100GbE SMF PMD Specification
- Wavelengths -

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WE light IT UP
Supporters: High Speed Optical Components Suppliers

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- Junichi Shimizu (NEC electronics, Ltd.)
- Atsushi Takai (Opnext, Inc.)
- Kiyo Hiramoto (Opnext, Inc.)

Outline

• Objective
• CWDM and LAN WDM comparison
• Further Discussion on wavelength
• Specification
Objectives

- To specify wavelength considering both the first generation and future generation in the view point of cost

- (This will help the optical device suppliers to concentrate on the laser development.)
The Supporters compared the CWDM and LAN WDM solutions for the first generation of 10km SMF application in [*1].
Supporters recommend CWDM from the view point of manufacturing and cost.
We updated the summary shown in a later foil to confirm the CWDM superiority.
Continue to propose CWDM wavelengths.

Wavelength Yield Impact

LAN WDM

Laser wafer wavelength distribution at $T_0$

Dead zone is defined by mux/demux and temperature tuning has a limit to compensate for dead zone

Likely that four different wafers need to be manufactured to support all lanes in LAN WDM proposal

CWDM

No Wavelength yield, testing, or temperature tuning. However, four different wafers MUST be manufactured to support all lanes in CWDM.
Limits of Temperature tuning

Laser wafer will have some wavelength distribution at Temperature, $T_0$

However, transmission performance degrades as the laser set temperature is shifted from $T_0$.

Note: Due to this temperature effect there will be some yield hit for LAN WDM

Laser wavelength can be tuned individually to shift the wavelength

~0.1 nm = 12.5GHz

1 °C

Performance

CDF

99%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1%

Pass

Fail
**CWDM and LAN WDM Summary**

(Update the presented material [*1]*)

<table>
<thead>
<tr>
<th>Item</th>
<th>CWDM</th>
<th>LAN WDM</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specification</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grid</td>
<td>1271 - 1331</td>
<td>1312 center</td>
<td></td>
</tr>
<tr>
<td>Pitch</td>
<td>20 nm</td>
<td>2 – 4 nm</td>
<td></td>
</tr>
<tr>
<td>Tolerance</td>
<td>+/- 6 nm</td>
<td>+/- 0.36 – 0.8 nm</td>
<td></td>
</tr>
<tr>
<td><strong>Laser for 1st generation</strong></td>
<td></td>
<td>Cooled EA-DFB</td>
<td></td>
</tr>
<tr>
<td><strong>Laser development</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical Issue</td>
<td>25G 1310nm EA-DFB</td>
<td>25G Operation is the major challenge</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25G Wavelength grid is very minor challenge</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Laser Manufacturing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wafer fabrication</td>
<td>4 kinds wafer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wavelength yield</td>
<td>100%</td>
<td>Lower yield</td>
<td></td>
</tr>
<tr>
<td>Wavelength test</td>
<td>No</td>
<td>Required</td>
<td></td>
</tr>
<tr>
<td><strong>Laser Availability</strong></td>
<td></td>
<td>Same</td>
<td></td>
</tr>
<tr>
<td><strong>Optical MUX/DMUX(^2)</strong></td>
<td>compact</td>
<td>Large and/or high cost</td>
<td>Similar to DWDM performance</td>
</tr>
<tr>
<td>Future</td>
<td>Cooled DFB, Uncooled EA-DFB, Uncooled DFB</td>
<td>Cooled DFB</td>
<td></td>
</tr>
</tbody>
</table>


[2] Updated
• We also discussed the future cost reduction scenario and concluded uncooled DFB with the CWDM wavelengths will give the lowest cost. (see the next foil)
• We also reviewed the technologies that are used in 2.5 and 10Gbit/s SMF applications and we confirmed DFB technology has achieved the lowest solution. (see the next next foil)
• As a result we confirmed CWDM wavelengths will give the low cost solutions.
Likely Laser Structures for 802.3ba SMF PMD

- **DFB (Distributed Feedback) Laser**
  - Simple Structure
  - Simple control and operation
  - Commercially used in 10GBASE-LR, 1000BASE-ZX

- **EA-DFB (Electro-Absorption DFB) Laser**
  - Requires optimization of two MQW sections
  - Larger chip/die size
  - In addition to APC (Automatic Power Control), EA bias control is also required
  - Temperature control and thermo electric cooler required
  - Commercially used in 10GBASE-ER, ZR, XFP DWDM products
DFB is the Lowest Cost Solution

- DFB gave the low cost solution <=10Gbit/s SMF applications, which we can expect the same solution in 100GbE (4ch).

Figure of merit: $B^2/L$
Scenario for cost reduction for the future

- Uncooled DFB solutions will achieve the lowest cost, while they accept only CWDM wavelengths.
• Feedback for greater distance from end users included many comments on much higher patch panel counts with shorter distances
• Consider alternate model with shorter fiber length but higher patch panel loss budget
• Key merit is that the dispersive effects would be limited
• It’s much easier and cost effective to build devices which have high attenuation than to build devices with high attenuation and dispersion
Link budget specification alternatives

- A 4km solution with high attenuation (for additional penalties from patch panels etc.) is less costly than a 10km reach and has more un-allocated budget

<table>
<thead>
<tr>
<th>Parameter</th>
<th>4km (more attenuation budget than 10km spec.)</th>
<th>10km (Ref)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
<td>Max.</td>
</tr>
<tr>
<td>Tx output power (dBm)</td>
<td>+1.8 (OMA)</td>
<td>+1.8 (OMA)</td>
</tr>
<tr>
<td>Extinction ratio (dB)</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Power budget (dB)</td>
<td>9.3</td>
<td>9.3</td>
</tr>
<tr>
<td>Connector loss (dB)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Fiber loss (dB)</td>
<td>1.7</td>
<td>4.2</td>
</tr>
<tr>
<td>Allocation for penalties (dB)</td>
<td>5.6</td>
<td>3.1</td>
</tr>
<tr>
<td>Rx sensitivity (dBm)</td>
<td>-7.5 (OMA)</td>
<td>-7.5 (OMA)</td>
</tr>
</tbody>
</table>

Note: CWDM Wavelength detailed specification to be defined in conjunction with mux/demux specifications
Summary

• We demonstrated CWDM cost and link budget superiority over another alternative

• We recommend to use 4km CWDM link specification for cost effective SMF links