Merits of Selecting CWDM for 10km SMF PMD - Impact of Wavelength Grid on Optical MUX/DMUX

opnext

WE *light* IT UP

Masato Shishikura
Matt Traverso
Kiyo Hiramoto
Atsushi Takai

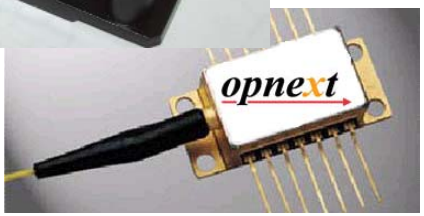
Motivation and contents of this presentation

- Motivation
  - Enable lowest cost, compact transceiver supporting the 10km SMF PMD in the first and future generations
  - Specify a wavelength grid which minimizes cost, size, & power dissipation both in year 1 and subsequent years
- Migration to Integration within the PMD
- CWDM vs. LAN-WDM Merit/Demerit
  - Wavelength Yield
  - Optical MUX / DMUX
  - Link Budget
  - Power consumption & size
  - Cost

Transmitter Technology Evolution: OSA

Discretes

Old LX4 TOSA

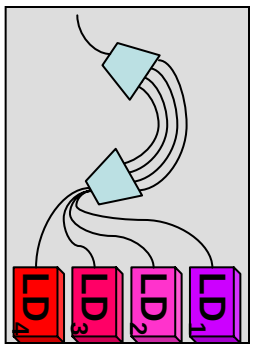


Merit
- Optimization per device
- Segments repair/rework
- Minimizes crosstalk
- Existing opt. packaging

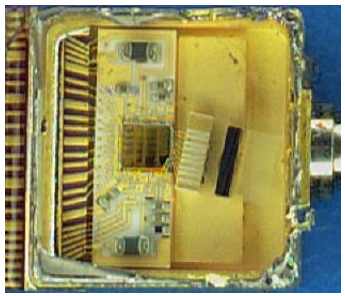
Demerit
- High packaging costs
- Large size

Hybrid

LDs+ AWG MUX



LX4 ROSA

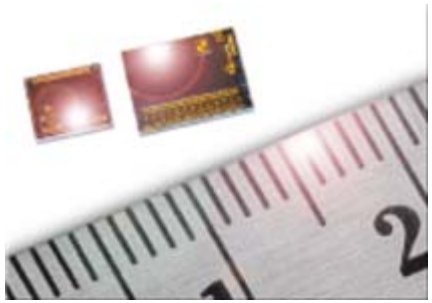


Merit
- Reduces size
- Reduces package costs

Demerit
- All components thermally connected
- Difficult to shield wire bonds
  - –Crosstalk = Radio Antenna
- Custom Packaging

Monolithic

Infinera PIC



Merit
- Minimum size
- Reduces package costs

Demerit
- All components thermally connected
- HIGH optical loss
- HIGH economic investment
- Custom Packaging

OSA = Optical sub-assembly

Wavelength Grid Comparison

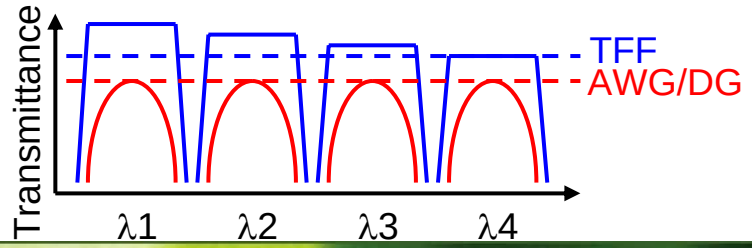
Item		CWDM	LAN WDM
Specification	Grid	1271 - 1331	1312 center
	Pitch	20 nm	2 – 4 nm
	Tolerance	+/- 6.5 nm	+/- 0.36 – 0.8 nm
Laser for 1st generation		Cooled EA-DFB	
Laser development	Technical Issue	25G 1310nm EA-DFB 25G Operation is the major challenge Wavelength grid is very minor challenge	
Laser Manufacturing	Wafer fabrication	4 kinds wafer	
	Wavelength yield	100%	Lower yield
	Wavelength test	No	Required
Laser Availability		Same	
Optical MUX/DMUX		Compact	Large and/or high cost
Link Budget		1~2dB Higher Path Penalty 1~2dB less O-Mux loss	Moderate to Difficult
Future		Cooled DFB, Uncooled EA-DFB, Uncooled DFB	Cooled DFB

