



Innovations in Fiber Optics

Traditional Optics for High-Speed Flexible Telecom System Applications

September 13, 2008

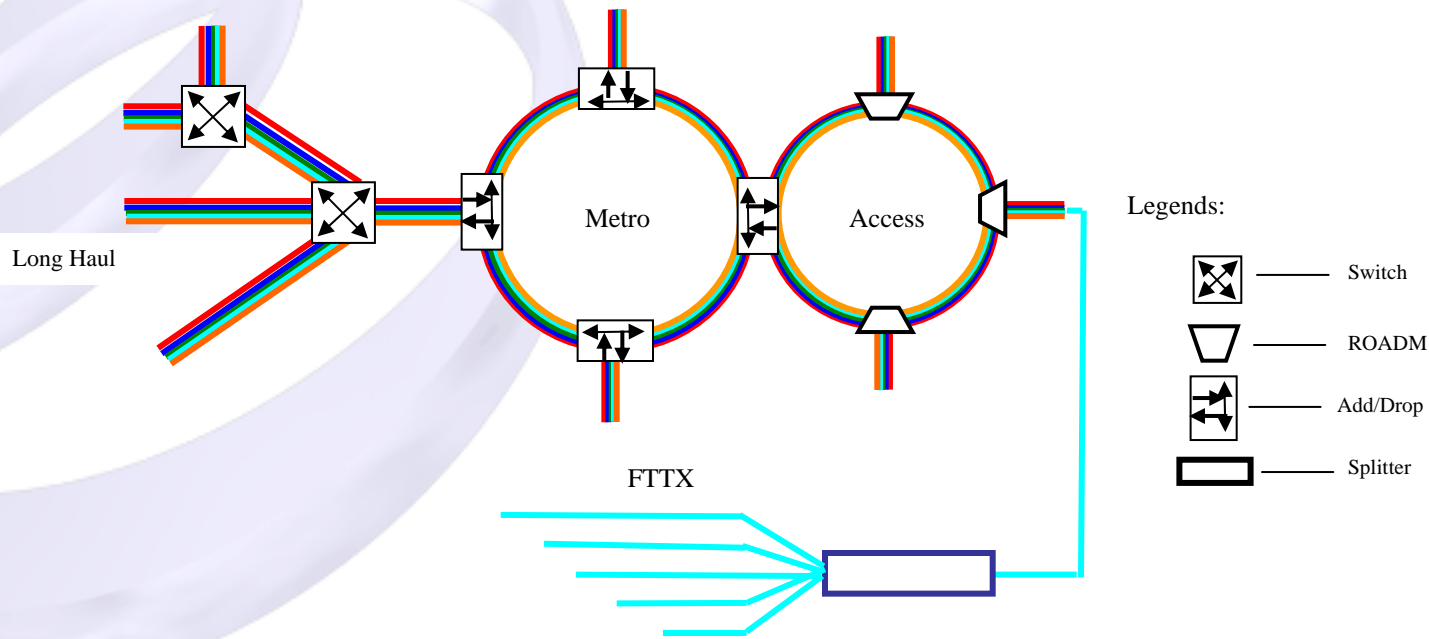
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OUTLINE

- **Background**
 - Optical Communications Networks
 - Bandwidth and Speed Requirements
 - Technology Solutions
- **What Optoplex Is Doing**
 - Optoplex Core Technologies
 - Optoplex's Products
 - Applications
- **Market Potentials**
- **Summary**

Optical Networks

Schematic of a typical optical communication network



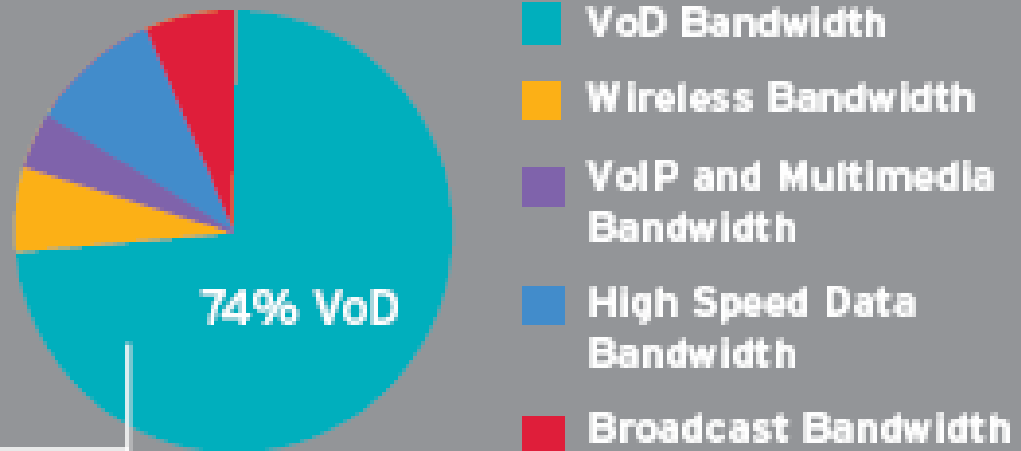
Deployment Considerations:

