8 Channel VCSEL Transceiver for 10-Gig

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IEEE 802.3 HSSG Interim Meeting

Dallas, TX

January 18-20, 2000

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10GBASE-SX8 Proposal

Data	8 duplex channels; 1.5625 Gb/s/channel
Fiber	Multi-mode fiber (Installed Or New)
Sources	VCSEL's
Wavelengths	778nm - 865nm
Mux	Plastic Molded Optic
Detectors	Silicon
Demux	Plastic Molded Optic
Electonics	Same inputs as LX, on-transceiver SerDes

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8-channel CWDM Benefits

- Achieves 200m on installed MMF
- Potential for even greater distance on new MMF
- Meets typical environmental requirements
- Leverages Parallel Optics electronics technologies

LOWEST COST OPTION

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Can this be done? YES!

- **Injection-molded optics** - Precision complex optical systems and connectors can be molded and replicated in volume.
- **Standard interference filters** - Small filter size yields 1000's of parts per wafer growth.
- **VCSEL based** - Leverages 1000BASE-SX laser sources and vendors
- **Silicon Detectors** - Large active area, high-speed, low-cost detectors for the near infrared.
- **Passive alignment** - Mux / Demux assemblies feature alignment-free construction.

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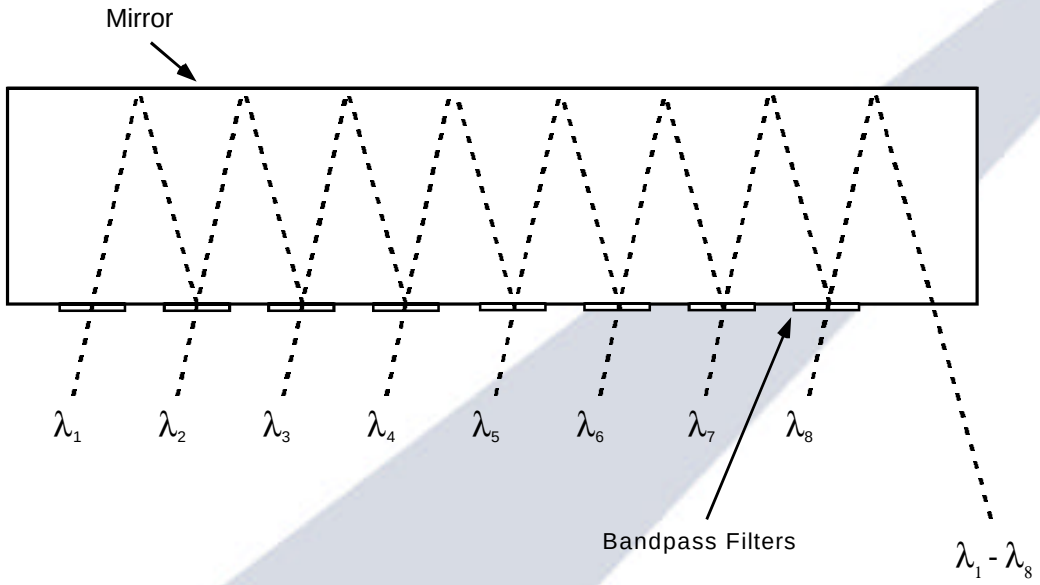
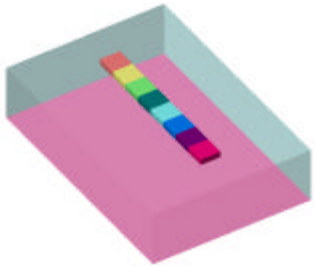
Optical Mux / Demux

- Zig-Zag construction
- Dual function for both combining and separating multi-wavelength optical signals





