

100GE 10km SMF Technology Alternatives

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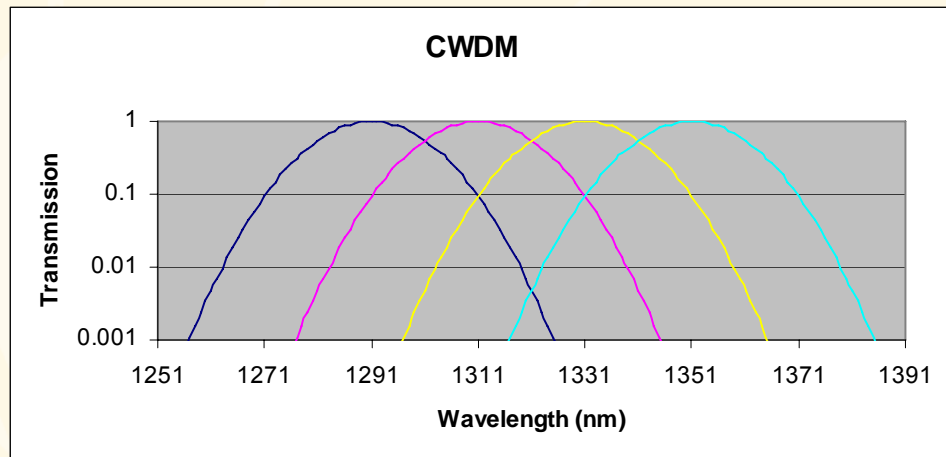
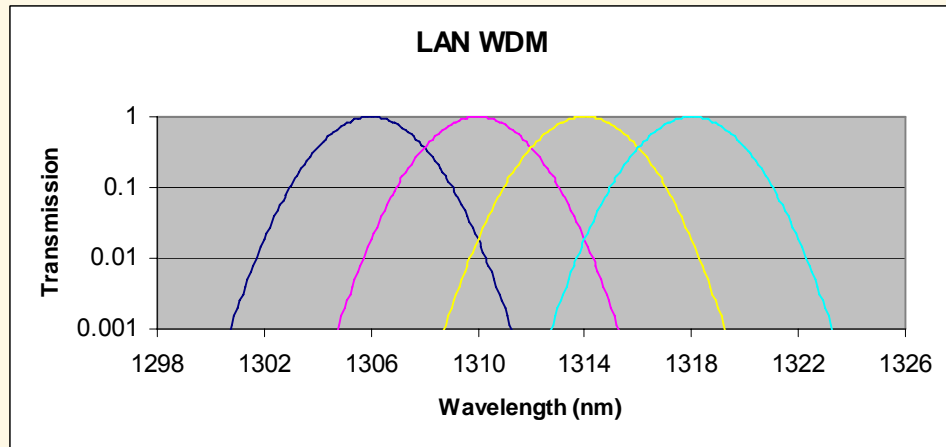
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10km SMF Outline

- WDM Grid Alternatives
- Propagation Properties
- Optics Alternatives
- Link Budgets
- Optics Integration
- Optics Shared Technology
- Alternatives Summary

10km SMF WDM Grid Alternatives

- Alt. 1: ITU G.694.1 widely spaced DWDM grid for LAN applications (LAN WDM)
 - 1306 – 1318nm (O band)
 - 193.1THz base
 - 400, 600, or 800GHz spacing (2, 3, or 4nm)
 - 1, 2, or 2.5nm width (**requires cooling** of TX optics)
- Alt. 2: ITU G.694.2 CWDM grid for LAN applications (CWDM)
 - 1291 – 1351nm (O band)
 - 20nm spacing
 - 13nm width (**requires cooling** of TX optics to support 100GE 10km reach)



10km SMF Propagation Properties

10km G.652 A&B SMF dispersion and fiber loss

- LAN WDM (4nm spacing)
 - $\lambda = 1318\text{nm}$ ($\lambda = 1306\text{nm}$ similar)
 - Max Dispersion (1319nm) = 18ps/nm
 - Max Loss (1319nm) = 4.2dB
- CWDM (20nm spacing)
 - $\lambda = 1351\text{nm}$
 - Max Dispersion (1356nm) = 52ps/nm
 - Max Loss (1356nm) = 4.7dB
- LAN WDM has 35% the dispersion and 0.5dB lower loss than CWDM