Speed, Bandwidth, Cost, → Technologies

Bandwidth Demands

Video on Demand (VoD): dominant driving force for bandwidth demands

Video bandwidth contribution



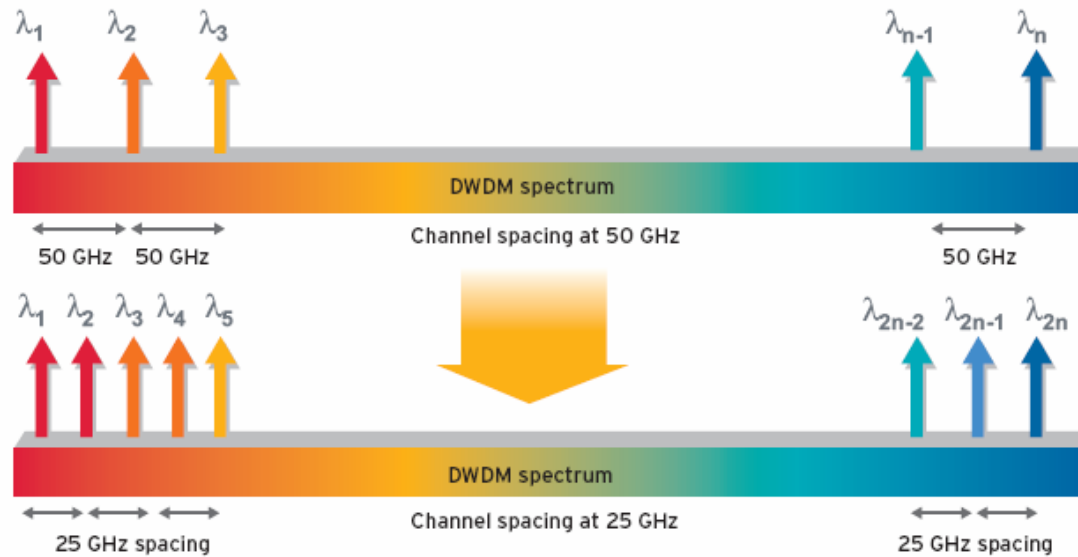
VoD will dictate network cost equation

Tier 1 office
720 Gbps 2009

Source: Nortel Analysis - North American Residential Bandwidth Profile

Solutions

1) Increase Channel Density



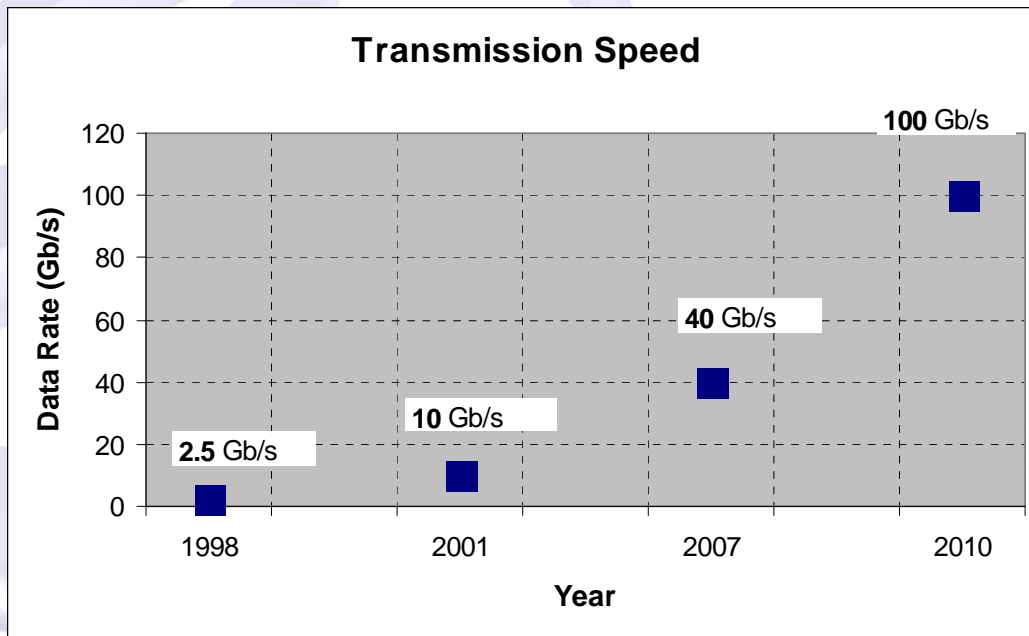
Technologies:

- DWDM (Thin Films, AWG)
- Interleaver (Micro-Optics, Fiber Grating)
- Long-Haul: 100GHz, 50GHz, 25GHz
- Metro: 200GHz, 100GHz
- Access: Tri or Bi-WDM
- FTTX: EPON, BPON, GPON...