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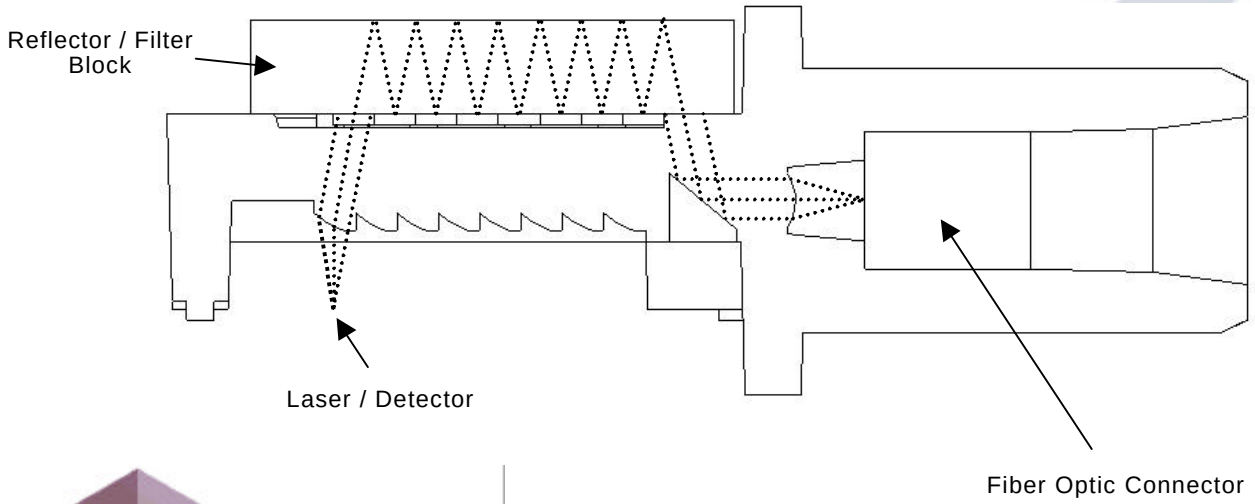
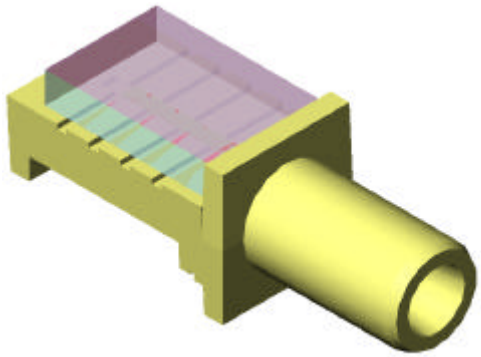
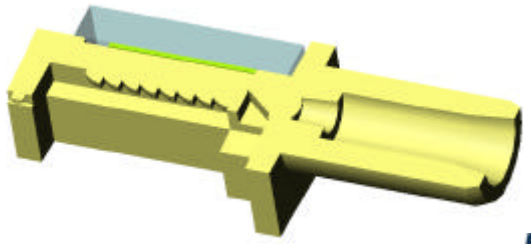
Multiplexer Coupling Optics

