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Integratable Optical Comb Source for Coherent Communications Systems

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Abstract: A coherent optical comb source is monolithically integrated. Optical combs were generated at 4 GHz and 5 GHz, with the combs produced independent of cleaved facets.

1. Introduction

The rapid increase in communications bandwidth consumption in recent years has motivated research into spectrally efficient communications which make optimal use of the current infrastructure. Wavelength division multiplexing (WDM) requires spectrally inefficient guard bands between each communication channel [1]. These guard bands can be removed by using a coherent optical comb to generate the channels, creating a “superchannel” [2]. A superchannel can lead to a significant increase in information spectral density (Gbps/Hz) so that Tbps superchannels can then be created using less total fiber bandwidth. The ability to integrate a coherent comb generator with optical multiplexers/demultiplexers, and modulators is an attractive prospect, as it would significantly reduce coupling loss, phase dependencies, and reduce the overall complexity of the system [3]. Other benefits include dramatic decreases in size and power consumption, along with a decrease in the cost per unit.

In this paper, we demonstrate a highly integratable comb generation device that is key to the development of robust and efficient integrated superchannel systems. The comb source relies on etched facets which are lithographically defined, rather than cleaved facets which improves performance and repeatability. The device schematic can be seen in Fig. 1(a), with a microscope image of the fabricated device in Fig. 1(b).

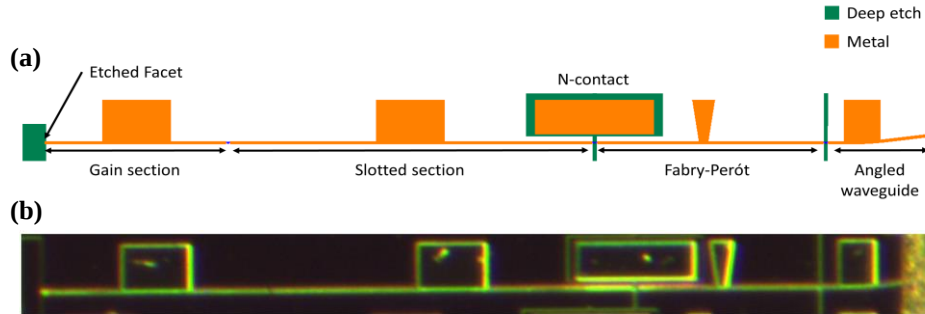


Fig.1 (a) Schematic of device showing metal contact pads, with each section labeled. The Fabry-Perot cavity is formed by two etched facets. The deep etch areas are etched through the quantum wells of the material. (b) Microscope image of the fabricated device.

2. Device design & fabrication

We have previously shown that a low linewidth comb can be generated from monolithically integrated injection-locked gain-switched lasers without an on-chip isolator [4]. The device presented here is an evolution of this work by removing the reliance on cleaved facets. The device consists of a 1300 μm long slotted Fabry-Perot (SFP) laser [5] coupled to a 400 μm long Fabry-Perot (FP) laser, with a 230 μm angled (7 degrees) waveguide to couple light out of the FP laser while reducing unwanted reflections. The SFP laser is a two section device consisting of a 500 μm gain section, and an 800 μm slotted section with 7 periodically spaced slots. The slot widths are 1 μm wide with the slot period approximately 114 μm . With a group index of 3.5, the slot period corresponds to a supermode spacing of approximately 600 GHz in the SFP optical spectrum. Etched facets are used to precisely define the cavity lengths. A deep etch of approximately 3 μm extending through the quantum wells and into the N-doped region is used to define both the etched facets and a top level N-contact. A shallow etch of 1.7 μm through the P-doped region, stopping above the quantum wells, is used to define the ridge waveguides and SFP slots. Gold contact pads were deposited while simultaneously depositing gold over the etched facet of the gain section of the SFP in order to increase reflectivity [6]. The device was fabricated using standard UV lithographic methods, similar to those used in [7]. No re-growth steps were involved.

2. Experiment & results

Etched facets and metal etched facets (MEFs) were estimated to have a reflectivity of 22% & 35% respectively by comparing threshold currents for similar length FP lasers with combinations of cleaved, etched, and MEFs. The device was mounted on a thermally controlled brass chuck and maintained at 23 degrees Celsius. Lensed optical fiber was used to couple light from the angled waveguide. An optical spectrum analyzer (OSA) was used to record the spectrum of the device (resolution: 0.01 nm). DC probes were used to bias each section with a GS (ground-signal) probe used to bias and modulate the FP laser. A bias tee was used to provide simultaneous DC & RF signals to the FP laser.

The FP laser and angled waveguide was biased at 80 mA & 12 mA respectively, and the optical spectrum was recorded by the OSA. The FP was found to be partially single mode at this bias, likely due to imperfections in the cavity. The SFP was then biased with 42 mA & 33 mA to the gain and slotted sections respectively. The OSA trace for the FP laser with and without optical injection from the SFP can be seen in Fig.2(a). Strong side mode suppression can be seen in the FP with the SFP on (SMSR: 35 dB).

The FP laser was gain-switched by applying a 25 dBm 4 GHz RF signal via the bias tee. The gain section, slotted section, FP laser, and angled waveguide biases were 66 mA, 49mA, 40 mA, & 21 mA respectively. 10 comb lines with powers within 3 dB of each other are obtained. A 5 GHz comb was generated by increasing the RF frequency and increasing the FP bias to 80 mA. All other parameters were as before. 7 comb lines within 3 dB were then obtained. The optical comb spectra can be seen in Fig.2(b) & (c).

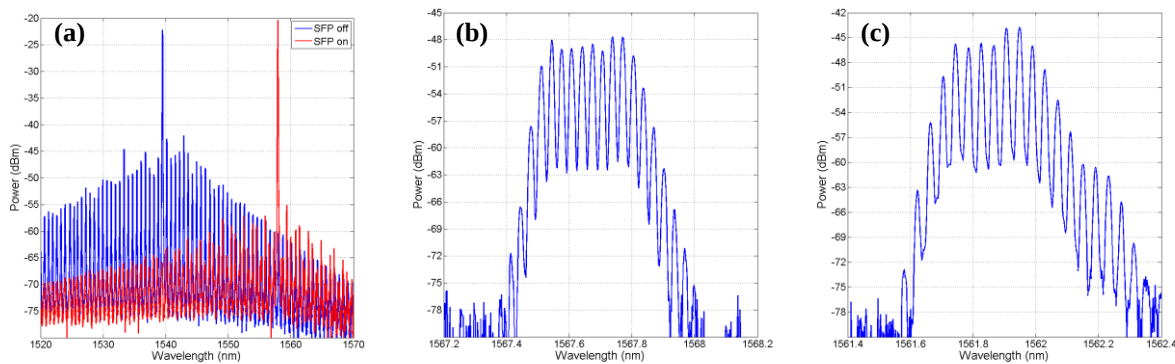


Fig.2 (a) Optical spectrum of FP laser with/without injection from the SFP. Spectrums were recorded through the angled waveguide section. (b) Optical comb with 4 GHz line spacing. 10 comb lines within 3 dBm. (c) Optical comb with 5 GHz line spacing. 7 comb lines within 3 dBm.

3. Conclusion

In this paper we have demonstrated a monolithically integrated comb source with zero reliance on cleaved facets. Etched facets and MEFs were characterized and implemented in place of cleaved facets. Flat optical combs were generated with 10 lines within 3 dB at 4 GHz, and 7 lines within 3 dB at 5GHz. This comb source is an excellent candidate for integration with multiplexers and modulators for the realization of a coherent WDM photonic integrated circuit.

4. Acknowledgements

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