Kotura Analysis: WDM PICs improve cost over LR4

IEEE P802.3bm - 40 Gb/s & 100 Gb/s Fiber Optic Task Force – Sept 2012

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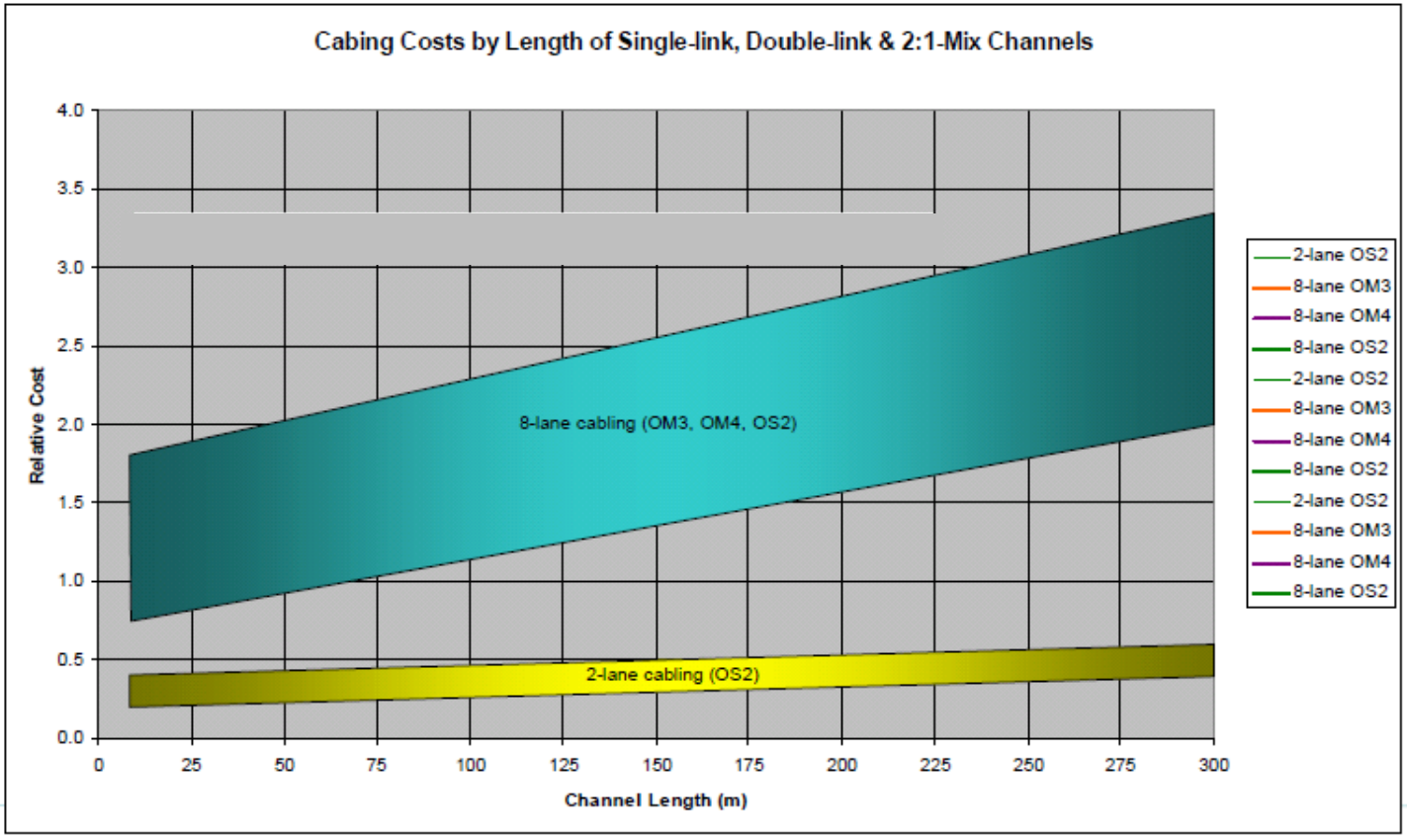
Recall the motivation for WDM PICs

- For the transceiver
  - "Reduction of number of components is key to achieve the lowest cost solution for data center applications" src: anderson_01_1111
- For data center cabling
  - Lowest cabling cost (by far) is 2 fiber SMF, source Cole_01_0512 (Abbott, Cole, Coleman, Kolesar, and Swanson)
- At the last meeting we were requested to provide some additional information on the cost of WDM PICs (within the IEEE guidelines regarding cost discussions)

