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Advances in Silicon Photonics Muxes and DeMuxes for CWDM and LAN WDM Applications

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Objective

- In the reflector discussion of 4 x 10 CWDM vs 40 Gbs serial for 40 Gbs for 10km SMF, some CWDM critics have challenged the capabilities of muxes and demuxes to be small enough to enable small packaging

- The purpose of this presentation is to show (again) that silicon photonics muxes and demuxes can:
  - **FIT** any of the proposed packaging options
  - **SUPPORT** automated assembly of lasers and detectors
  - **MEET** the performance requirements (low loss, low cross talk)
  - **PROVIDE** a migration path to a Terabit systems

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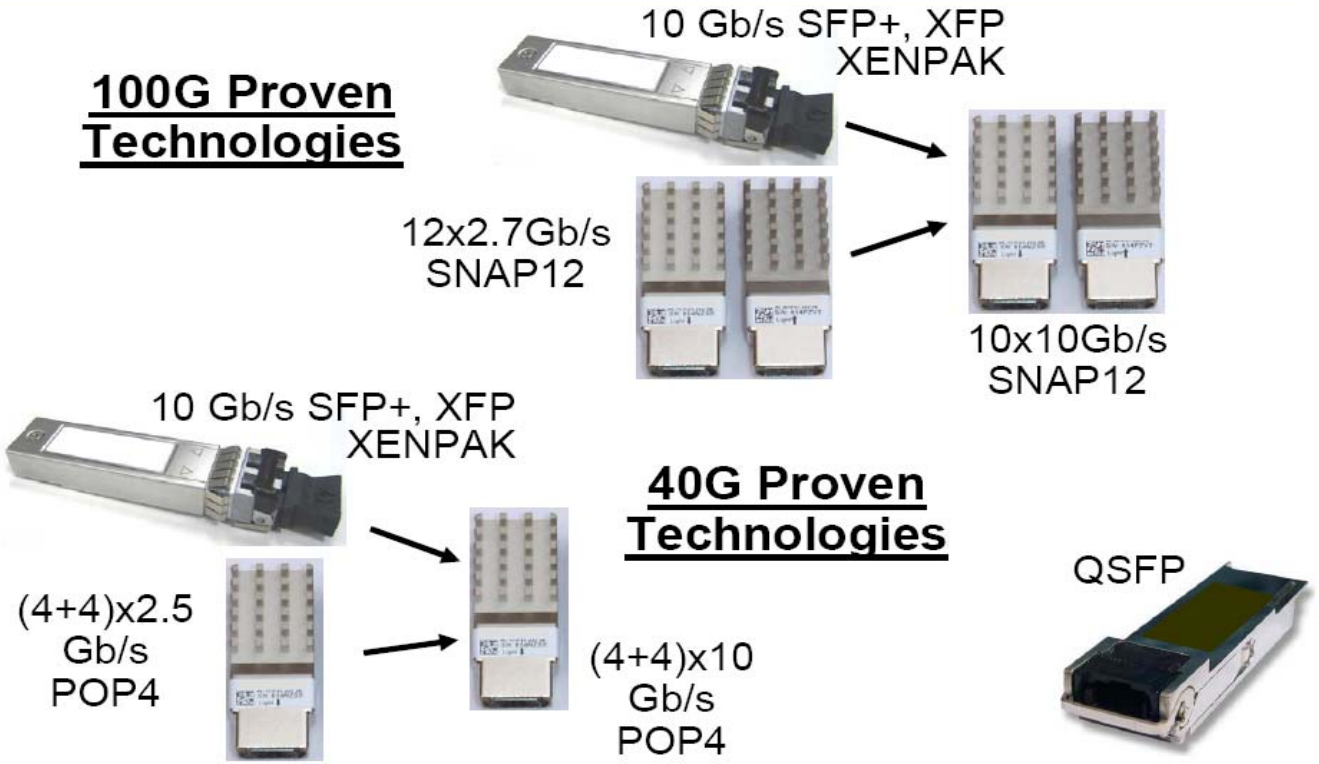
Size: Can Our Chips Fit 40G Form Factors?

