Objectives for 100 Gb/s shorter-reach PMDs

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IEEE 802.3 100 Gb/s Wavelength Short Reach PHYs Study Group

Background-1

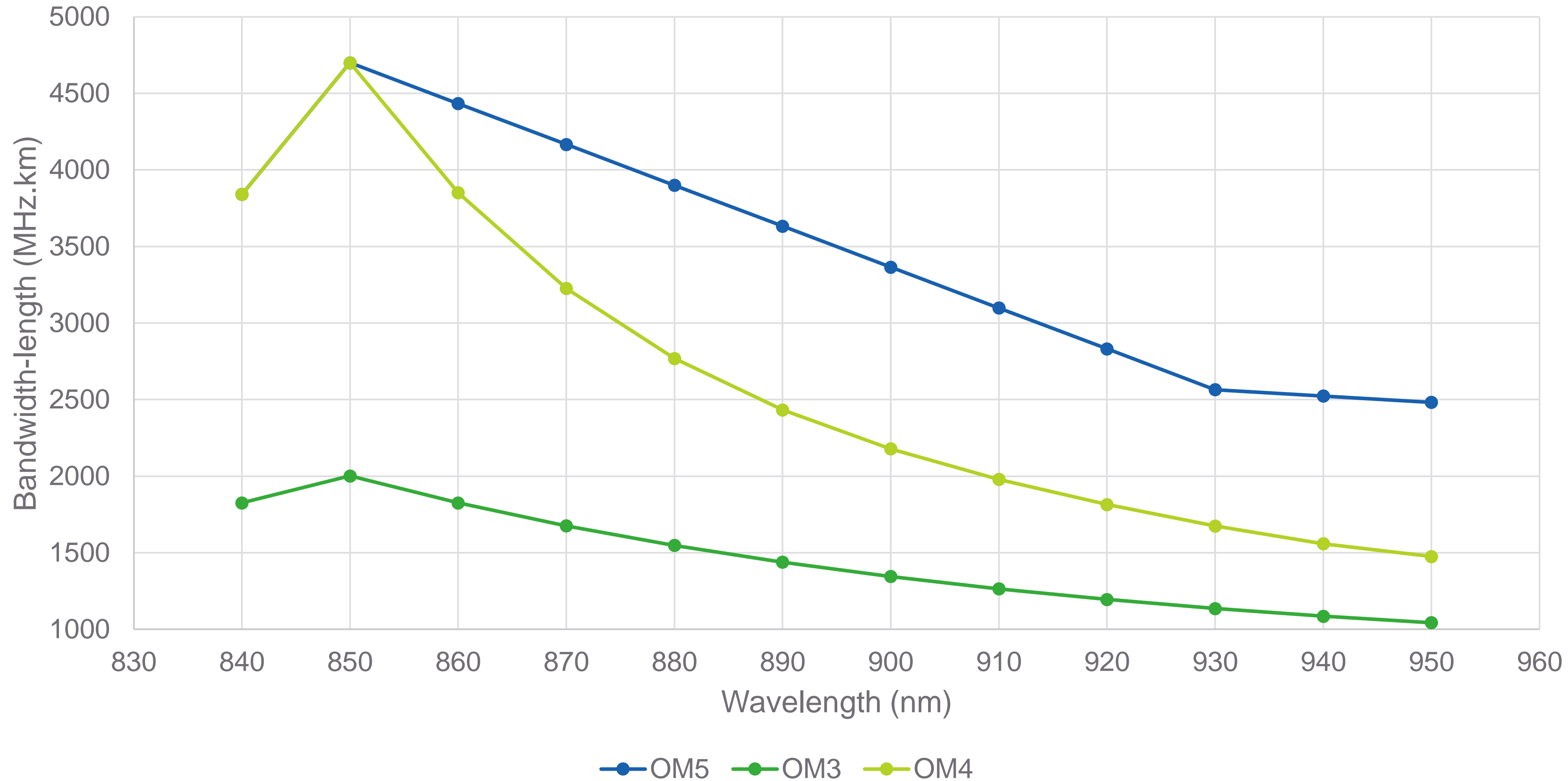
- lewis_100GSR_01_0120.pdf proposed 2 objectives:
  - Objective for MMF backwards compatibility and intra Data Center reach
    - The adopted objective of 50 m on 1 pair of MMF is enough for some data centers, but not all.
    - No mention of backwards compatibility with 50G-SR or 25G-SR in the adopted objectives.
  - Objective for intra-rack and active cable applications
    - This was not listed separately in the adopted objectives.
    - Backwards compatibility is not needed, but lowest cost is needed.
    - A PMD capable of 50 m reach on OM4 fiber may be uncompetitive with a PMD developed specifically for very short reach, such as 10 - 20 m.
  - This contribution explores some of the tradeoffs for MMF reaches shorter than the adopted objective(s).