Value Proposition for WDM PICs is Significant

Cabling Channel Costs

- Calculated installed cabling cost for channels supporting various PMDs



Key Points:

1. WDM solutions would use the same 2-lane cabling (OS2) used for LR, LR4

2. The complexity of any nR4 proposal should be compared to SR4 and SR10

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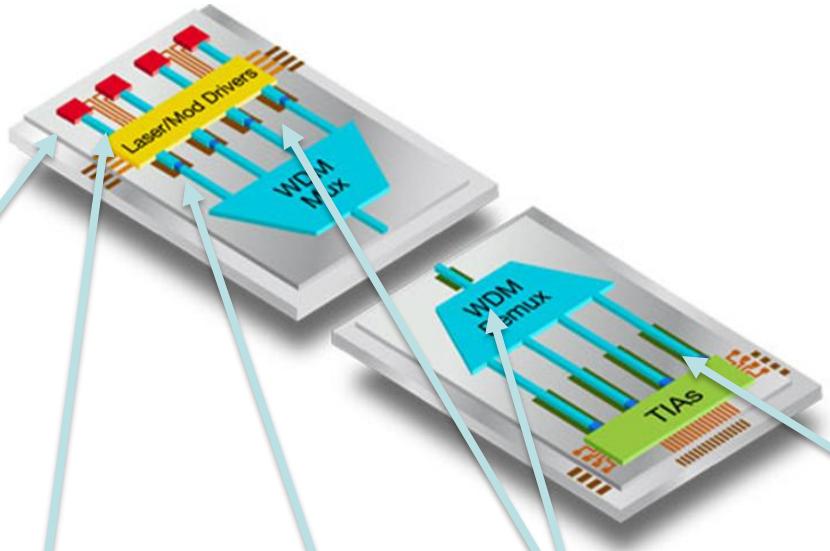
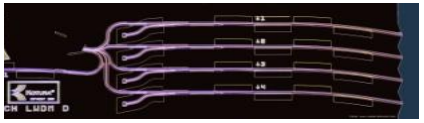
Recall that all the key components are integrated

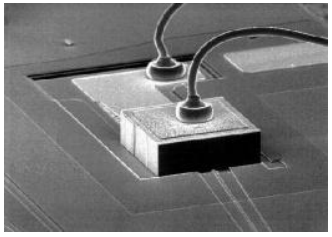
Opto-electronic integration of all components except laser eliminates dozens of piece parts