100G and 40G Form Factors



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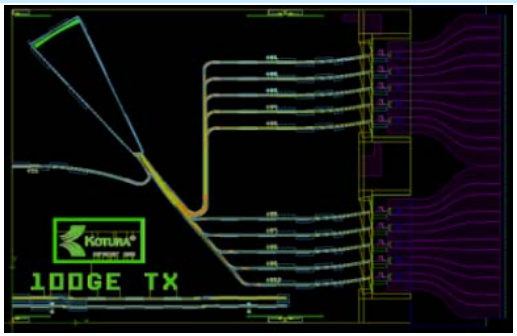
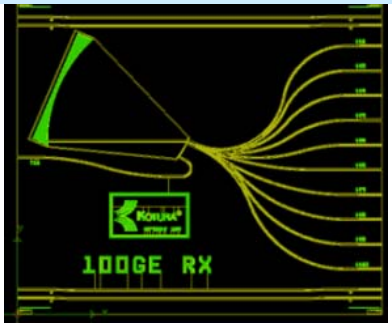
Example of 10 Channel CWDM Mux and Demux

Mux - Transmitter



13 x 9.5 mm

DeMux – Receiver



11 x 9.5 mm

- 20 nm Wavelength Spacing (CWDM)
- Reflector grating designs are 1/10th the size of traditional AWGs
- Width driven by pitch for lasers and detectors to support the needs of the assembly process
- Laser bars are flipchip bonded onto the Silicon chip
- More than small enough to fit any of the proposed packaging architectures

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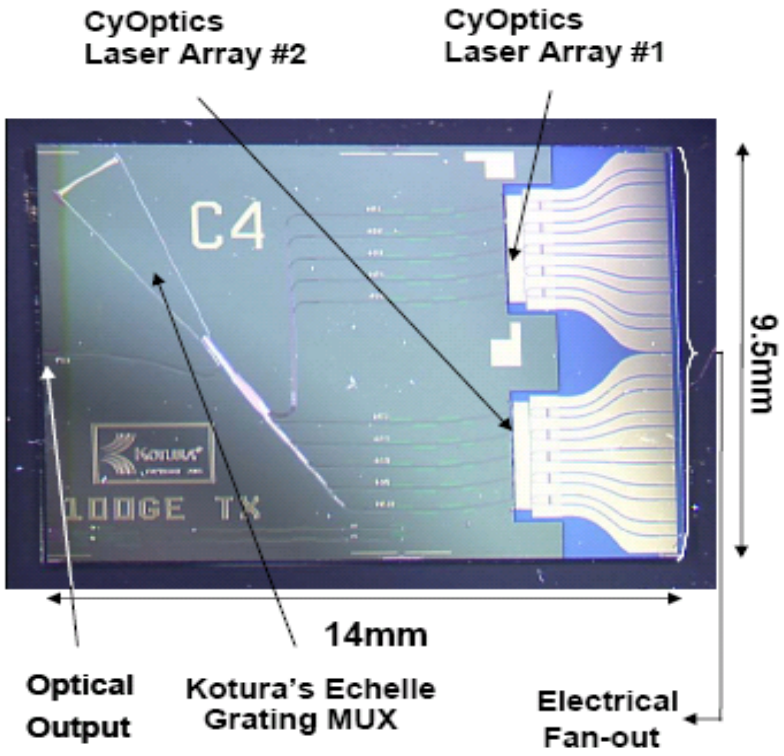
A Kotura Transmitter Chip For CyOptics' Laser Arrays

PLC based 100GbE Transmitter

10x10Gbps DFB arrays with SOI MUX



- PLC Mux: SOI Echelle Grating (Kotura)
- PLC with 2 sites for coupling of 2 laser arrays
- Each array with 5 CWDM DFB lasers
  - array 1: 1430 – 1510nm
  - array 2: 1530–1610nm
  - 20nm spacing on ITU grid
  - uncooled operation 0-85degC
- Design optimized for yield