Background-2

- parsons_100GSR_adhoc_01_021320.pdf showed that a 30 m reach on OM3 could be achieved with a single PMD also capable of 50 m on OM4 fiber.
  - Required VCSEL bandwidth is 23.3 to 23.8 GHz for OM3/OM4 respectively
  - Overall signal bandwidth at receiver is 21.25 GHz [cascade of BW_{VCSEL}, $BW_{Chromatic\ Dispersion}$, and $BW_{Modal\ Dispersion}$]
- king_3cm_adhoc_01_062818.pdf included details of the calculation of effective bandwidth for MMF, based on the 10GE spreadsheet model 10GEPBud3_1_16a.xls and TIA worst case OM3/OM4 EMB values versus wavelength.

- This contribution uses the same methodology to understand the reach limitations and VCSEL bandwidth requirements for 850 nm and 940 nm VCSELs on OM3/OM4/OM5 fiber with minimum EMB and CD characteristics as specified in IEC 60793-2-10.

IEC worst case EMB-length product for OM3, OM4 and OM5



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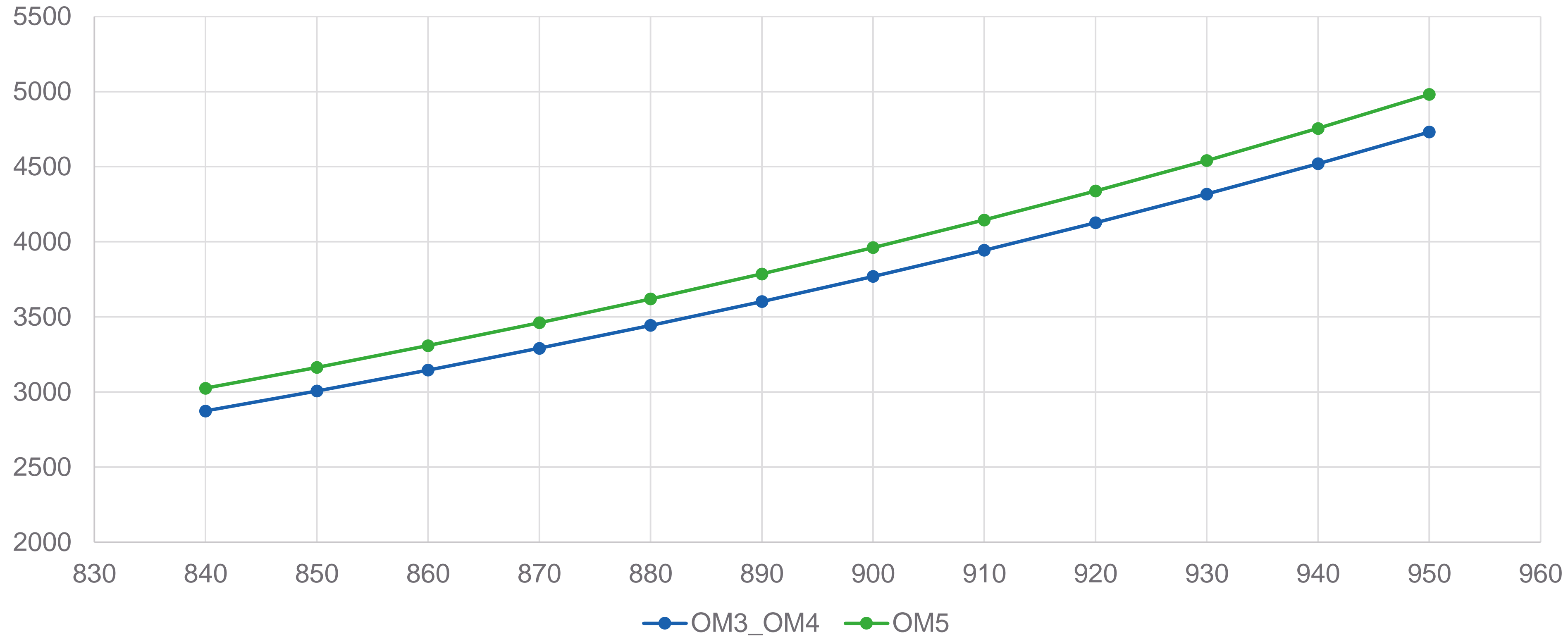
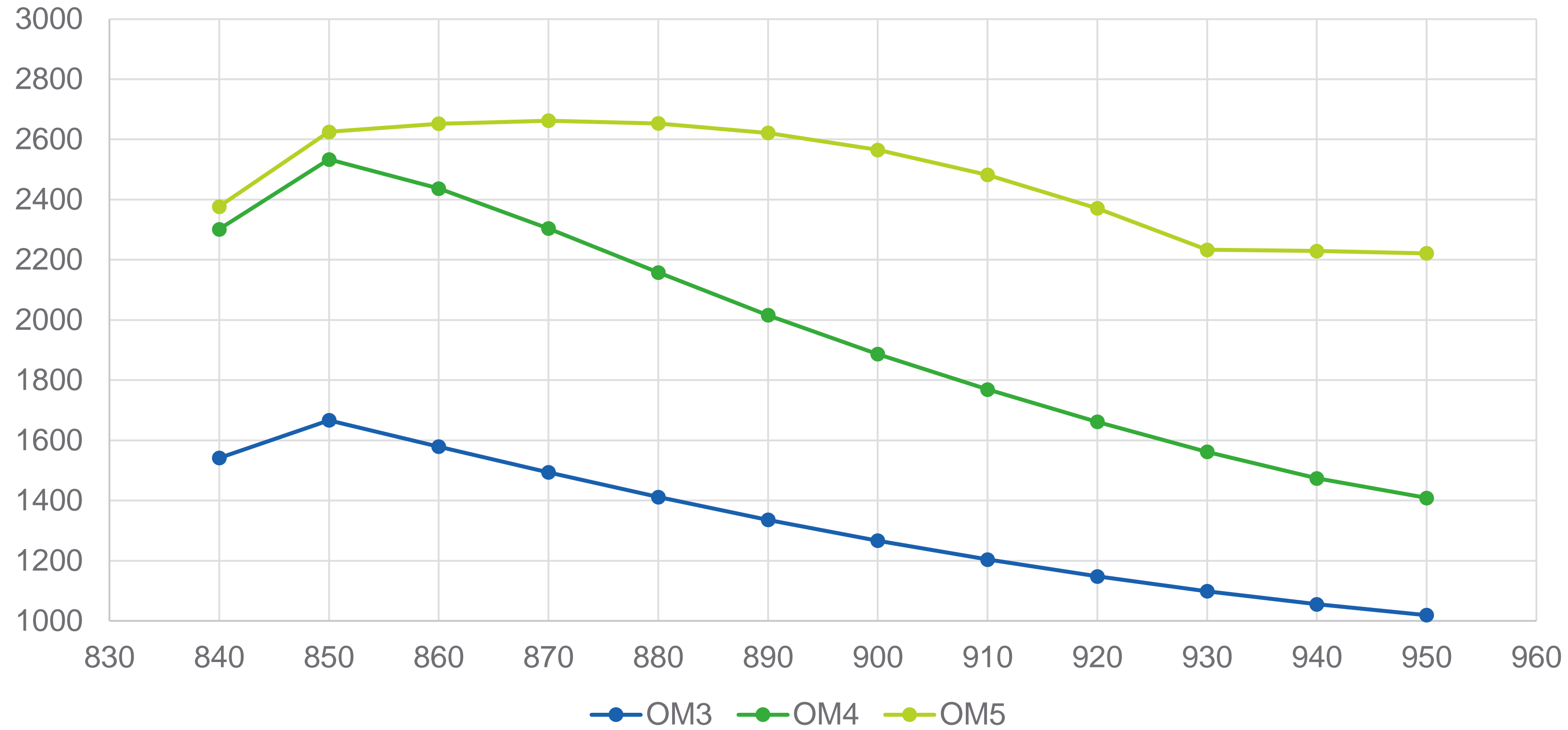
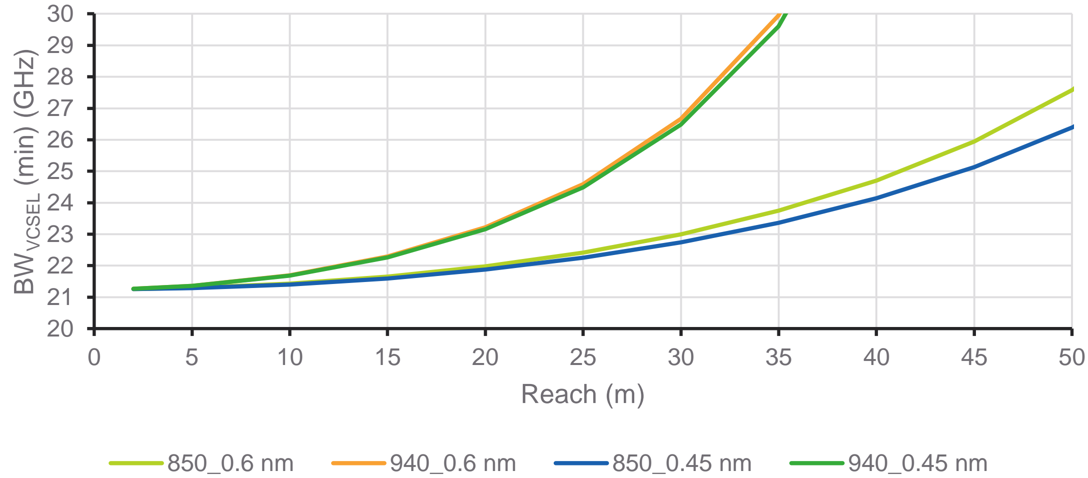
BW_{CD}-distance product versus wavelength