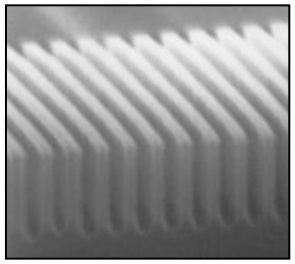
4x25 RX



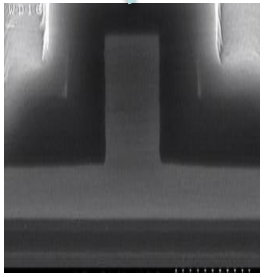
4x25 TX



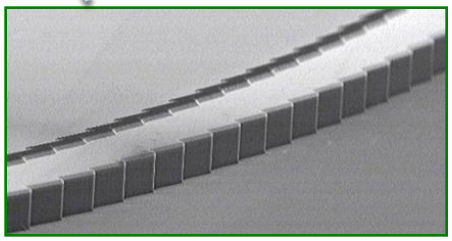
Light source



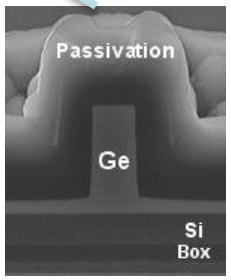
Grating



Modulator



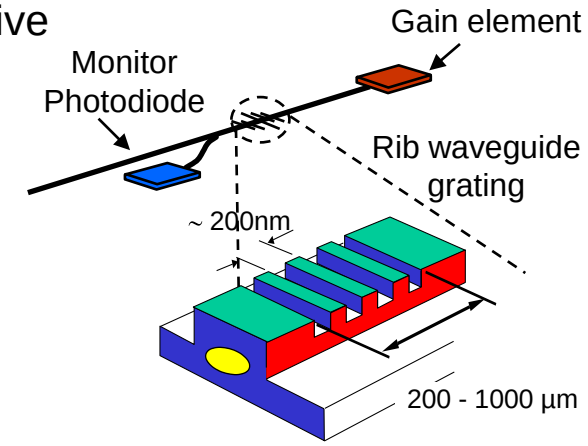
WDM Mux/Demux

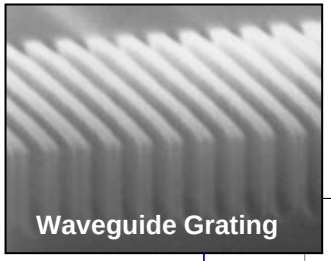


Detectors

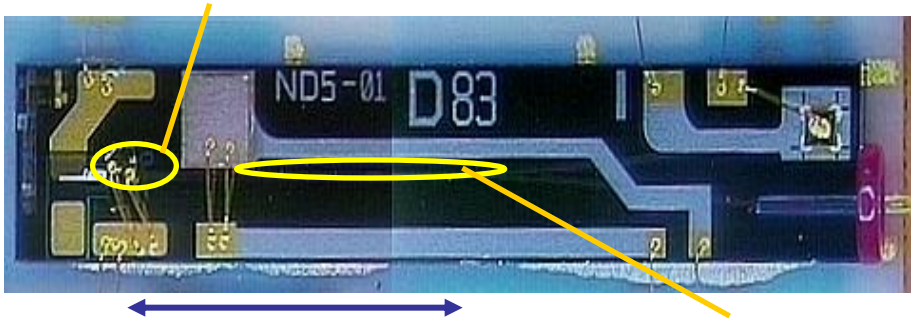
Low-Cost External Cavity (EC) Lasers

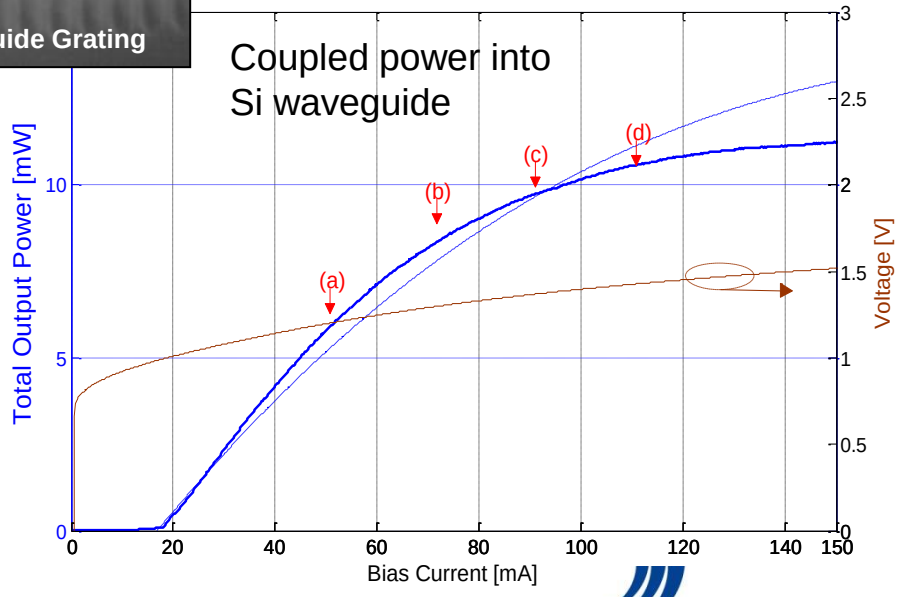
- Laser wavelength accuracy: ±50GHz absolute and ±5GHz relative
- Enables DWDM with accurate channel registration control.
- Use of commodity active components (RSOA's or FPs).
- Enables an array hybridization approach with generic actives.
- Parallel integration capacity to create multi-channel arrays
- <10kHz line-width demonstrated
- RIN <-140 dBHz^{-1}
- Chirp much lower than DFB (<x10)
- Wavelength tuning easily possible





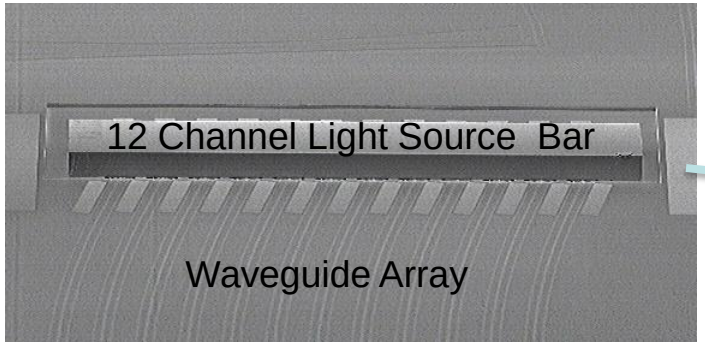
Amplification provided by InP gain element (front facet reflectivity <10^{-4})