13 Stefan Rochus

CyOptics

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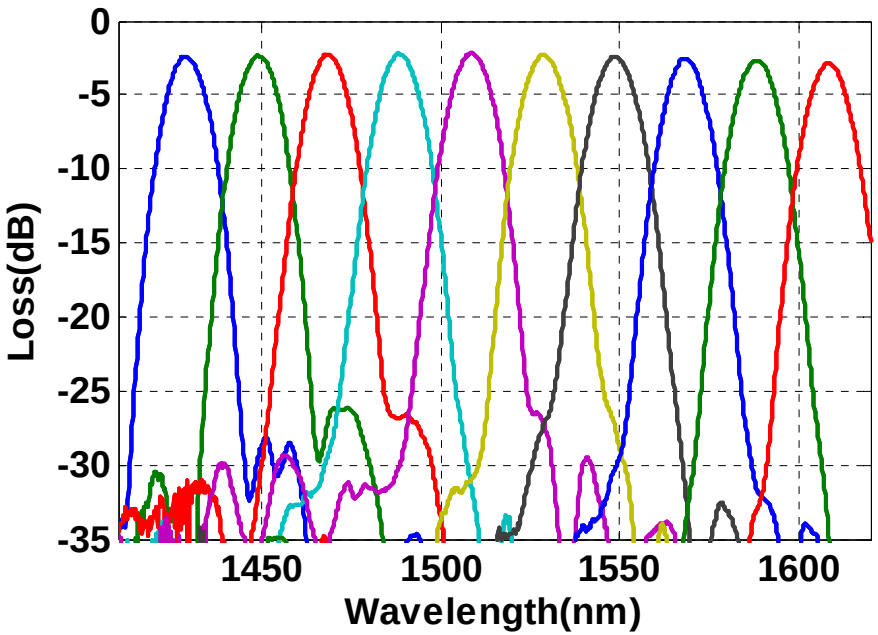
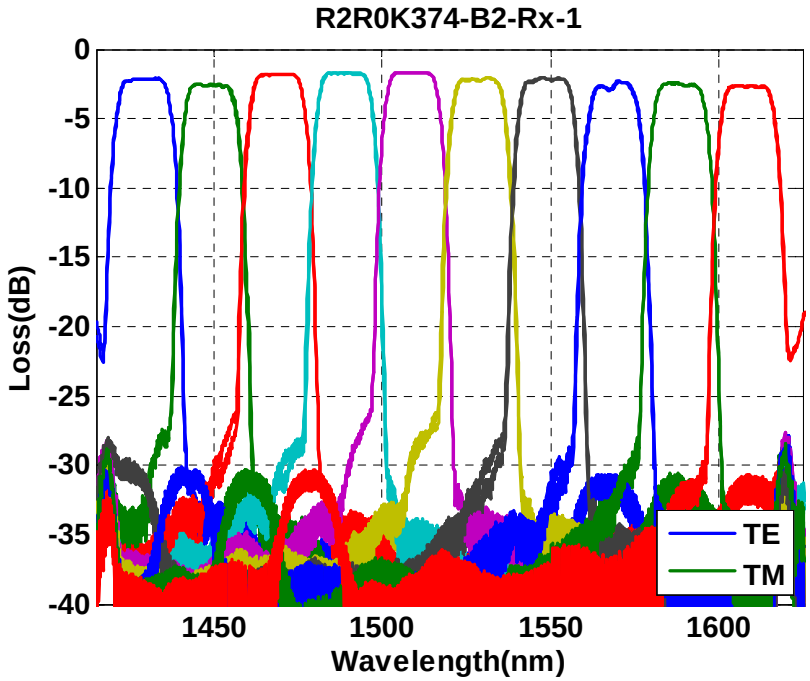
Recent data from 10 Ch CWDM samples





- **Transmitter (left)**
  - Low loss Gaussian mux demonstrates on chip loss of < 3 dB
  - Flat response over broad spectrum (1430-1610)
- **Receiver (right)**
  - Flat top filter design works over broad temperature range
  - Low loss demonstrates < 3dB on chip loss for Demux
  - Cross talk of < 25 dB