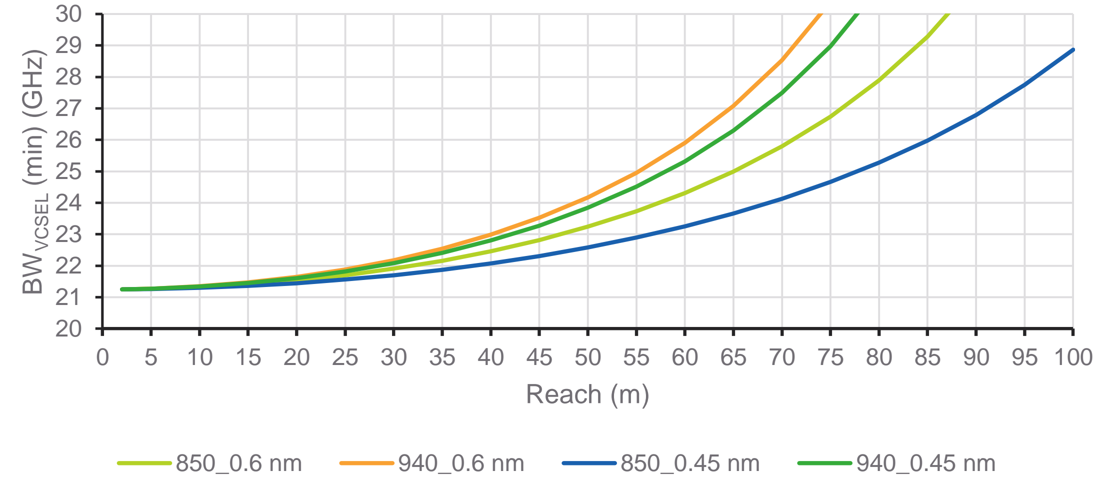


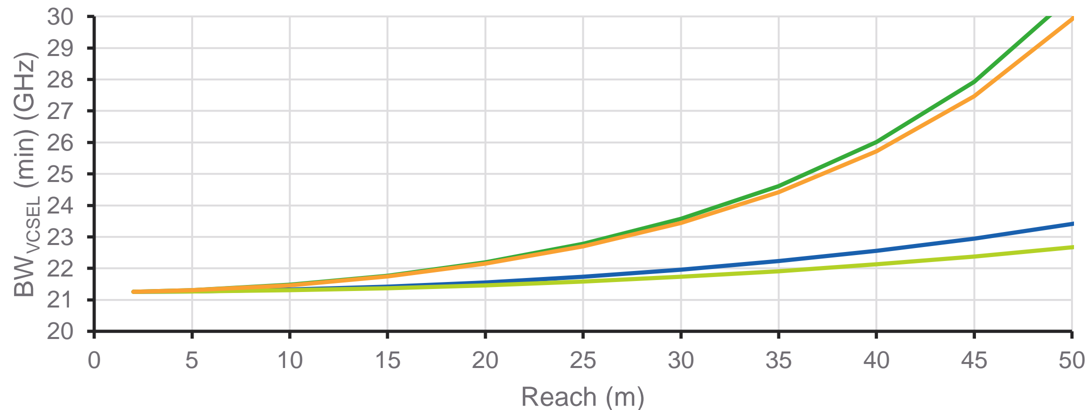
BW_{eff} – distance product versus wavelength



BW_{VCSEL} versus reach and spectral width







- 940 nm VCSELs require higher BW for all classes of 850-optimized MMF
- For VCSEL BW of 23 GHz, the reach differences are minimal

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Why 940 nm and not 980 or some other wavelength?

- 940 nm is used for 3D sensing (3DS) because:
  - There is a dip in atmospheric transmission at 940 nm which means less solar background vs 980 nm.
  - For low speeds, it is detectable by silicon PDs.