- **Injection Molded Optic**







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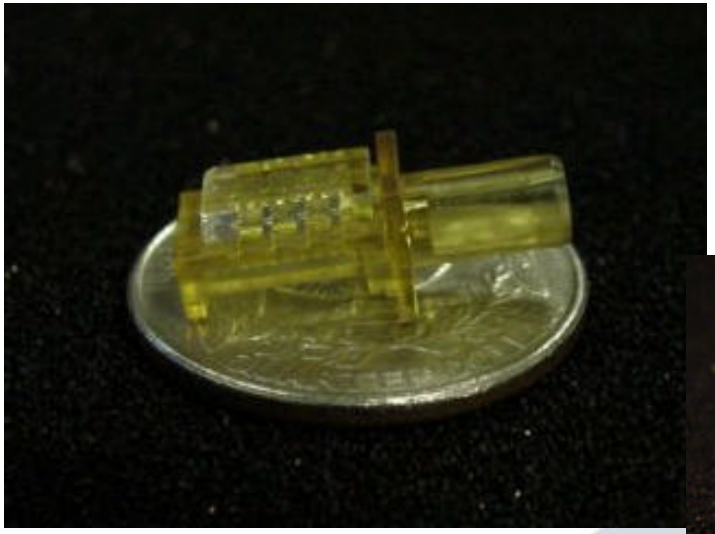
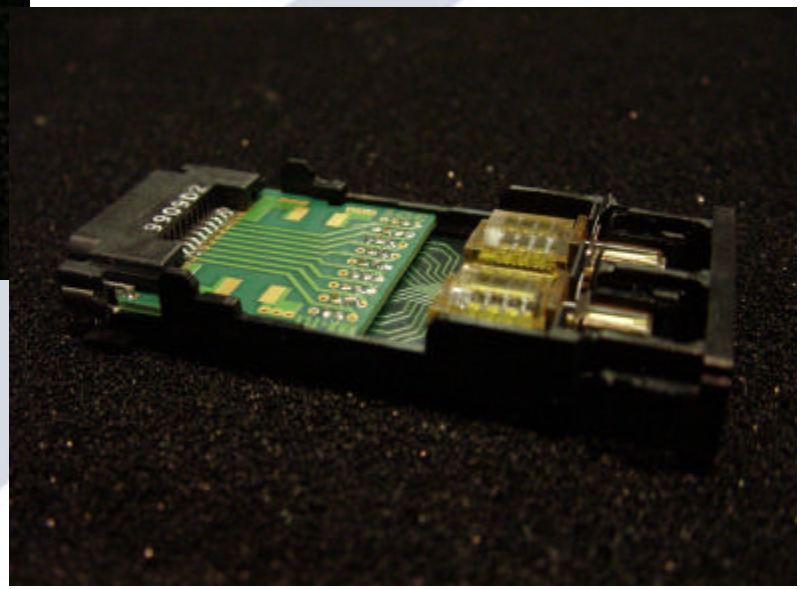
Optical Multiplexer





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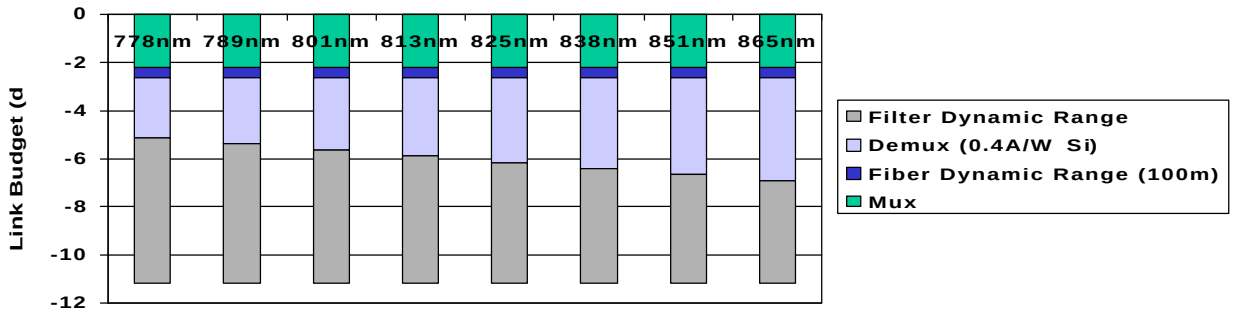
Optical System Performance

- Multiplexer losses (-2.2dB)
  - Absorption (-0.7dB)
  - Filters (-0.5dB)
  - Connectors (-0.5dB)
  - Alignment (-0.5dB)
- Demultiplexer losses
  - Beam divergence dominates losses



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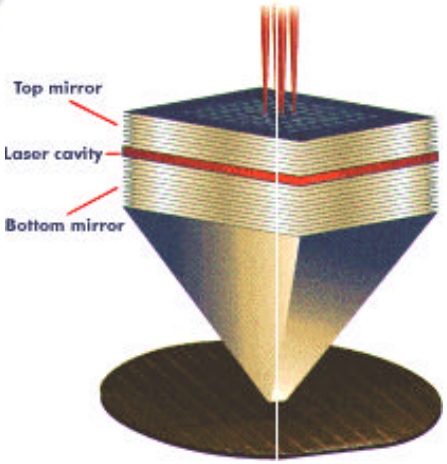
VCSEL Laser Sources

- Leverage 1000BASE-SX laser sources and vendors
- VCSEL wavelengths are easily fabricated over a wide spectral range (775 - 865 nm)
- Current wafer growths yield ~10,000 lasers with small wavelength spreads (± 1-2 nm)