Solutions

2) Increase Baud-Rate in the Transmission Line

Long-Haul/Metro Deployment



- Multiple-Rate Co-existence
- Upgradeable

COST !!!

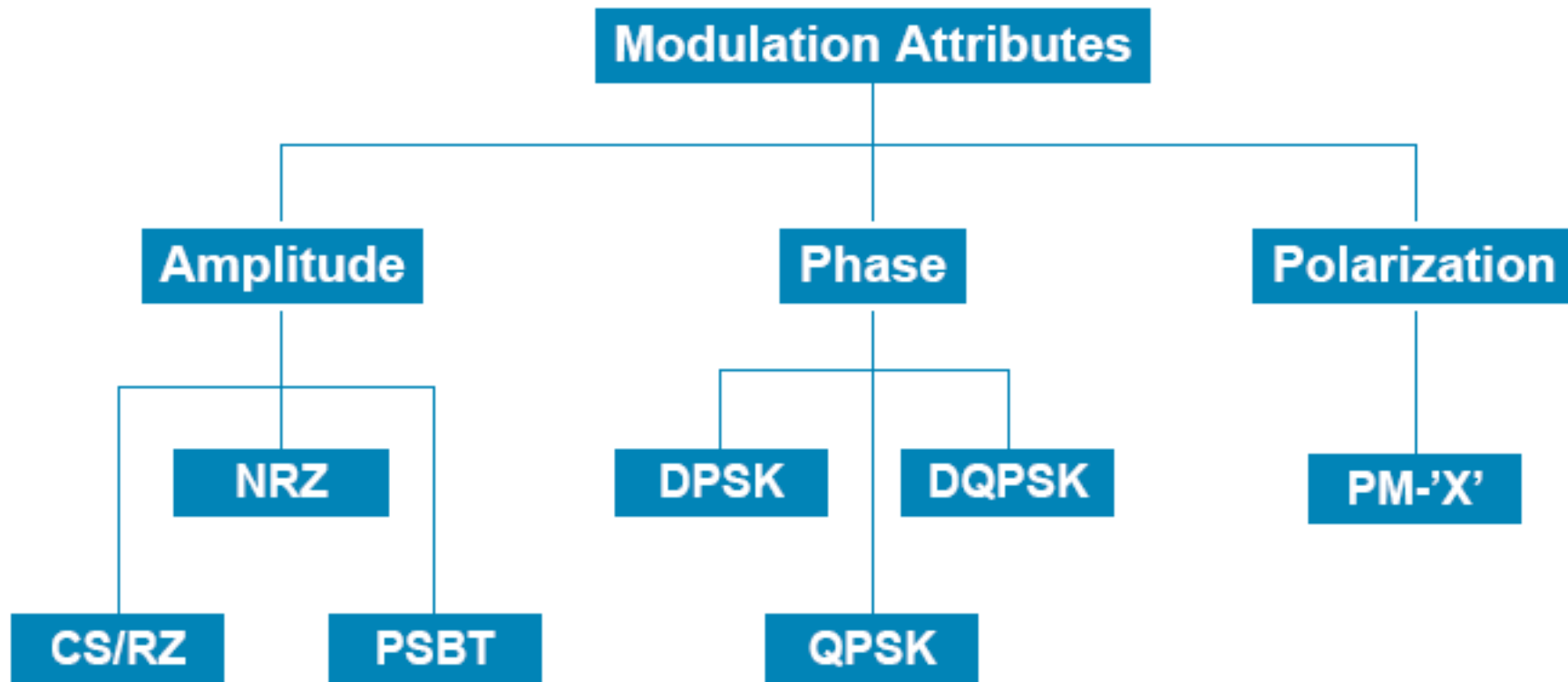
Speed	Acceptable Cost	Actual Cost
10G	X	
40G	2.5X	~ 4X
100G	5 - 6X	~ 5 - 6 X

Access: BPON/EPON → GPON: Mb/s → Gb/s

Now: 1.25G, 2.5G transceivers → 10Gb/s transceivers

Solutions

3) Advanced Modulation Schemes



Where 'X' Can Be DPSK, DQPSK, QPSK, etc. ...

Comparison of Modulation Schemes

	OOK	PSBT	DPSK	DQPSK	QPSK	PM-(D)QPSK
OSNR Sensitivity	16dB/ 0.1nm	16dB/ 0.1nm	13dB/ 0.1nm	15dB/ 0.1nm	13dB/ 0.1nm	11dB/ 0.1nm
PMD Tolerance	1ps	2.5ps	2.51ps	5ps	5ps	10ps
CD Tolerance	+/- 50ps/nm	+/- 150ps/nm	+/- 100ps/nm	+/- 200ps/nm	+/- 200ps/nm	+/- 800ps/nm
Electronics Complexity	Medium	Medium	Medium	Low	Low	High
Photonics Complexity	Low	Low	Low	Medium	High	High

Notes:

1) CD: SMF28 Fiber: 16.7ps/nm km

2) 40Gb/s, Binary standard modulation, PMD spec of $0.2\text{ps}/(\text{km})^{1/2}$ \rightarrow 100km transmission !!!