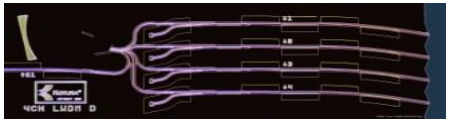


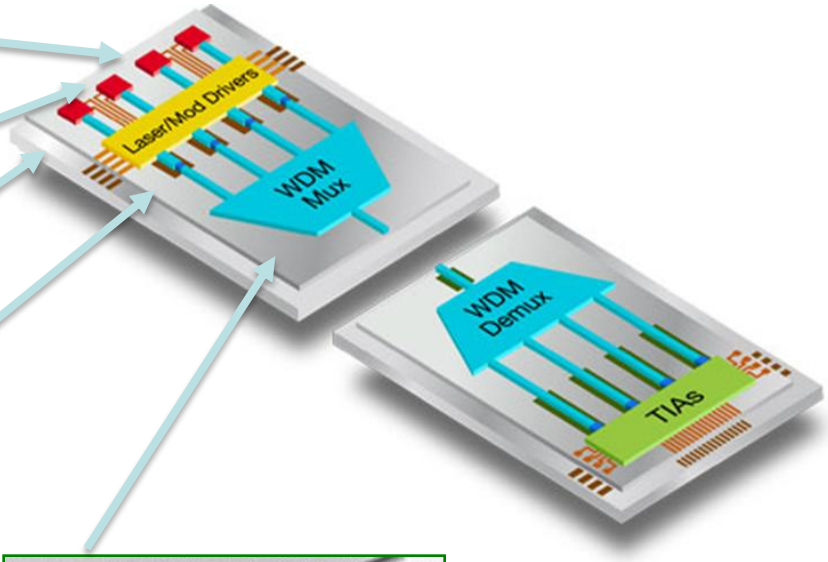


KOTURA

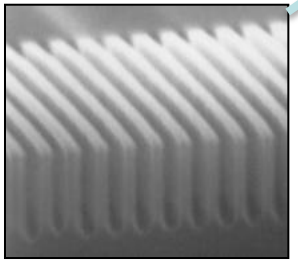
Integrating WDM lasers onto the transmitter chip



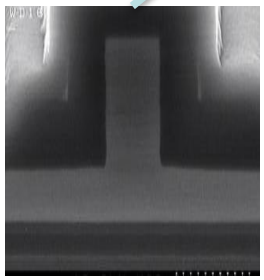




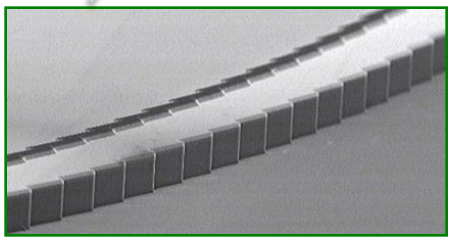
Generic GE-style gain chips create WDM external cavity lasers after bonding. They can be easily made in arrays.



