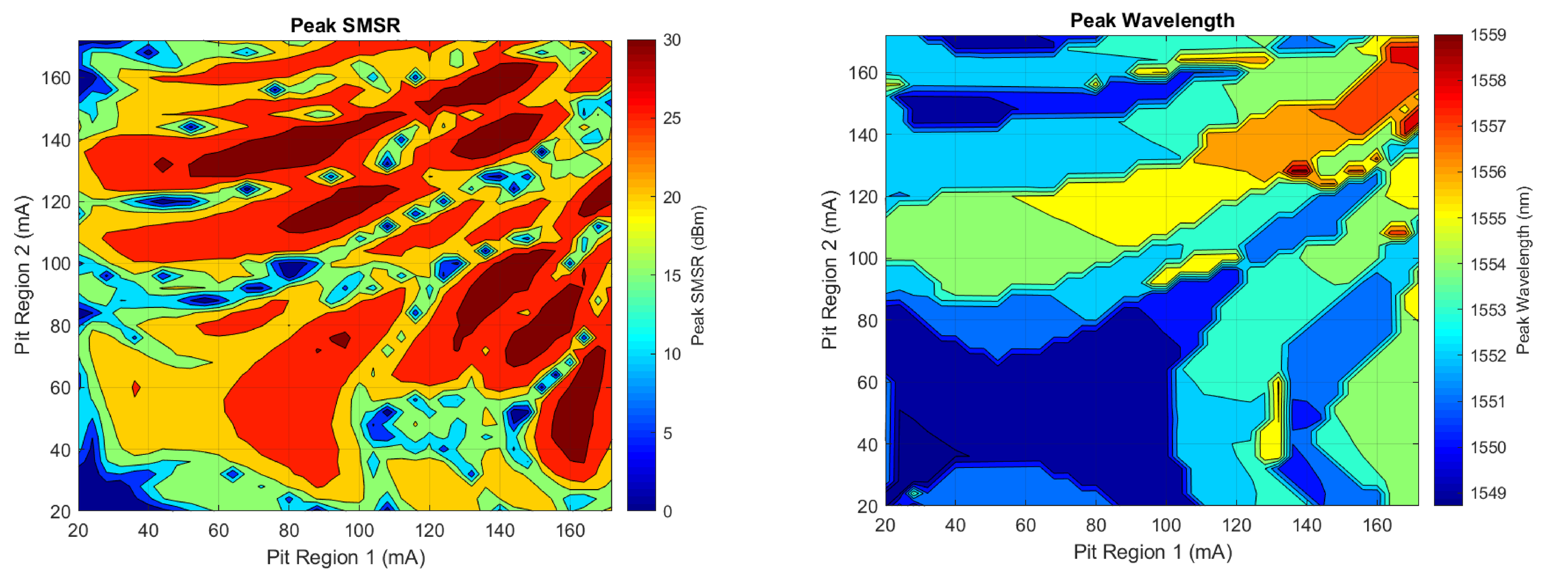

Fig.3. – Tuning maps of the master laser section

The Gain section of the device was biased with 100 mA and the current through sections Pit 1 and Pit 2 was swept. Single mode behavior (>30 dB SMSR) was observed for an approximate wavelength tuning range of 10 nm as shown in Fig. 3.

4. Comb Generation

To generate the optical combs, the slave section was biased just above threshold current. The master laser was then powered and injected into the slave via biasing the MMI section to passivation with a current of 120 mA. The injection locked slave was then gain switched by applying a high power RF sinusoidal signal (> 20 dB) at frequencies near 3 GHz from a signal generator to directly modulate the current.

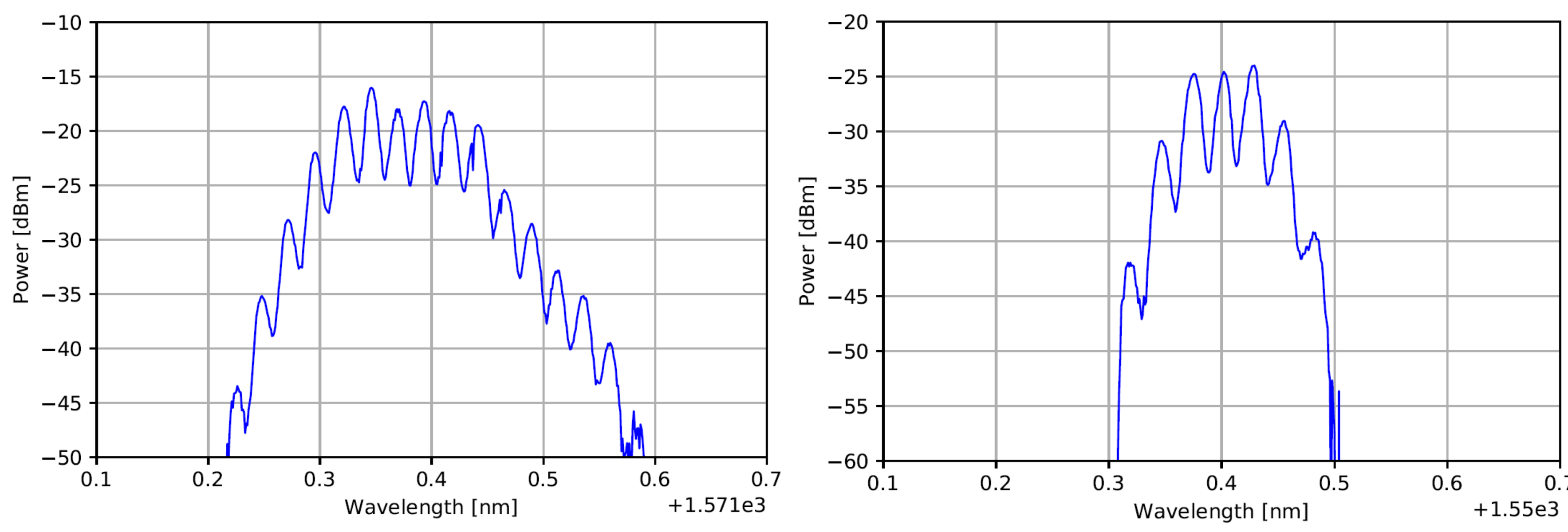

Fig.4. – Sample combs generated from device. Gain was set at 100 mA. On the left is a frequency comb of 2.905 GHz. On the right is a comb of 3.6 GHz.

5. Conclusion

A dual output frequency comb has been demonstrated using the gain switching technique. The master laser, formed by pit-based sampled grating mirrors, was used to injection lock two separate slave FP lasers. This device has been shown to have a highly single mode output, suitable for gain switching. Multiple combs were obtained from each output ranging from 2.9 GHz - 3.6 GHz.

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