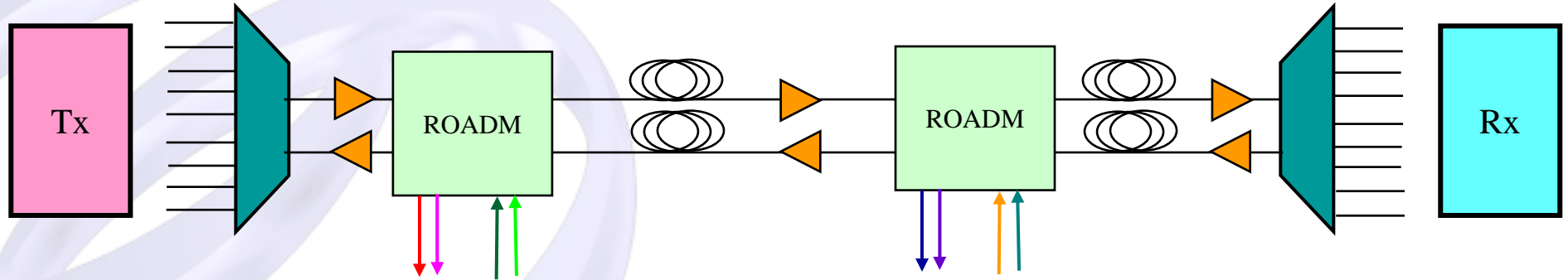
High Speed Components

10Gb/s → 40Gb/s → 100Gb/s

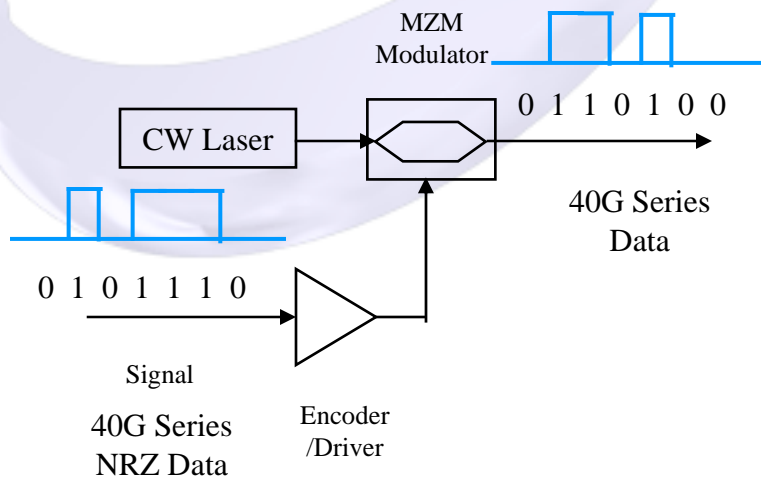
- Lasers
- Advanced Modulation Schemes
- Dispersion Compensation (CD and PMD)
- Optical Detection
- Monitoring

40Gb/s with DPSK

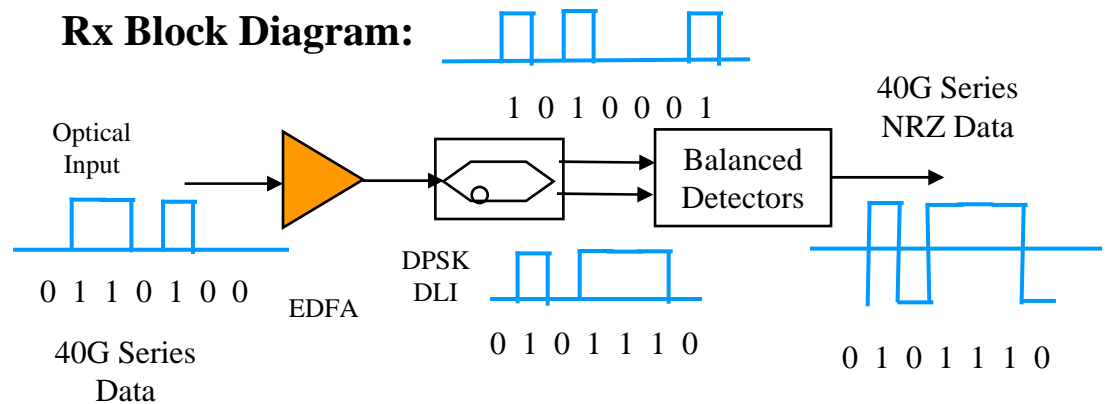
Block Diagram of DWDM based 40Gb/s with DPSK



Tx Block Diagram:

