VCSEL Technologies for High-capacity Dense WDM Networks

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Long-wavelength vertical cavity surface emitting laser (VCSEL) technologies can represent an alternative solution for the development of transmitters with reduced cost, power consumption and footprint for very-high capacity metropolitan area systems. Exploiting direct modulation (DM) and advanced modulation formats, such as discrete multitone (DMT), and aggregating multiple DM-VCSELs emitting in the C-band with dense wavelength division multiplexers (WDM) in SOI chips allows to achieve multi-Tb/s transmitter module with 25 GHz granularity [1].

The interplay between the frequency chirp induced by VCSELs DM and the tight filtering of network WDM multiplexers plays a crucial role in the transmission performance. In this paper, we compare the adoption of two different long-wavelength InP VCSEL technologies: high-bandwidth short-cavity devices and MEMS-based widely-tuneable VCSELs [1]. We evaluate their performance in case of DM employing DMT modulation, providing more than 50-Gb/s capacity per wavelength; coherent detection (COH-D) is used to target hundreds of kilometres distances thanks to DSP chromatic dispersion (CD) compensation.

At first, we performed chirp measurements on a short-cavity 20-GHz long-wavelength VCSEL emitting at 1533.4 nm, and on an 8-GHz MEMS-based VCSEL tuneable over about 70 nm in the C band [2], see Fig.1 a).

These parameters were used to evaluate the transmission performance as a function of the optical signal to noise ratio (OSNR) and of the number of crossed nodes (i.e. number of WDM filters) employing a 25-GHz channel spacing WSS, with 21-GHz FWHM. The VCSEL modulation frequency bandwidth was set to 18 GHz in both cases to specifically evaluate the chirp impact. We considered both dual sideband (DSB) and single sideband (SSB) DMT modulations with less than 25 GHz optical spectrum, composed by 256 sub-carriers and a cyclic prefix of about 2.1% of the symbol length; the signal electrical bandwidths were 10 GHz and 20 GHz respectively.

(a)

VCSEL	α linewidth enh. factor	κ adiabatic
Tuneable	2.75	$8.3\cdot10^{12}$
Short-cavity	3.7	$1.52\cdot10^{13}$

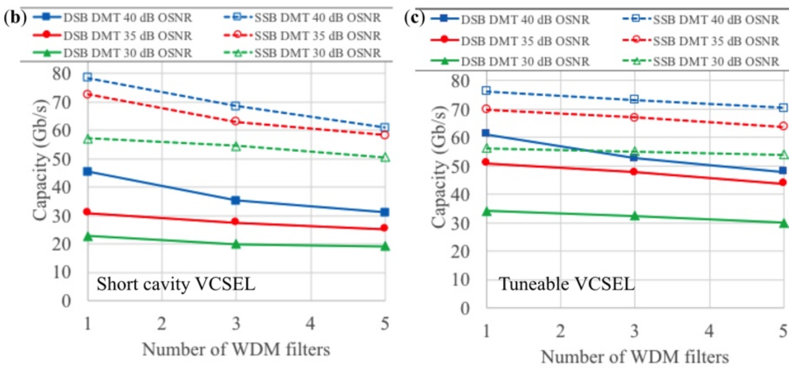

Fig. 1 a) Measured chirp coefficients. b)-c) Transmission capacities vs number of crossed WDM filters for: 40-dB OSNR (blue square), 35-dB OSNR (red circle), 30-dB OSNR (green triangle), and DSB DMT modulation (continuous line full symbols), SSB DMT modulation (dashed line open symbol) b) short-cavity VCSEL . c) tuneable VCSEL.

Fig. 1 b) and c) show that lower chirp (tuneable) devices support much higher capacities for a higher number of crossed nodes, in particular for DSB modulation; however, SSB outperforms DSB modulation due to a higher spectral efficiency. 50 Gb/s capacity per wavelength can be achieved in case of short cavity technology only for SSB DMT modulation and the evaluated OSNR range guarantees this target for more than 260 km SSMF transmission. However, if devices characterized by chirp parameters as the tuneable VCSEL would be available in combination with short-cavity-like modulation bandwidths, even the DSB DMT modulation would allow a 50 Gb /s capacity for 40 dB OSNR and up to 3 WDM filters with a maximum reach of 200 km.

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References

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