  - No distracting “red glow” as with 850 nm VCSELs.

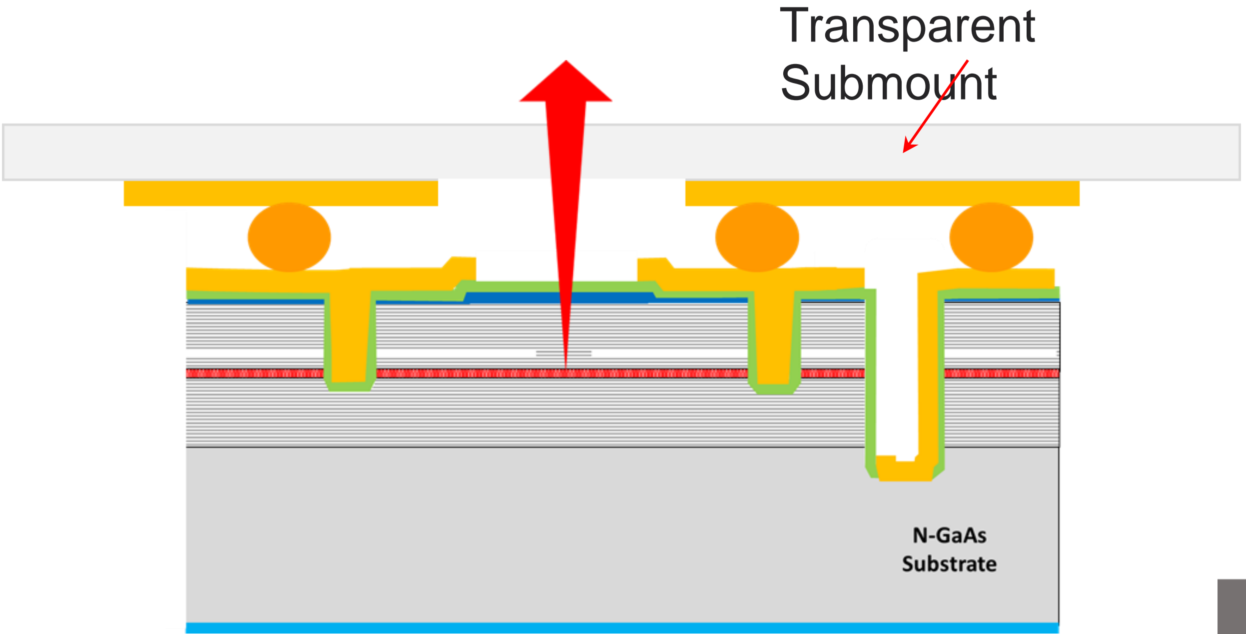
- 940 nm has reached a lower cost point than 850 nm VCSELs
  - > 500 million array chips, each with 100’s of VCSELs shipped to date
  - 6-inch wafers used for fabrication

- A 50 Gbd PAM4 VCSEL is a different device design to the 3DS array
  - 3DS is high-power & high-efficiency to minimize battery use
  - 3DS operates at 10’s to 100’s of MHz, whereas datacom requires 10’s of GHz.
  - Spectral width is < 0.45 nm over temperature.
  - The datacom chip reduces parasitic capacitance & inductance by having very small bond-pads to achieve high frequency operation.