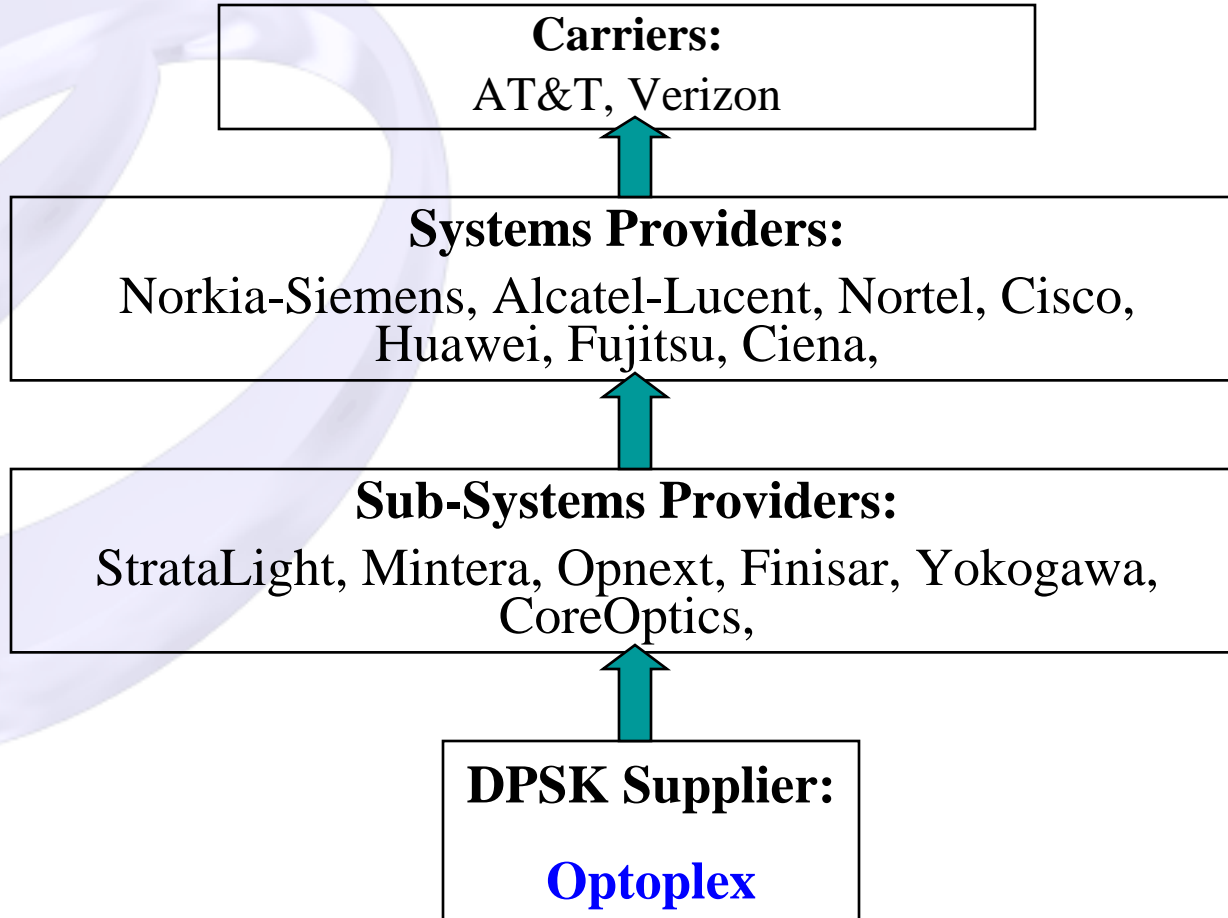


Rx Block Diagram:



40G/100G Leaders

Deployment: USA started. Europe and Japan in planning stages



Optoplex Technology Foundation

All Based On Traditional Optics !!!