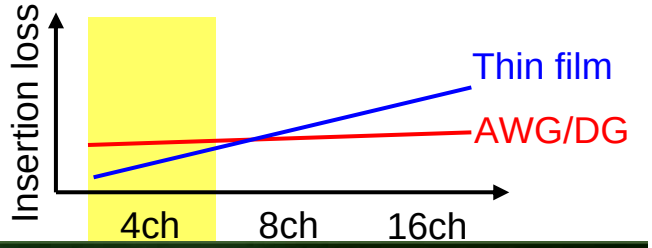
Optical MUX / DMUX Alternative

- Thin film filter (TFF) : low loss & compact
- Arrayed waveguide grating (AWG) : large loss if using CWDM
- Diffraction grating (DG) : smaller and lower loss than AWG

Item	Thin film filter (TFF)	Arrayed waveguide grating (AWG)		Diffraction grating (DG)	
		Silica	Semicon.(*1)	Silica	Semicon.
Pass band shape	**Flat top**	**Gaussian**		**Gaussian**	
4ch Insertion loss	**~2.5 dB**	**~3 dB**	**~7 dB**	**0~2dB lower loss than AWG?**	
TE-cooler	**Not required**	**Maybe not required**	**Required**	**Required**	
Notes	• Compact / low loss • Loss depends on channel count • **Existing CWDM and DWDM**	• Loss doesn't depend on ch. count • Flat top existing, but large loss • Larger size • **Existing DWDM O-MUX/DMUX** • **1300nm type does not exist, need to develop**		• Smaller than AWG • Polarization-dependant loss issue • **Does not exist**	

[1] johnson_01_0108, Jan, 2008

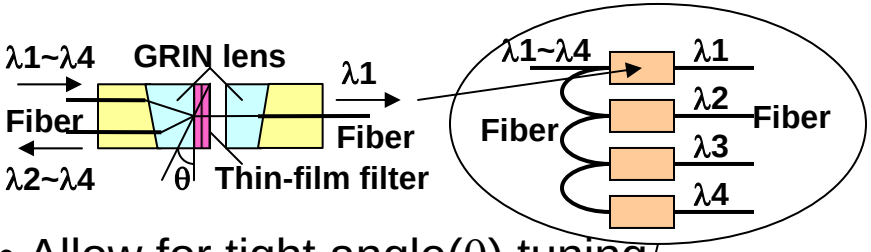




TFF based Optical MUX / DEMUX

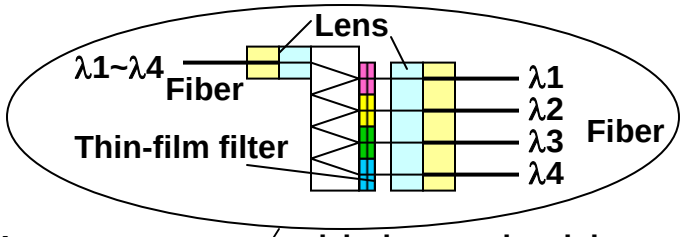
- TFF based O-MUX / DMUX have low loss around 2.5 dB
- Zig-Zag type is very small and preferred for compact transceiver
- Existing LX-4

1) 3-port type (1λ add or drop)



- Allow for tight angle(θ) tuning
- Used in DWDM or CWDM
- Large module size due to cascaded connection using fiber