EXTREMELY LOW COST LASERS



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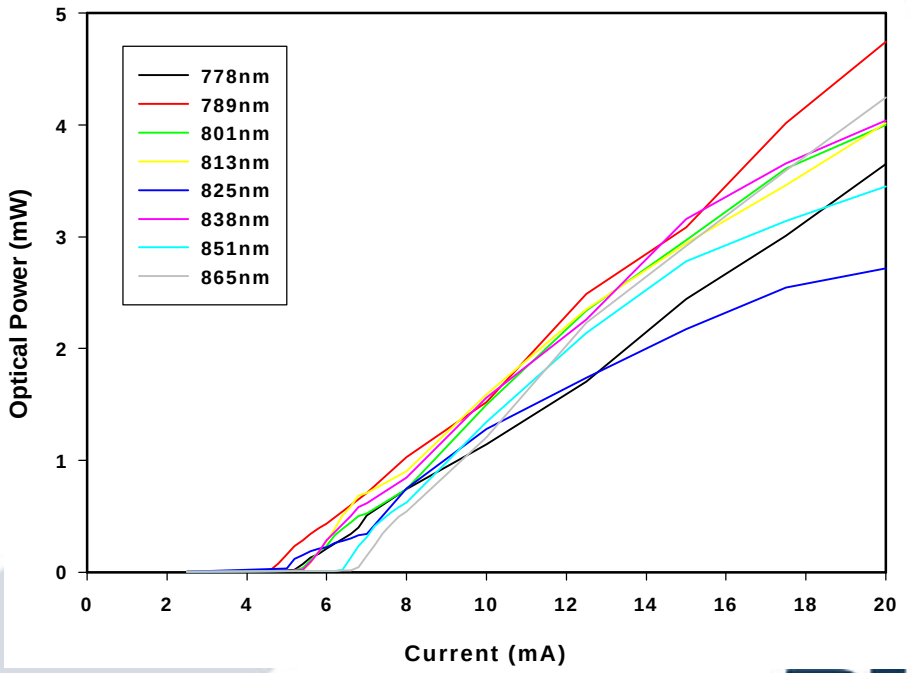
VCSEL Performance

- Low threshold current (5 - 7 mA)
- Fast rise / fall times (< 200ps)



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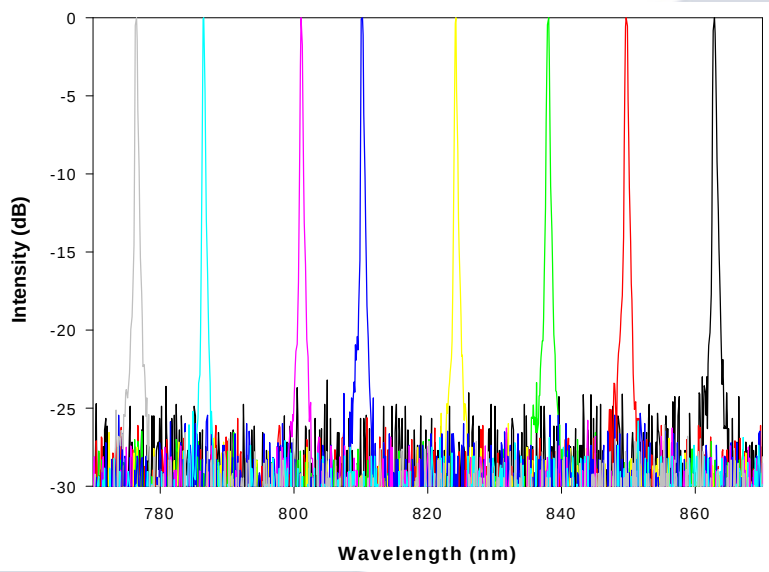
Channel Spacing

- Wavelength Tolerances
  - VCSEL manufacturing (±1-2 nm)
  - Thermal drift (0.06nm/ºC)
  - Filter center wavelength (± 0.4nm)
- 5.5 THz spacing



Parameters	λ (nm)
Laser 1 @ 35°C	778.0
Laser 2 @ 35°C	789.3
Laser 3 @ 35°C	800.9
Laser 4 @ 35°C	812.8
Laser 5 @ 35°C	825.1
Laser 6 @ 35°C	837.8
Laser 7 @ 35°C	850.8
Laser 8 @ 35°C	864.3