**Ultra-Precision
Assembly &
Packaging**

+

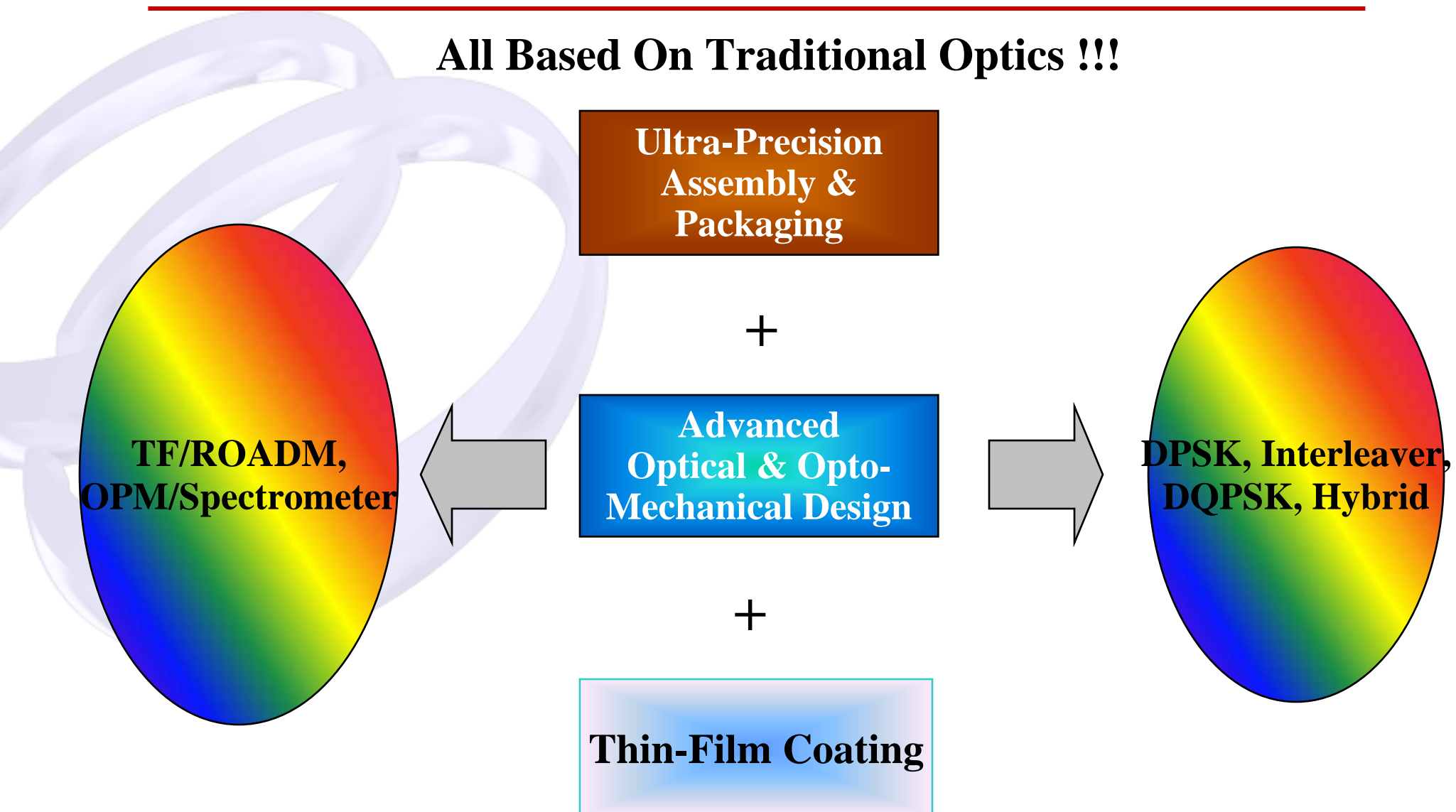
**Advanced
Optical & Opto-
Mechanical Design**

+

Thin-Film Coating

**TF/ROADM,
OPM/Spectrometer**

**DPSK, Interleaver,
DQPSK, Hybrid**



Applications

Advanced Modulation Schemes for High Speed:

- 40Gb/s: DPSK, DQPSK
- 100Gb/s: Optical Hybrids, and QPSK Mixer

DWDM

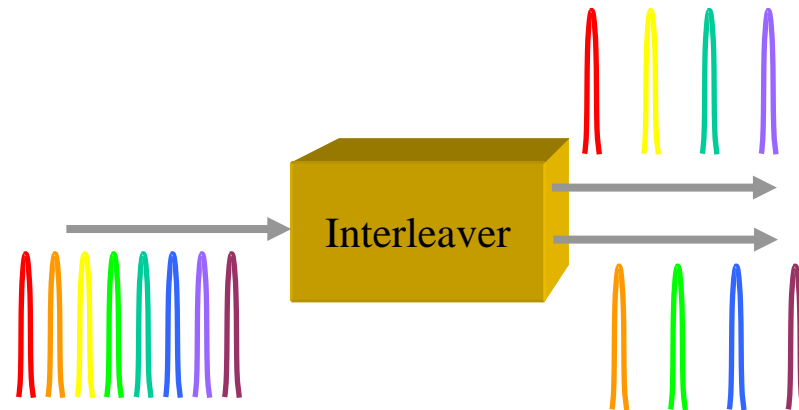
(100GHz → 50GHz → 25GHz → 12.5GHz)

- Interleavers

40Gb/s ROADM

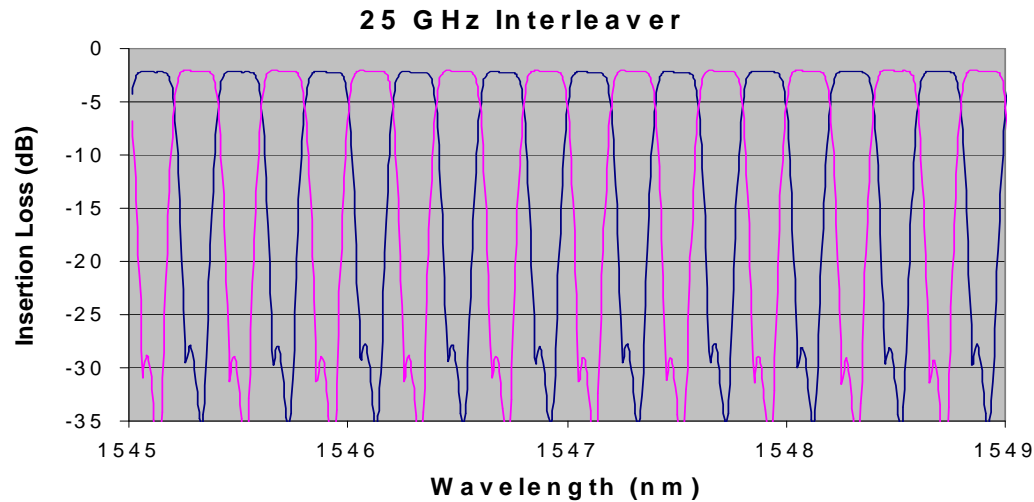
- Optical Channel Monitor (10 and 40 Gb/s Compliance)
- Tunable Add/Drop