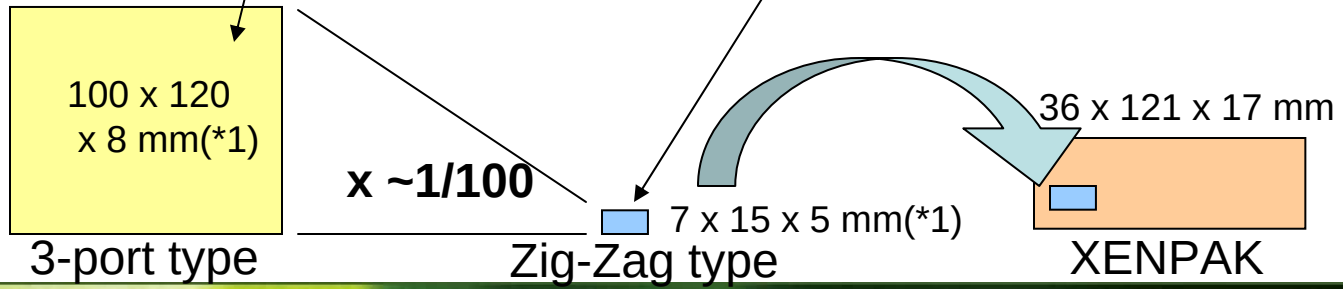
2) Zig-Zag type (4λ, very compact)



- Very compact with large incident angle
- Used in CWDM

✓ How about LAN WDM ?

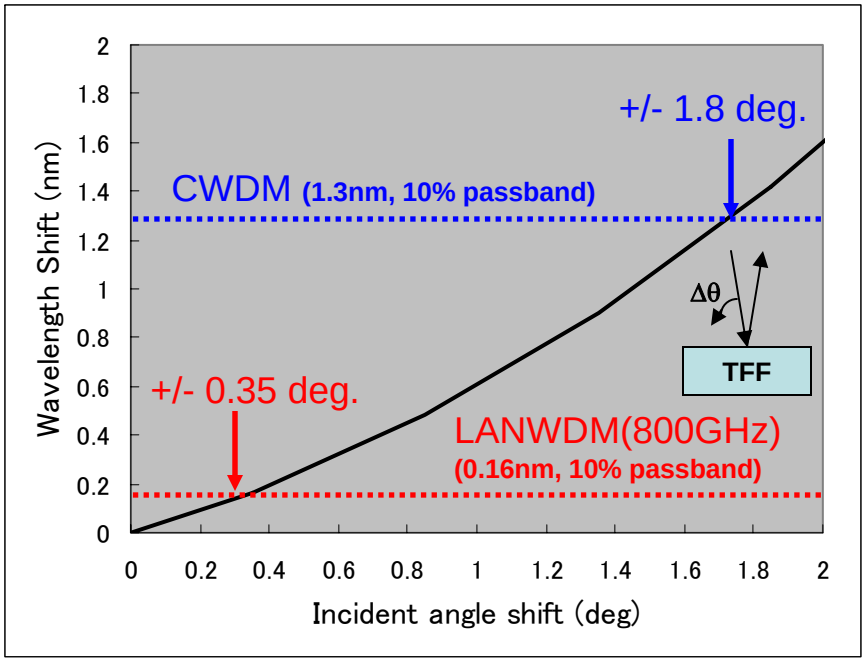
O-MUX/
DMUX size



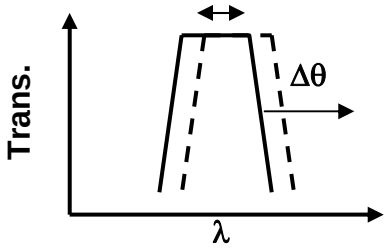
[1] From some manufacture's web site, commercially available

TFF based Zig-Zag type for CWDM and LAN WDM

- Estimated TFF incident angle tuning range (within +/- 10% passband wavelength shift, single reflection)
  - CWDM : +/- 1.8 deg (possible)
  - LAN WDM: +/- 0.35 deg (possible but very difficult)
- Zig-Zag O-MUX/DMUX can be applied for CWDM, but very difficult for LAN WDM (even 800GHz) due to tight angle tuning

