10Gbit/s Modulation of a Fast Switching Slotted Fabry-Pérot Tunable laser

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Fast wavelength tuning has received interest recently as a mechanism for optical packet or burst switching. These techniques have the potential to make efficient use of the bandwidth available in wavelength division multiplexed (WDM) networks by allowing optical traffic grooming with sub-wavelength granularity. By modulating each individual packet onto different wavelengths, packets can be routed using simple optical filtering techniques. The important characteristics of the tunable lasers for such applications include tuning range, side-mode suppression ratio (SMSR), output power, and switching speed. The most suitable tunable lasers for use in optical packet switched networks are electronically tunable sampled grating distributed Bragg reflector (SG-DBR) and grating coupler sampled-reflector (GCSR) devices, which currently can achieve tuning ranges in excess of 60nm, SMSRs exceeding 40dB, output powers above 10dBm, and switching times below 5ns using advanced switching circuitry [1].

Previously [2], we demonstrated wavelength switching times in the order of 1ns for discrete tuning between five channels spaced by 10 nm across a 40nm band, using a laser based on a slotted Fabry-Pérot (FP) structure. These devices are based on a single epitaxial growth, and are thus much simpler to fabricate than SG-DBR lasers for example. The design of the laser has since been refined and the average channel spacing between eight accessible channels has been reduced to approximately 2.7nm (340GHz). We also show that it is possible to externally modulate the output of these lasers error free with high speed data. In an optical packet switching application, it is important to know how soon after the switching event the laser can be modulated with the data packet, as this will directly affect the network throughput. We show these lasers have extremely fast switching times.

The device used is a three-section, 3µm wide ridge waveguide laser based on commercially available material. During the fabrication a series of slots are introduced into the front and back sections, which act as sites of internal reflections. The slots are etched to a depth that just penetrates the top of the upper waveguide resulting in an internal reflectance of ~ 1% at each slot. The front, middle, and back sections are 180, 690 and 170 microns long respectively. In this work the back and middle sections are tied together electrically allowing simpler control of the device. By varying the applied DC currents, eight discrete channels are observed over a range of approximately 19nm.

For the switching measurements, the back and middle section were driven with a DC current of 148mA and the front section was directly driven with a non-return to zero (NRZ) pattern generator with rising and falling edge times of 365ps and 130ps respectively, peak to peak amplitude of 185mV and an offset of +387mV. This caused the optical output from the laser to switch between channels at 1537.5nm and 1540nm. The optical signal was then amplified and modulated with 10Gbit/s NRZ pseudo-random bit stream (PRBS) data before being split with a 50:50 coupler; each portion then passing through a tunable optical bandpass filter with a bandwidth of 0.2nm centered on the channels. Both filtered channels were then viewed on a digital sampling oscilloscope. Figure 1 shows both channels switching on. A different offset time was used for each channel so that both could be viewed simultaneously. It shows that both channels exhibit a rise time of <500ps, and that the eyes are open after less than 3ns for the 1540nm channel and less than 1ns for the 1537.5nm channel. We expect that the closed eye at the beginning of the traces is due to jitter in the switching time accumulating in subsequent acquisitions of the sampling oscilloscope and wavelength drift under the filter passband caused by thermal transients. In order to measure how soon after a switch, data could be transmitted error free, we performed time resolved bit error rate (BER) measurements (10ns gating window, 10ps step interval). Figure 2 shows how the BER varies as the gating window sweeps across each signal as it turns on. The point marked t_{ref} shows where the error rate has dropped below $1x10^{-9}$.

The work presented shows that tunable lasers based on low cost slotted FP structures can provide the fast switching speeds typical of optical packet switching techniques.

[1] J.E.Simsarian, M.C. Larson, H.E. Garrett, Hong Xu, T.A.Strand, IEEE Photon. Technol. Lett., 18, pp 565 – 567, 2006

[2] F. Smyth, E. Connolly, B. Roycroft, B. Corbett, P. Lambkin, L.P.Barry, IEEE Photon. Technol. Lett., 18, pp 2105 – 2107, 2006

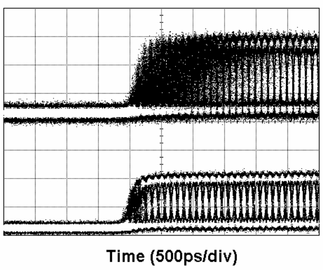

Figure 1: 1540nm (top) and 1537.5nm (bottom) channels switching on with a rise time < 500ps

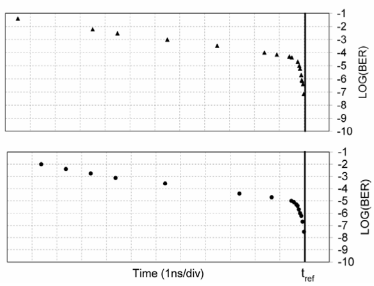

Figure 2: Time resolved BER measurements for 1540nm (top) and 1537.5nm (bottom)