Chirp Managed Optical Link based on a Directly Modulated InP/Si DFB Laser

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In order to meet the requirement for applications such as inter-datacenter interconnection and PON systems, a high speed data transmission over at least 20 km of standard single mode fiber is desired [1]. Transmission over such long distances has been done traditionally using externally modulated light sources in the C band, because fiber losses are minimal in this wavelength band and the inherent chirp of directly modulated laser diodes decreases the dispersion tolerance of the link. This limits the transmission link distance for the directly modulated optical signal to about 5 km at 10 Gb/s.

Recently it has been shown that by an interesting technique called chirp management an optical signal from a directly modulated laser can be transmitted in standard single mode fiber over distances much longer than the dispersion limit [2]. This, together with the other advantages of direct modulation such as a better power budget, a smaller footprint and a lower cost makes this technology a promising solution for the medium distance optical link. In this approach, the transient chirp of the directly modulated laser diode is kept small by modulating the laser diode at high bias current with a small extinction ratio. Biasing the laser at high current supplies extra benefits such as high-output power, wide modulation bandwidth (BW), stable single-mode operation, and low timing jitter. The adiabatic chirp in this case (resulting in a '1' bit having a different optical frequency then a '0' bit) is then used to our advantage: using an optical filter at the output of the laser to suppress the logical '0' frequency then gives a higher extinction ratio.

In the past years, there has been interest in using silicon photonics for interconnects and PON applications and work on InP-on-Si lasers has caught quite some attention. Heterogeneously integrated laser diodes have been shown capable of high-speed direct modulation [3]. Here we present 10 Gb/s on-off-keying data transmission using a directly modulated InP-on-Si laser over 20 km of SSMF, together with an external tunable optical filter for chirp management. Our previous lasers were suffering from low frequency roll-off and because of this roll-off the performance of the link was PRBS pattern dependent [4]. As one can see in Figure 1-a, the heterogeneously integrated DFB laser consists of a central DFB section with two adiabatic tapers on both sides. These tapers act as semiconductor optical amplifiers which have a very low modulation bandwidth (a few GHz). In order to eliminate the cut-off effect of these taper sections, they were electrically isolated from the laser body by an ICP dry etching of the top InGaAs-P type contact layer. A small signal measurement was done with a KEYSIGHT PNA-X 67 GHz network analyzer after isolation. A 3dB modulation bandwidth of 15 GHz is obtained at a bias current of 100 mA (Figure 1-b). The active layer consists of 8 InAlGaAs quantum wells. Threshold currents at room temperature of 20 mA, output powers in the silicon waveguide above 3 mW at 100 mA, and a series resistance of 7 Ω were measured for these lasers.

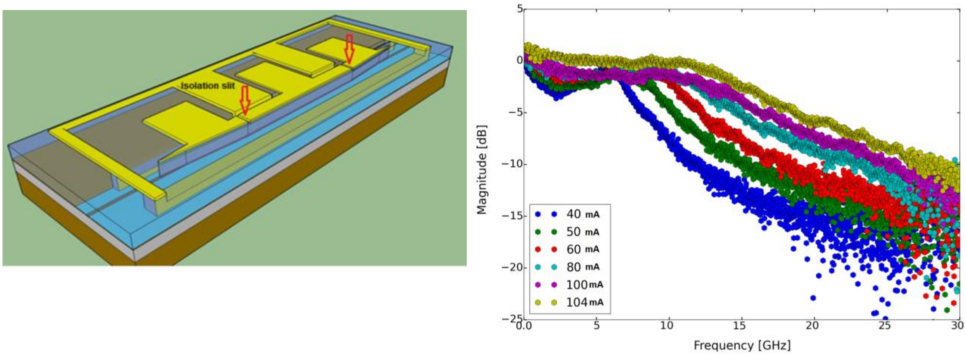

Fig. 1. Schematic of the DFB laser with isolated tapers (left), small signal response of the laser (right).

For the large signal measurement, a Santec-350 optical filter that is tunable in wavelength and bandwidth is inserted after the laser diode for the chirp management. The laser was biased at 50 mA. The large signal measurement has been done in two configurations: for back-to-back and after transmission over a 20 km SSMF. An RF signal of 0.6V from an SHF-PPG was applied for the modulation, but because of strong impedance mismatch between the laser and the 50 Ω transmission line, around 0.2 V was actually applied to the laser. Figure 2-b shows the effect of eye opening at 10 Gb/s when the optical filter is used. The extinction ratio of the signal was increased from 5.9 to 16.3 dB by the application of the optical filter. Two different PRBS pattern lengths of 2^7-1 and 2^{31}-1 were used in order to check the link pattern dependency. We did not observe any noticeable power penalty for two different patterns. However we measured 1.5 dB power penalty for transmission over 20 km SSMF.

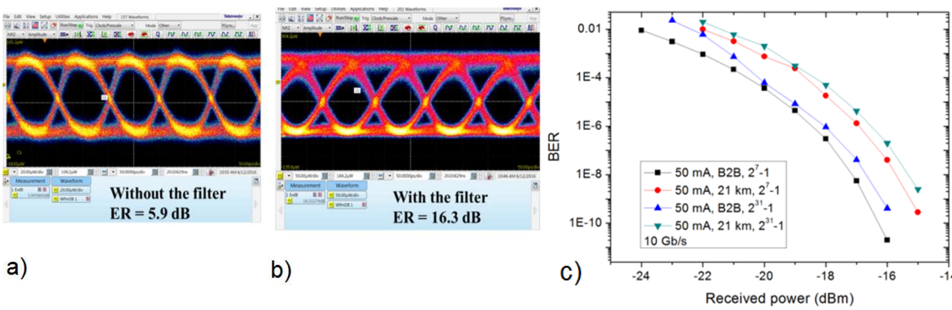

Fig. 2. Extinction ratio of the eye diagram at 50 mA bias without the filter (a), with the filter (b), BER vs received power at 10 Gb/s for two different PRBS patterns lengths (c).

References

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