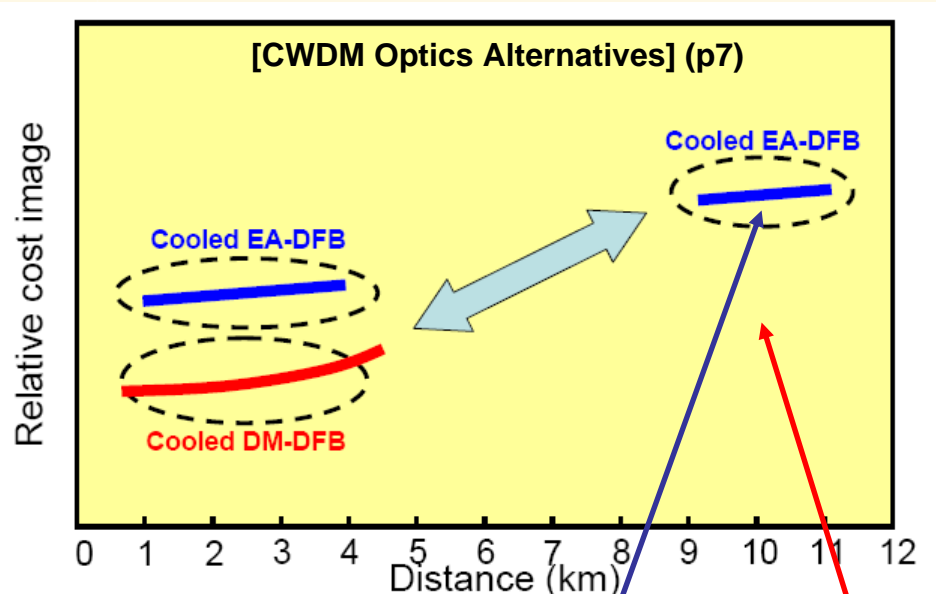
10km SMF Optics Alternatives

- CWDM Optics alternatives from traverso_01_1107 (supported by XLMD MSA: Eudyna, NEC, Oki, OpNext, Sumitomo Electric.)

“For 10km link, only [cooled] EA-DFB will be choice due to much dispersion” (p7)

“DM-DFB will be cheaper but can achieve only shorter distance” [or lower dispersion] (p7)

“Cooled DFB [is] relatively low cost” (p5)



- CWDM Optics alternatives from jiang_01_0507

“... only EML [= EA-DFB] supports 10km [distance]” (p8)


- LAN WDM Optics alternatives

For the 10km reach there are two alternatives: cooled EML and cooled DML

- LAN WDM Optics alternatives from jiang_01_0507

“[LAN WDM] enable DML [= DM-DFB] for the 10km reach for future low cost potential” (p10)

10km SMF Link Budgets

10km SMF 25G	CWDM EML (EA-DFB) $\lambda = 1351\text{nm}$ ER = 7dB	LAN WDM EML (EA-DFB) $\lambda = 1318\text{nm}$ ER = 7dB	LAN WDM DML (DM-DFB) $\lambda = 1318\text{nm}$ ER = 4.5dB
Fiber Loss (G.652 A&B)	4.7	4.2	4.2
ER penalty (versus ER=10dB)	1.0	1.0	2.5
CD	1.0 ¹	0.4 ²	1.6 ³
Connector & other losses (cross-talk)	3.0	3.0	3.0
Total budget	9.7 	8.6	11.3 ⁴

- ¹ traverso_01_0907, EML: $\lambda = 1357.5\text{nm}$, $\alpha = 1.0$, 10km (p10)
- ² traverso_01_0907, EML: $\lambda = 1319.0\text{nm}$, $\alpha = 1.0$, 10km (p10)
- ³ traverso_01_0907, DML: $\lambda = 1357.5\text{nm}$, $\alpha = 4.0$, 4km (p13)
- ⁴ higher link budget is offset by higher DML output power (versus EML)

10km SMF Optics Integration

- LAN WDM Optics monolithic integration low cost potential from cole_01_0907 (supported by CyOptics, NTT Lab, Oki, Eudyna, Mitsubishi, Sumitomo Electric, NEL)
“LAN WDM 6nm to 12nm band results in significant low cost potential through manufacturing monolithic laser arrays, [and] ultimate low cost potential through monolithic integration of Mux/DeMux.” (p7)
- LAN WDM Optics monolithic integration low cost potential from nagarajan_01_1107
“To achieve low cost – simple high yield processes are required, >40nm band gap shift (400GHz channel spacing) for optimal performance ... “ (p5)
- CWDM Optics monolithic integration low cost potential from nagarajan_01_1107
“Larger wavelength (e.g. CWDM) are more complex/costly [and] push the limit of integration technology” (p4)
- CWDM Optics will always use discrete EMLs and Mux/Demux as optics integration requires expensive non-standard process steps that do not lead to overall cost savings.

10km SMF Optics Shared Technology

- LAN WDM 10km Optics shared development cost and volume with 40km from cole_01_0907 (supported by CyOptics, NTT Lab, Oki, Eudyna, Mitsubishi, Sumitomo Electric, NEL)
“Amortization cost is reduced by sharing development expenses with 40km reach.” (p7)
“Unit cost is reduced through economies of scale by sharing volume between all reaches (... 10km, 40km.)” (p7)
- LAN WDM 10km Optics shared development cost and volume with 40km from jiang_01_0507
“Increase the total volume base with the combined 10km & 40km market demand.” (p10)
- CWDM 10km Optics are different from 40km Optics (which use LAN WDM) and require two different sets of optics

10km SMF Alternatives Summary

LAN WDM PMD	CWDM PMD
1 st Gen uses cooled EMLs	1 st Gen uses cooled EMLs
1 st Gen will be lower cost due to higher yield due to 1dB more link margin	1 st Gen has 1dB less link margin
Next Gen has significant cost reduction potential due to use of cooled DMLs	Cost reduction potential limited due to restriction to only use cooled EMLs
Next Gen has significant cost reduction potential due to monolithic optics integration (laser arrays, mux/demux)	Cost reduction potential limited due to restriction to only use discrete EMLs
Reduced initial cost by sharing optics development with the 40km reach	Requires a separate optics development from the 40km reach
Reduced cost (volume driven) through sharing of optics with the 40km reach	Requires separate optics from the 40km reach

LAN WDM grid is recommend as the best choice for the 10km reach