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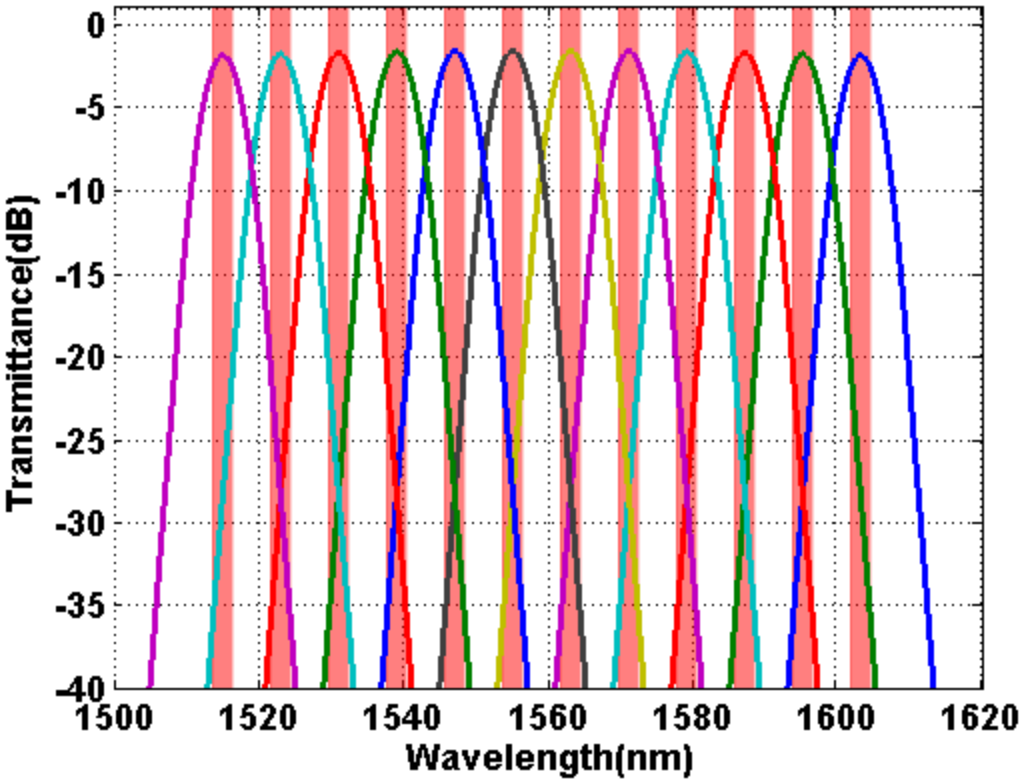
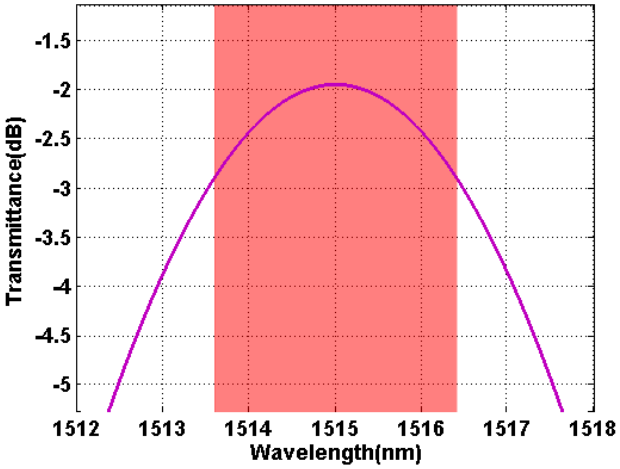
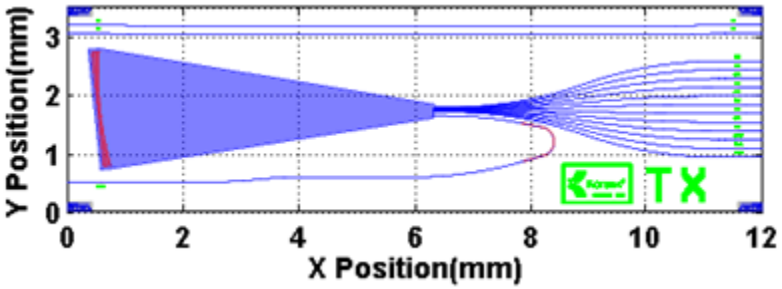
LAN WDM 12 ch x 8nm Mux Spectrum