Interleavers

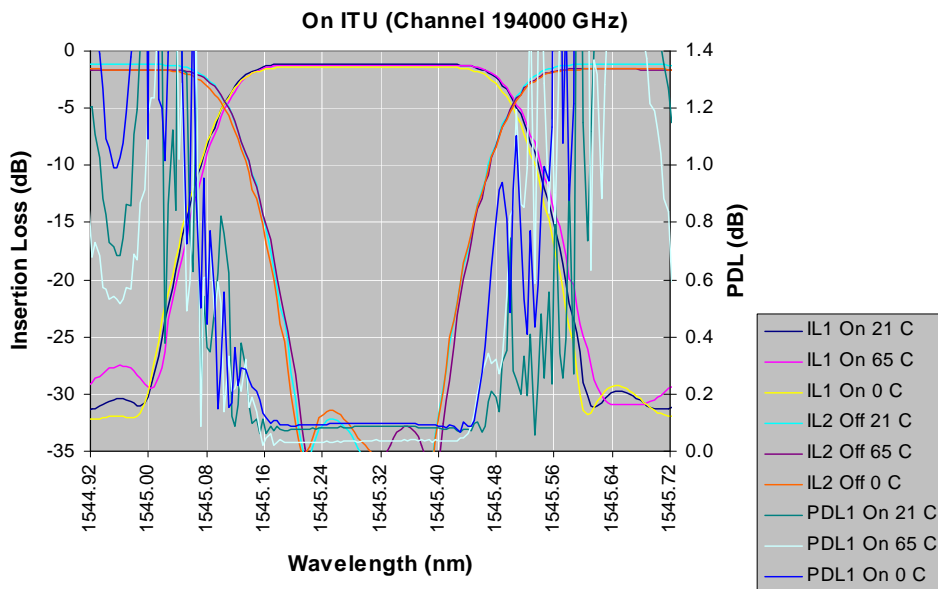


- Improving system performance (bandwidth, isolation, dispersion, uniformity)
 - Sub-band demux for flexible OADM (for banded tunable add/drop)
 - To add/drop large number of channels
 - To Achieve ultra-dense WDM
 - For future upgrade
-
- High-end Interleaver manufacturer
 - The ONLY one capable of volume production for 25GHz/12.5GHz

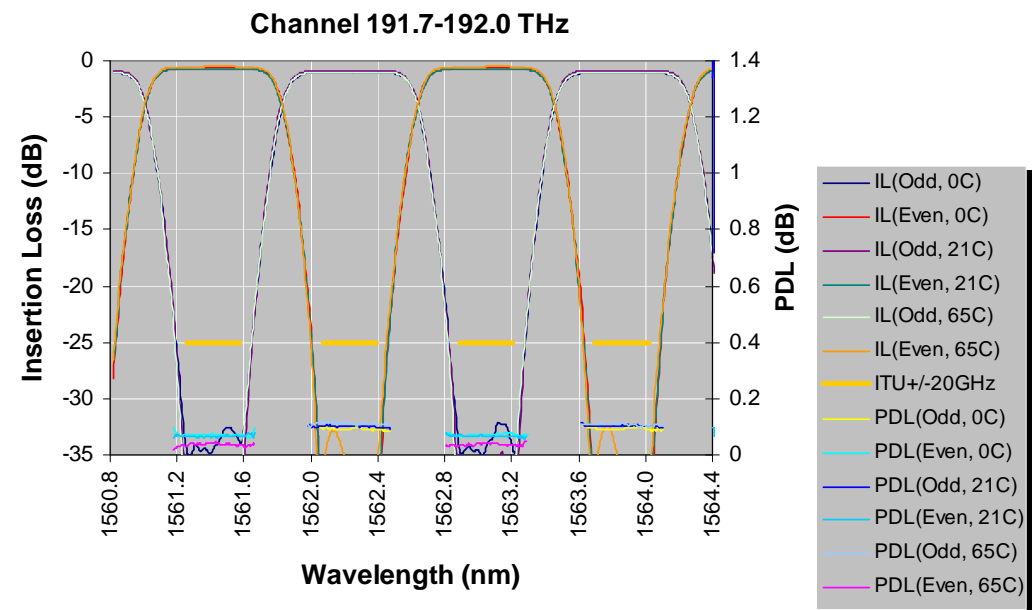
Interleaver: Performance



25 - 50 GHz



50 - 100 GHz



100 - 200 GHz

Switchable Hitless Interleaver



Mode 1: Interleaver mode

Port-A: All channels
Port-B: Even channels
Port-C: Odd channels

Mode 2: All-pass mode

Port-A: All channels
Port-B: All channels
Port-C: No light



During mode switch,
Even-channels are not affected — Hitless!