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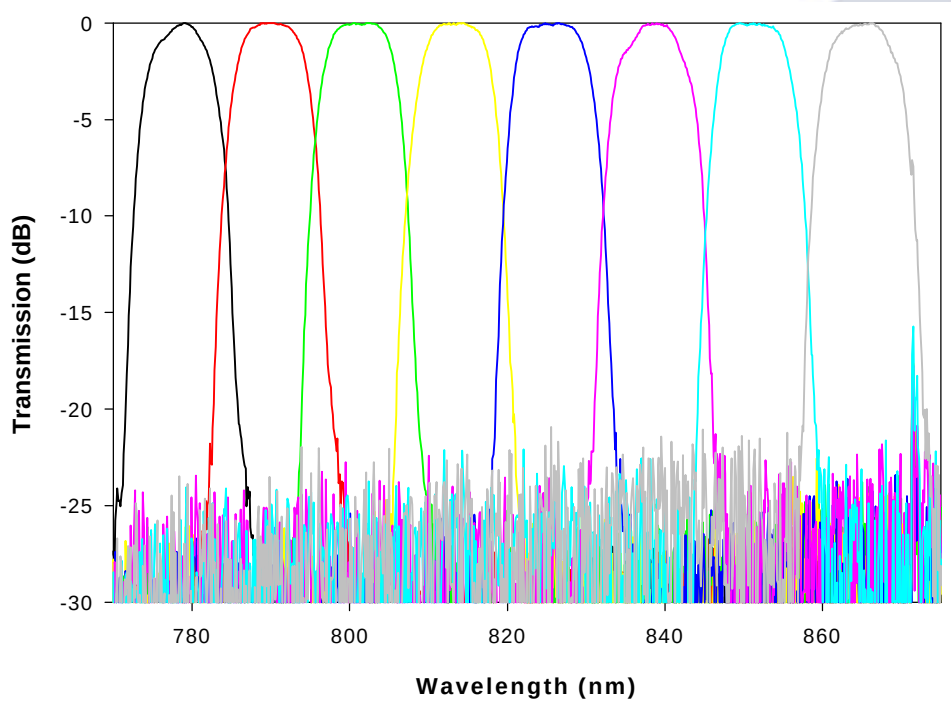
Filter Performance

- Environmentally stable filters (0.2 nm shift from 0 - 100°C)
- High transmission efficiency (> 90%)



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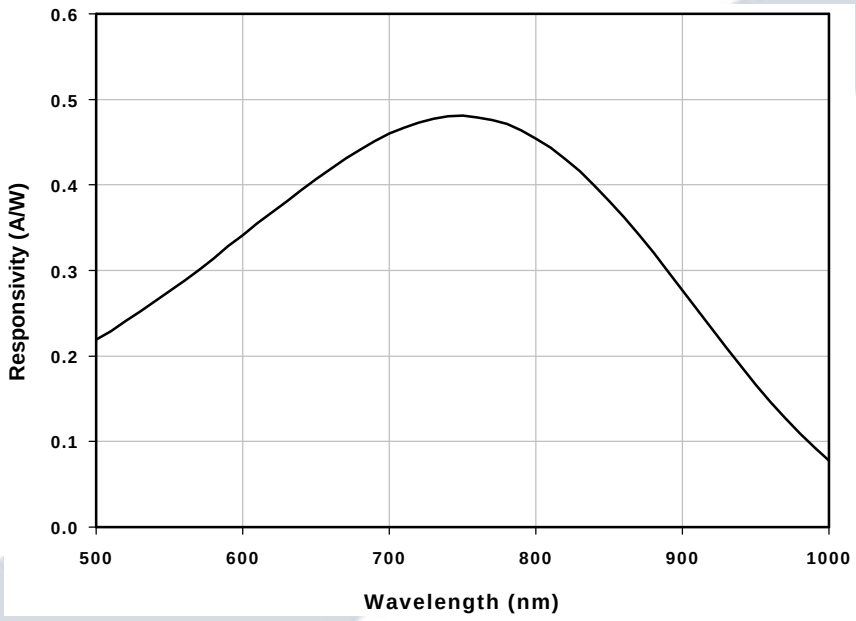
Detectors