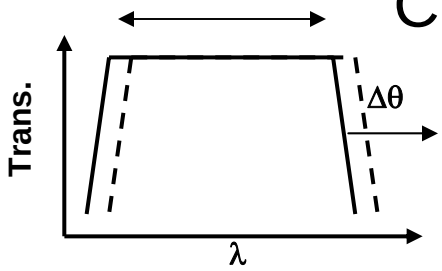


LAN WDM



- Need tight angle tuning
- Center WL shifted
- S- and P-plane split

CWDM



- Relax angle tuning
- Higher yield
- Compact

TFF based Zig-Zag cost comparison for CWDM and LAN WDM

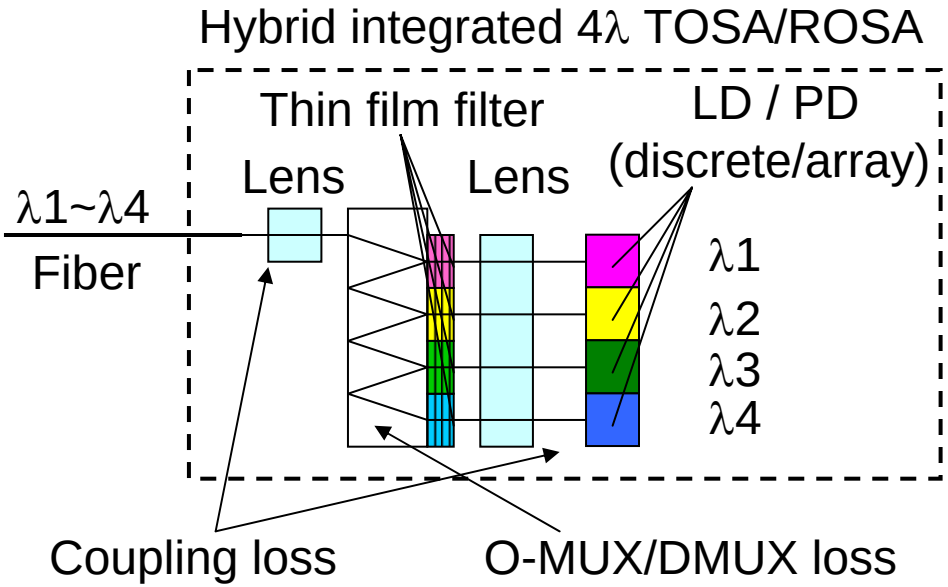
- CWDM TFF-based Zig-Zag O-MUX / DMUX is lower cost than LAN WDM based on DWDM technology

Item	CWDM	LAN WDM	Note
Grid	1271 - 1331	1312 center	
Pitch	20 nm	2 – 4 nm	
Pass band	+/- 6.5 nm	+/- 0.36 – 0.8 nm	
LD linewidth(*1)	+/- 0.1 nm (EML), +/- 0.2 nm (DML)		@25G
Number of layers(*2)	**50~100**	**150~200**	TFF
Assembly tolerance(*2)	**Relax (+/- 1.8 deg.)**	**Very tight (+/- 0.35 deg.)**	
Zig-Zag type cost	**Low**	**High**	
Availability	**Existing**	**Not existing even DWDM**	

[1] HSSG, jiang_01_0507, May, 2007
[2] http://www.cubeoptics.com/img/FCKeditor/File/cwdm_white_paper.pdf

Hybrid Integration of Zig-Zag for TOSA and ROSA

- CWDM can apply Zig-Zag O-MUX/DMUX to hybrid-integrated TOSA/ROSA with collimated optics
- These are compact, low insertion loss and low power consumption
- LAN WDM is hard to apply Zig-Zag O-MUX/DMUX



Arrayed Waveguide Grating (AWG) and Diffraction Grating (DG) Optical MUX / DMUX

- DG is low insertion loss for discrete LAN WDM O-MUX / DMUX, but TE-cooler is required and it has PDL issue
- Si-based O-MUX/DMUX is lower cost if very high volume
- These are waveguide-based devices, their concerns are PDL and coupling loss to LD in hybrid integration case