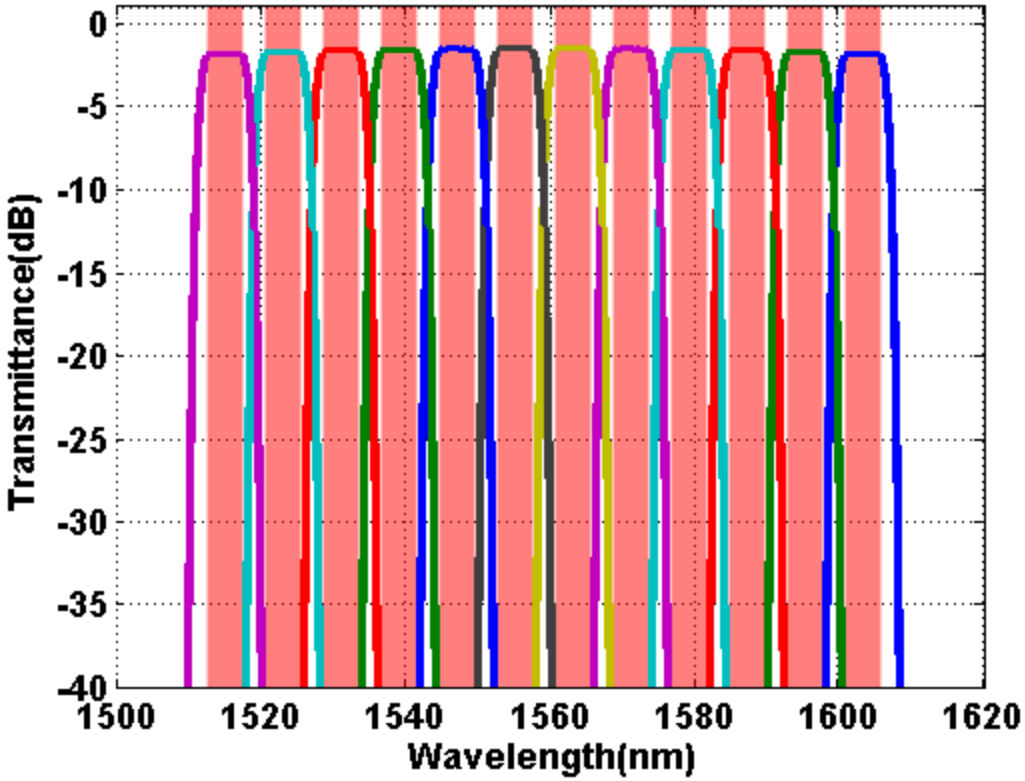


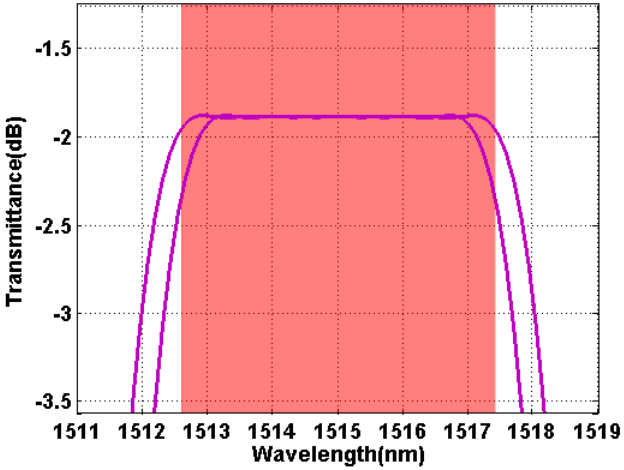


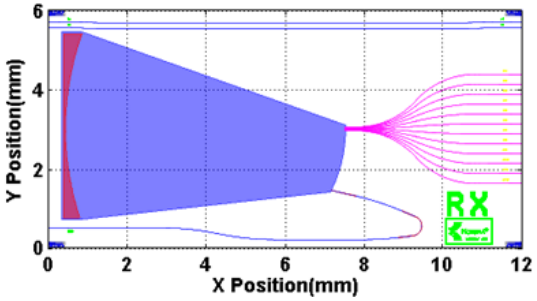


Insertion Loss	< 4 dB
1dB Passband	2.8nm

LAN WDM: 12 ch x 8nm Demux Spectrum