Laser Grating

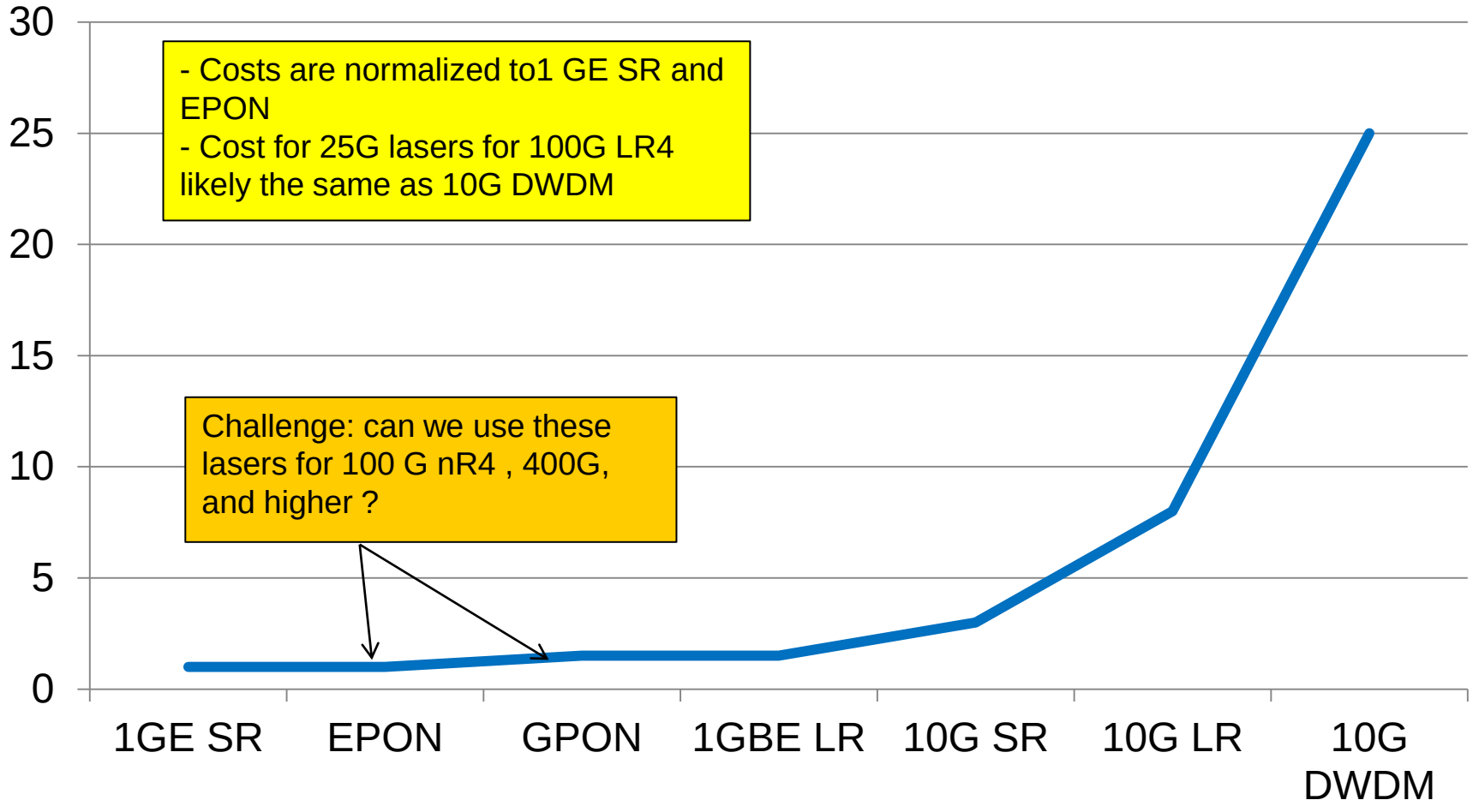


Modulator



WDM Mux/Demux

Kotura estimate of laser sub-assembly costs



Kotura Internal Analysis- The BOM

	SR4	Silicon photonics nR4	LR4
Lasers	1t 4x25G VCSELs	1t 4 FP lasers	5t 4 WDM 25G DMLs
OSA	1u Lens, carriers	1u SP integrated modulators & WDM	5u Integration of WDM and Laser subassemblies
Drivers	1v CMOS or SiGe	1v CMOS or SiGe	2.5v SiGe or GaAs
Detector Array	1.5w 4x25G detector	1w SP integrated detectors & WDM	2.5w Integration of WDM and Detector array
CDR Array	1.5x	1x	2x (LR spec tougher)
Package	1y non hermetic	1y non hermetic	3y hermetic
Connector	5z MPO	1z LC	1z LC

Reduction in Assembly Costs

1. Integration minimizes optical assembly
2. Wafer scale flip-chip bonding of 4-channel gain array
   - Automated, passive alignment
   - 40 seconds per array
3. Wafer scale testing
4. Die attach 4x25 CMOS driver array
5. Die attach TIAs on Rx
6. Connectorize TOSA-ROSA in QSFP/CFP4

Low Cost Checklist

- √ Use CMOS where ever possible
- √ No WDM specific lasers, no laser sub-assembly (no isolators, beam collimators, lens cap, etc.)
- √ No hermetic packages
- √ No active laser alignment
- √ No detector sub assembly
- √ No TEC
- √ No WDM assembly
- √ Use duplex connector instead of arrayed MPO

Silicon photonics is one low-cost WDM PIC example

- CMOS chip fabrication
- Low-cost, flip-chip bonded Gig E style light source
- Full integration of laser grating, modulator, mux/demux and detectors
- CMOS drivers and TIAs
- Minimal piece parts
- Electronics style assembly
- Non hermetic packaging