- Silicon detectors yield 1000's / wafer for pennies
- Large apertures (200µm)
- Low voltage bias (2 volts)
- High electrical bandwidth (2 GHz @ 2 V)
- Good responsivity over spectral range



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Maximum Optical Power

- Eye safe power @ 850nm < - 4dBm
  - For eye safe, each channel < -13dB
  - Must have more signal
- Using open fiber control
  - Each laser (~ +5 dB)
  - Total power (~ +14dB)
- Flexibility to run higher powers - opens door to lower Bit-error-rates

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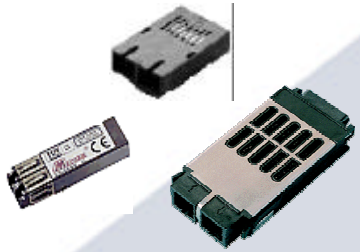
Manufacturability

- Alignment
  - Passive optical subassembly alignment
  - 4 - 40 micron component placements
  - Standard high-speed automated assembly equipment available
  - Assembly process is CM compatible
- Form Factor
  - MTRJ-style
  - GBIC-style
  - 1x9-style



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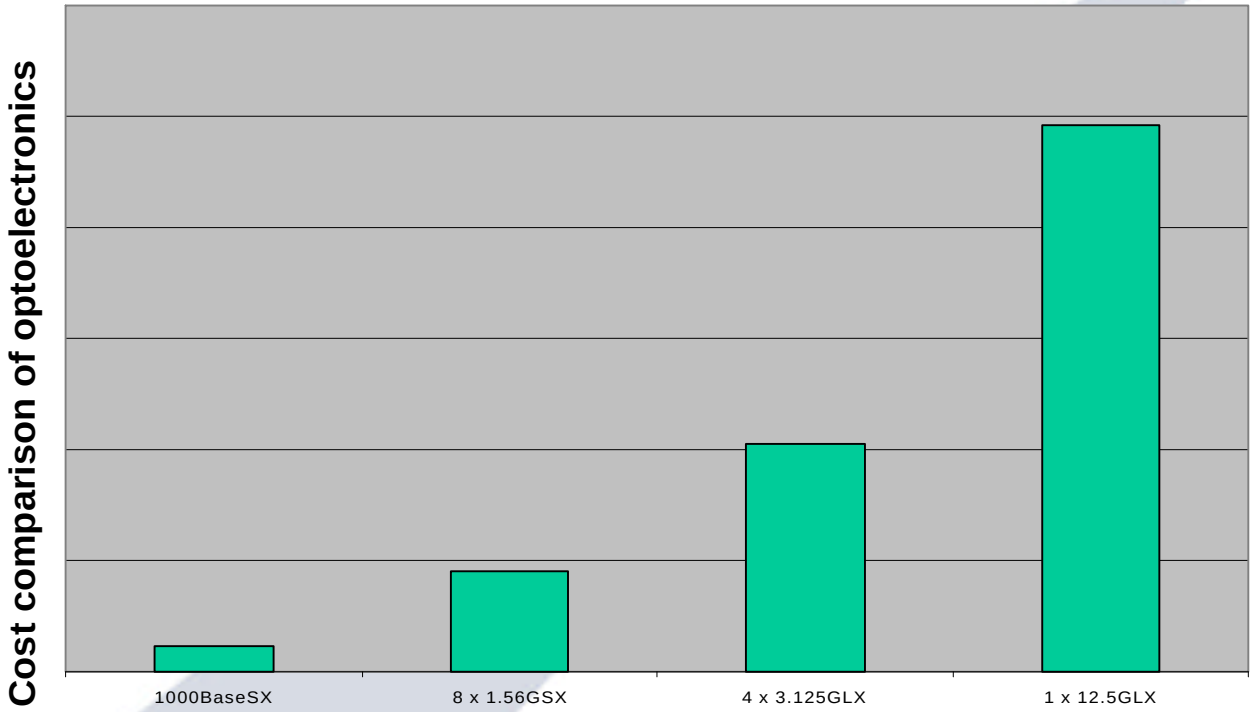
Optoelectronics cost