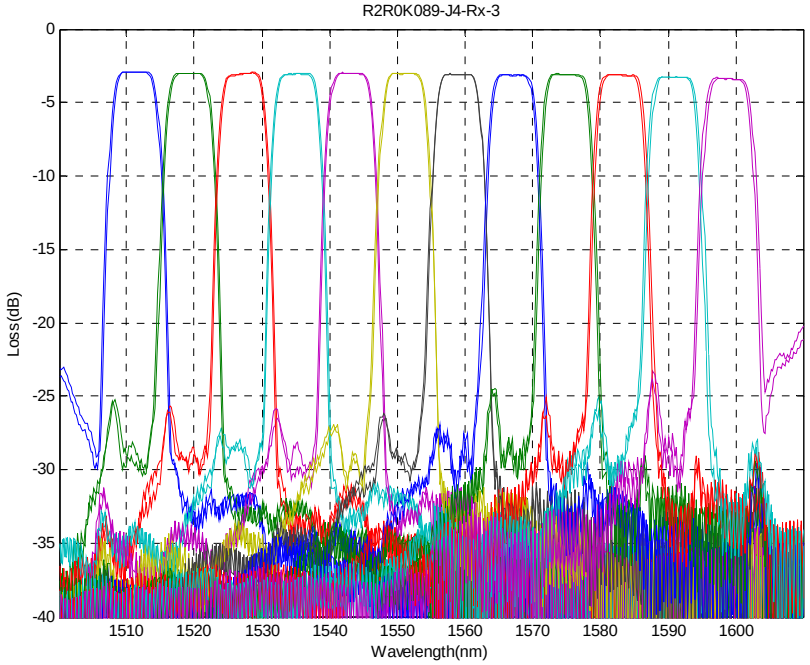


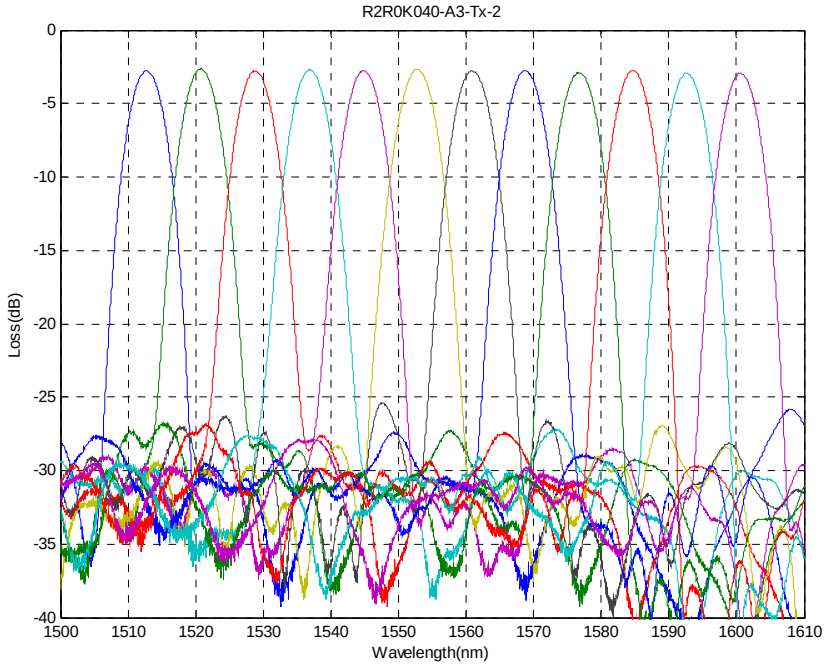




Insertion Loss	< 4 dB
1dB Passband	4.8nm
Adjacent Xtalk	20dB
NonAdjacent Xtalk	25dB