Item	Arrayed waveguide grating (AWG)		Diffraction grating (DG)	
	Silica	Semicon.(*1)	Silica (*2)	Semicon.
4ch Insertion loss	~3 dB	~7 dB	0~2dB lower loss than AWG?	
TE-cooler	Maybe not required	Required	Required	
Chip area	x 1(~50x30mm^2)	~ x1/10	~ x1/4(~20x20mm^2)	~ x1/20
Module size	(130x65x20mm^3)	---	---	---
CWDM	N/A (higher loss due to wide pass band)			
LAN WDM	N/A (large size)	YES(higher loss)	YES	YES
Notes	• Loss not dependent on ch. count • Larger size • Existing DWDM O-MUX/DMUX		• Smaller than AWG • Polarization-dependant loss issue • Not existing	

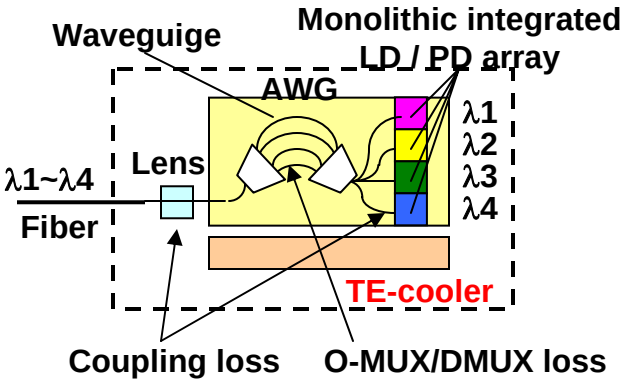
[1] johnson_01_0108, Jan, 2008
[2] Janz et al., IEEE PTL, Vol.16, No.2, p503-505 (2004)

Hybrid / Monolithic integration using AWG and DG for LAN WDM

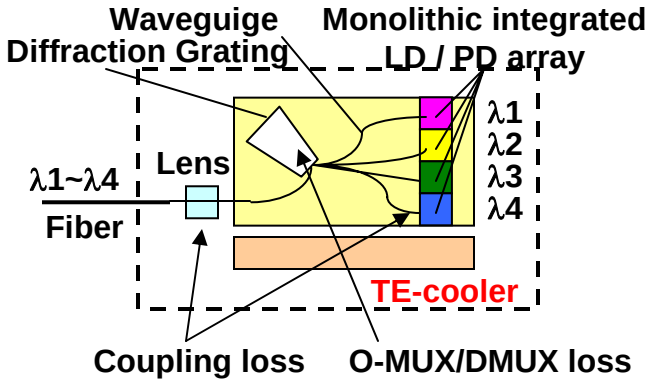
(1) Hybrid integration case (Silica or Silicon)
- Compact size, but high coupling loss between WG and LD or very tight alignment such as sub-micrometer

(2) Monolithic integration case (InP-based)
- More compact size and improved coupling loss, but higher insertion loss and higher investment is needed (*1)

Hybrid / Monolithic type (AWG)



Hybrid / Monolithic type (DG)



[1] In the case of 40km objective PMD, higher loss can be mitigated with optical amplification at the receiver

Summary

- TFF-based Zig-Zag O-MUX/DMUX for CWDM exists ***today***
- O-MUX/DMUX for LAN WDM is waveguide based
  - Difficult to reduce cost
  - Temperature dependent wavelength characteristics
  - Polarization dependent loss (PDL)
- Zig-Zag-based O-MUX/DMUX for CWDM can achieve hybrid packaging and reduced cost with collimated optics
- Monolithic integrated TOSA/ROSA for LAN WDM may have merit of size, but tradeoffs are higher power consumption, higher loss, and higher investment cost
- CWDM is highly preferred from the view point of O-MUX/DMUX cost and availability for both 1st Gen. and future Gen.