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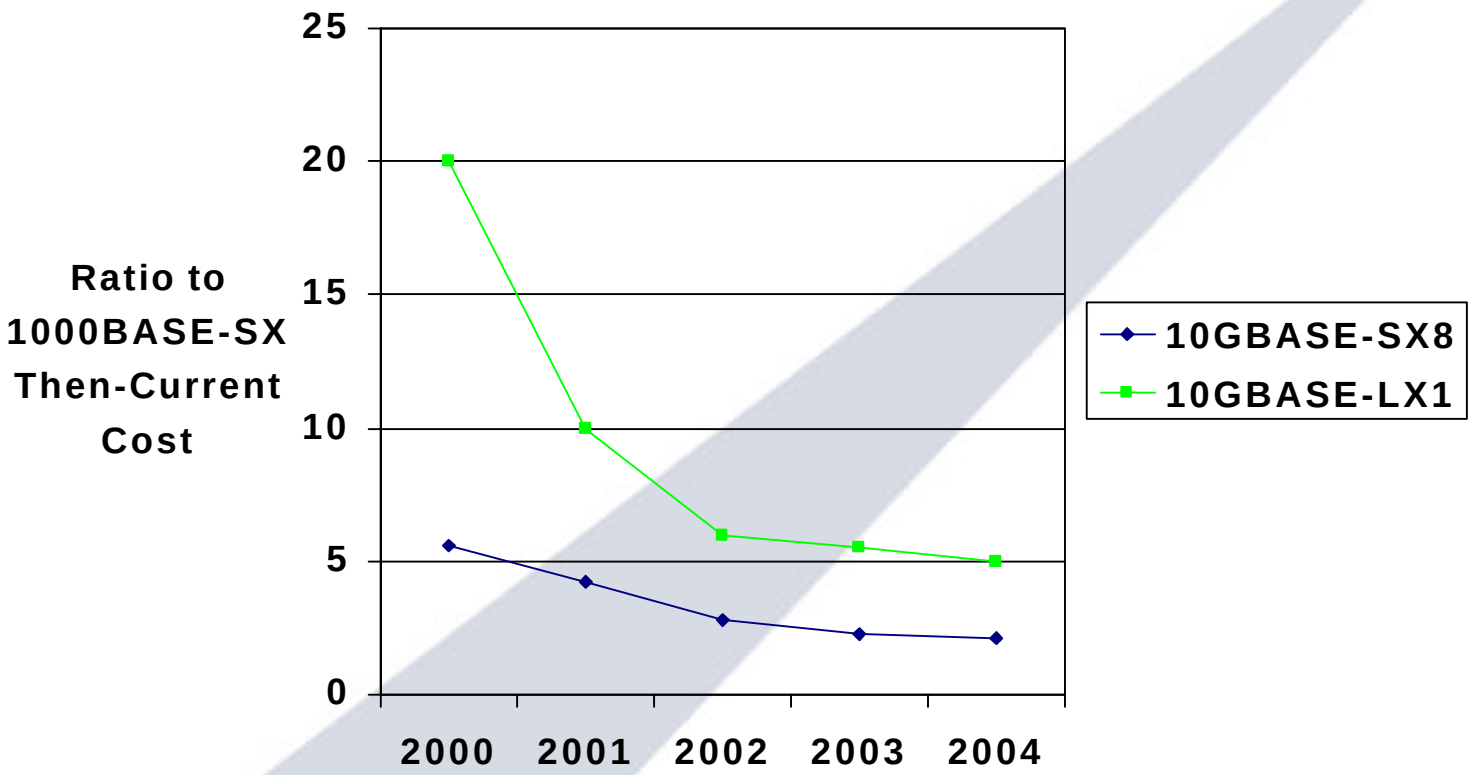
How fast will the cost of the optoelectronics drop ?



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Conclusions

Low cost multiplexing technology

Leverages Parallel Optics electronics technologies

10GBASE-SX CWDM offers the lowest cost solution

Low cost sources and detectors

200m on installed MMF

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