Recent Data on LAN WDM Devices



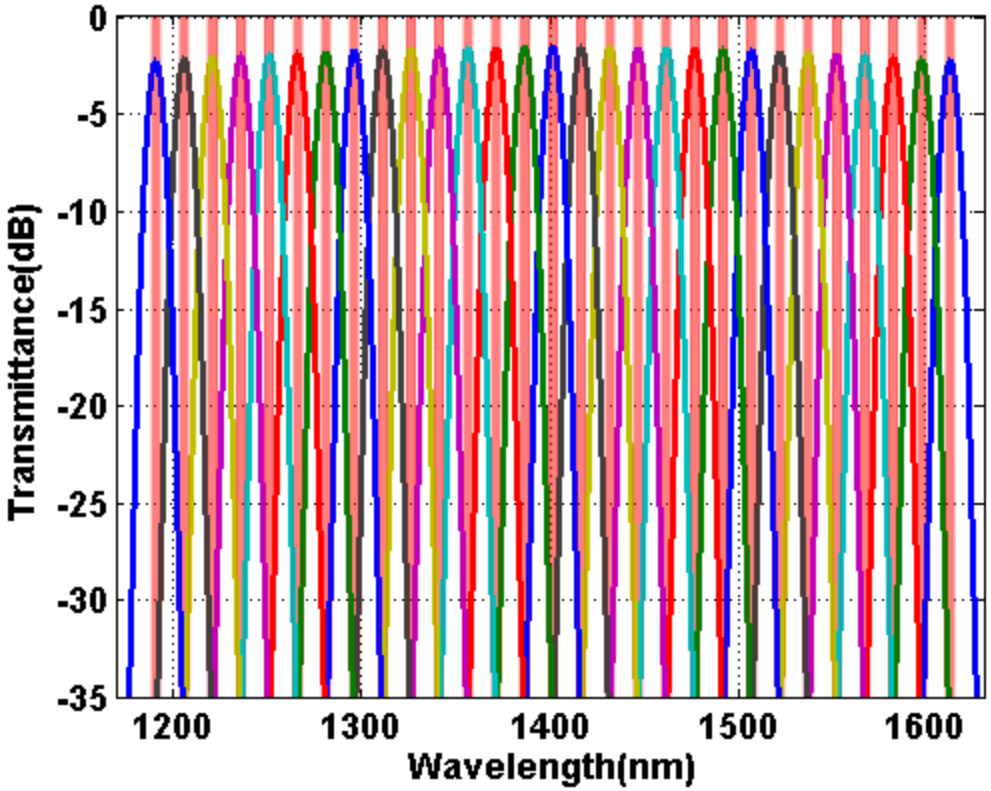


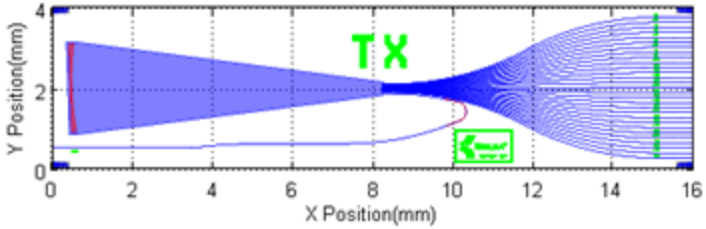
1. *Meets all critical specs for IL and crosstalk*
2. *Ready for volume manufacture*

Terapics: Terabit Photonics Integrated Circuits

- Joint development program between Kotura and CyOptics
- Funded by ATP
- Goal is to demo a Terabit on a silicon photonics chip by Oct. 2010
- CWDM wavelength spacing
- Automated assembly of lasers and detectors
- SMF for distances of 2 km

Simulation of 29 Ch x 15nm Mux Spectrum

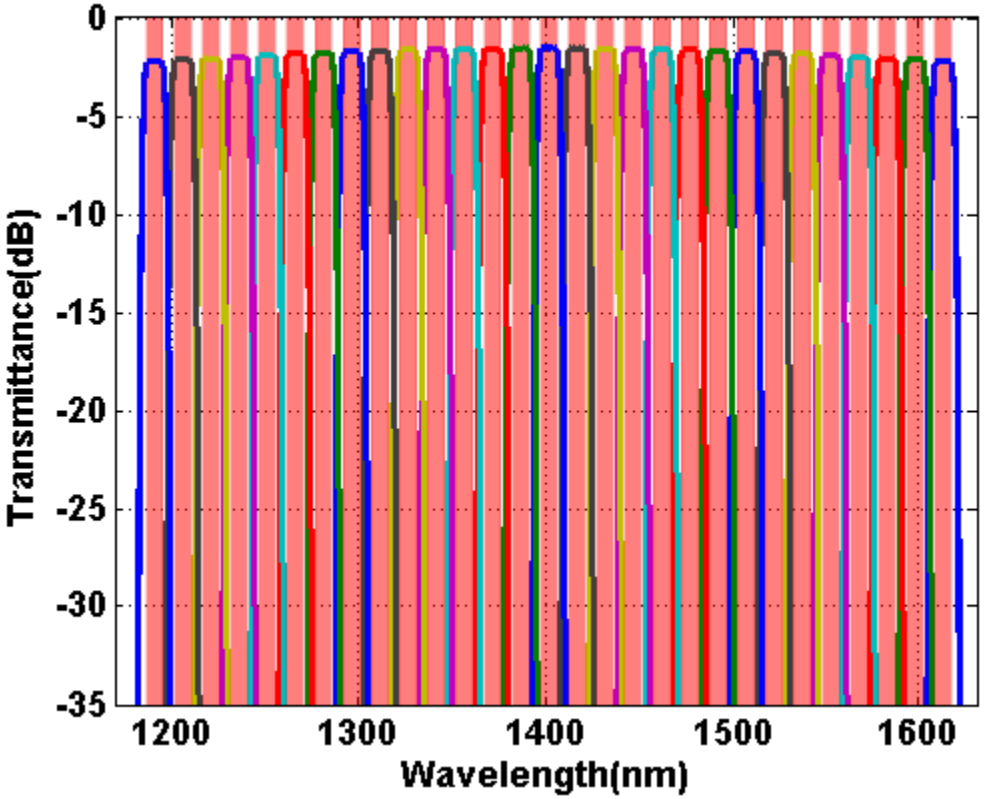


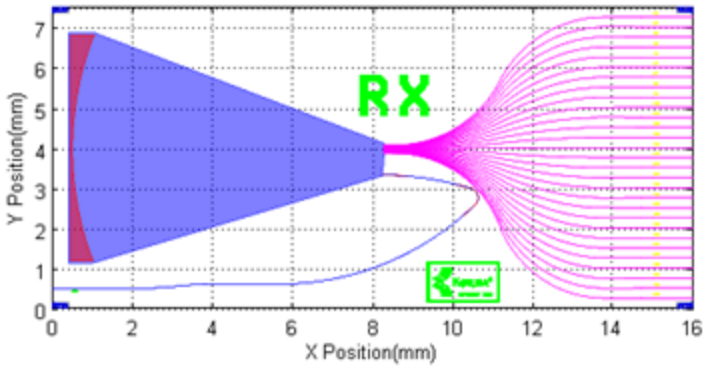


Insertion Loss	4.5dB
1dB Passband	4.5nm

1. *Only 25 channels required for a terabit*
2. *Extra channels in silicon chip to demonstrate even broader FSR capability*