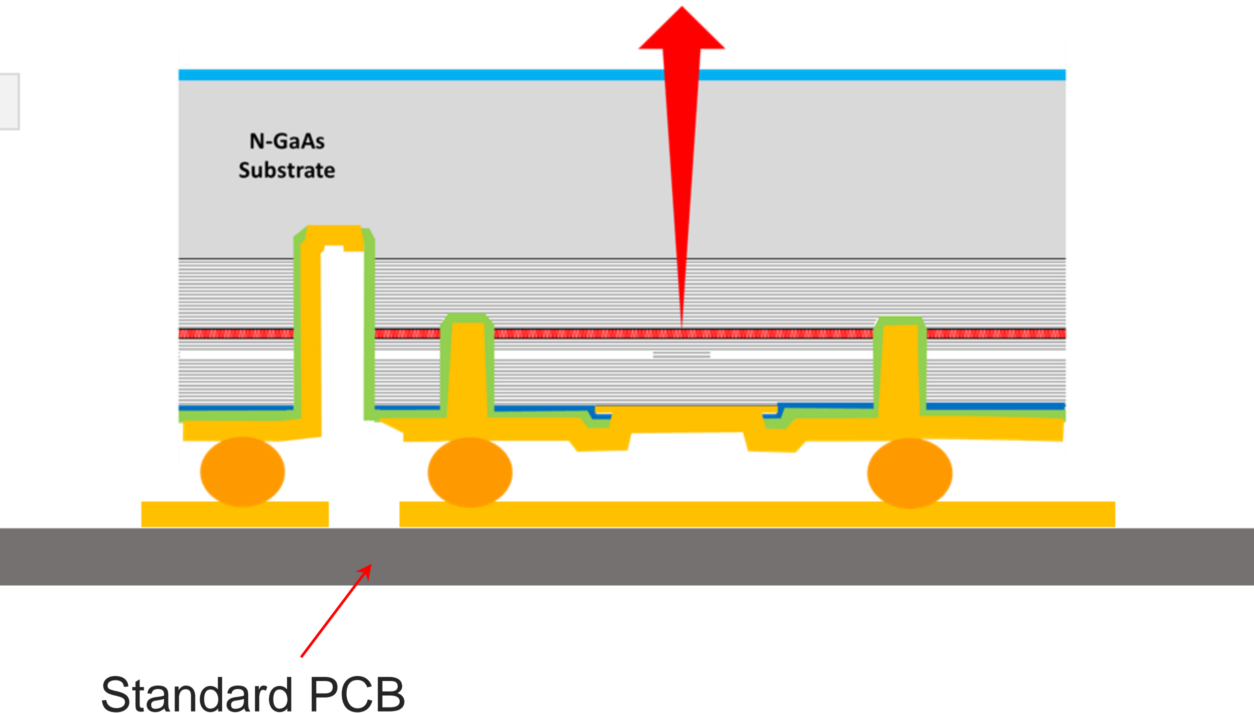
Flip-Chip VCSEL Attach – 850nm vs 940nm VCSEL

1. 850nm flip-chip attach requires expensive transparent submount to allow light to pass through
2. 940nm flip-chip attach can use standard PCB, since light can pass through the bottom of the substrate

Top Emitting



Bottom Emitting



Advantages of bottom-emitting (BE) VCSEL

- Flip-chip enables the required overall BW (driver + VCSEL chip) of ~ 23 GHz
- BE VCSEL can be flip-chip attached directly on a sub mount or PCB with good heatsinking and matched impedance lines from the driver IC.
- Can electrically pump the entire VCSEL aperture because no light needs to exit on the electrical side of the VCSEL.
- 850 nm flip-chip requires a transparent sub mount in the package. This makes heat sinking more challenging since transparent sub mounts (quartz usually) have poor thermal conductivity compared to copper or gold.

Recommendations

- Add an objective for intra-rack and active cable applications
  - Define a physical layer specification that supports 100 Gb/s operation over 1 pair of MMF with lengths of up to at least 20 m.
- Consider adding an interoperability objective between the 20 m and 50 m PMDs
  - Requires receivers of both to work over the superset of wavelengths and at the same power levels.

Thank you