Simulation of 29 Ch x 15nm DeMux Spectrum





Insertion Loss	4.0dB
1dB Passband	8nm
Adjacent Xtalk	20dB
Nonadjacent Xtalk	25dB

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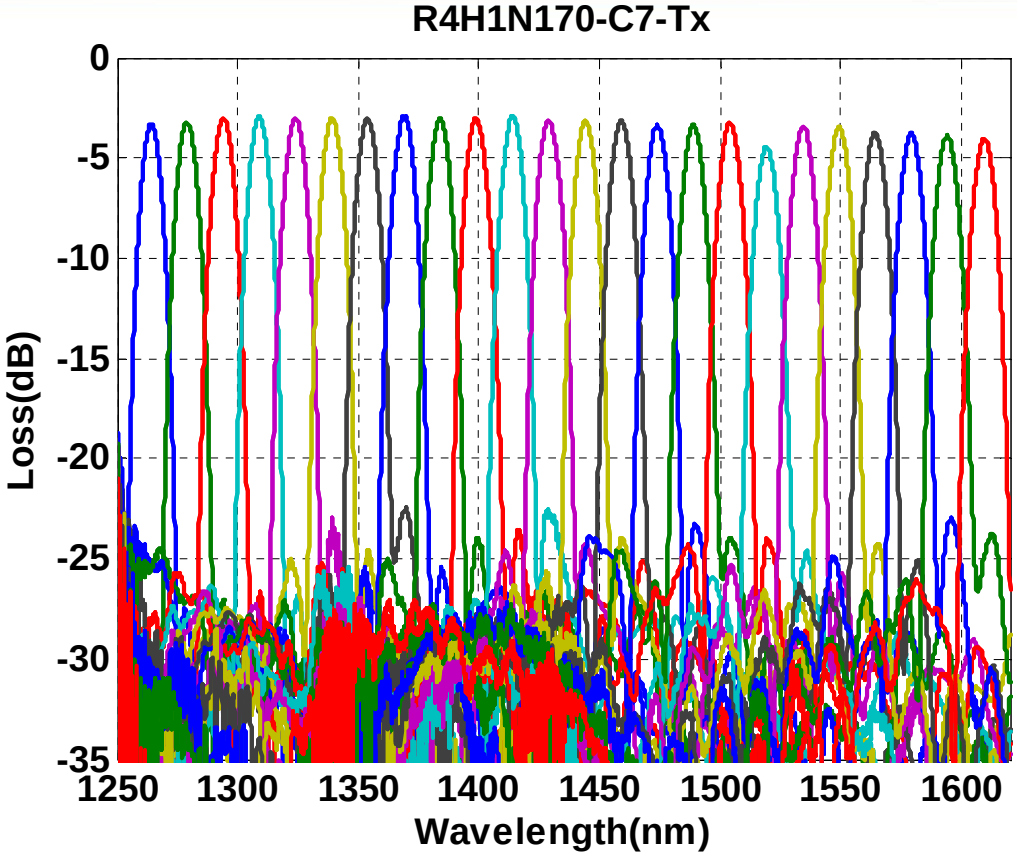
Measurements of the Mux Matches Our Simulation



- 15 nm channel-spacing device
- <4.5 dB loss demonstrated over 1250 – 1620nm (only 24 channels out of 29 can be measured due to current test setup wavelength limitations)
- Measurements have started on the Rx DeMux as well

Summary of Silicon Photonics Muxes and Demuxes

- Can be small enough for any packaging option
  - Xenpak is 121 (l) x 36 (w) x 18 (h) mm
  - Our Chip for 29 CWDM channels (1190-1610) measures 16 (l) x 4 (w) mm
  - Can easily fit 4, 10, 12 or even 25 channels in a Xenpak
  - Pitch (width) is usually function of assembly process for the lasers and detectors
- Can be mass produced at low cost in a commercial CMOS foundry
- Low loss designs support both the CWDM and LAN DWDM applications
- An excellent solution for 4 x 10 CWDM for 40 Gbs 10km SMF