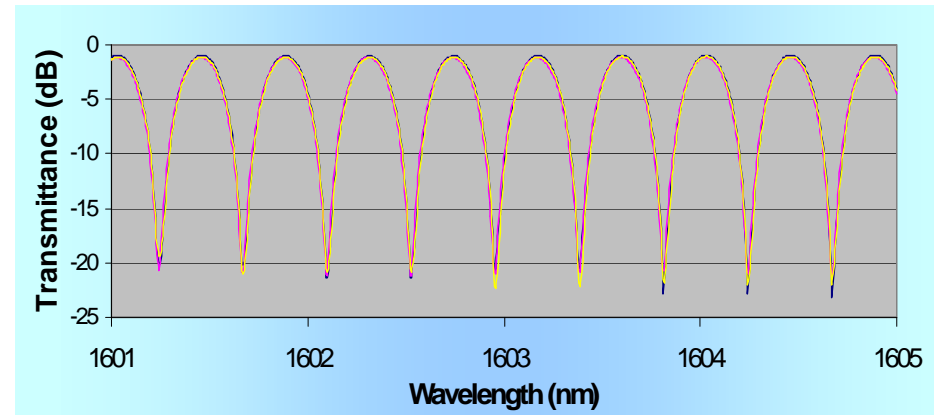
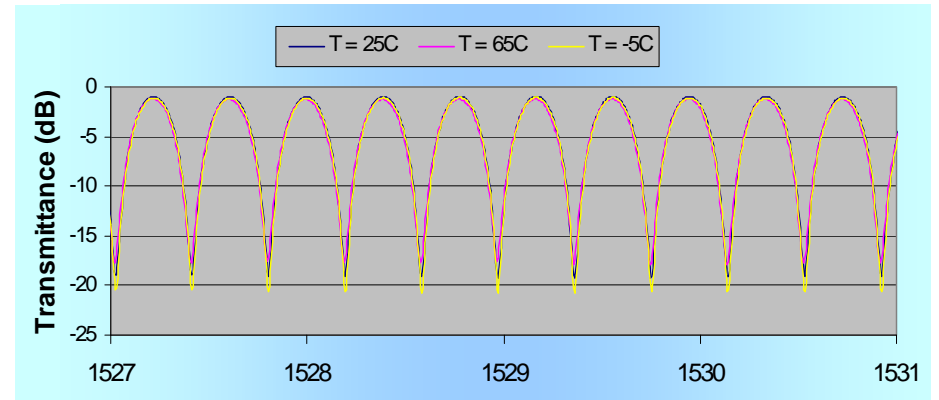
- Add/drop one-half (alternating) channels
- Low-cost system upgrade from 100GHz to 50GHz channel spacing

First one in the market !

DPSK Demodulators



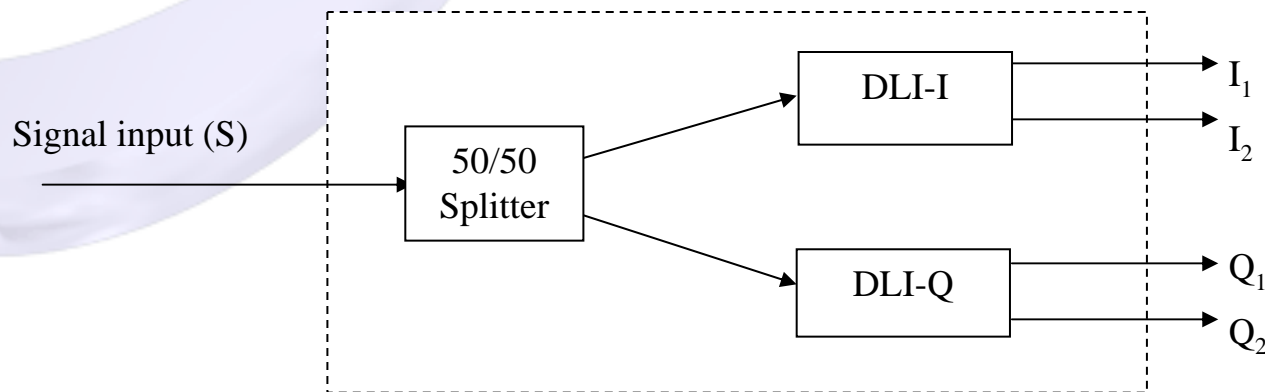
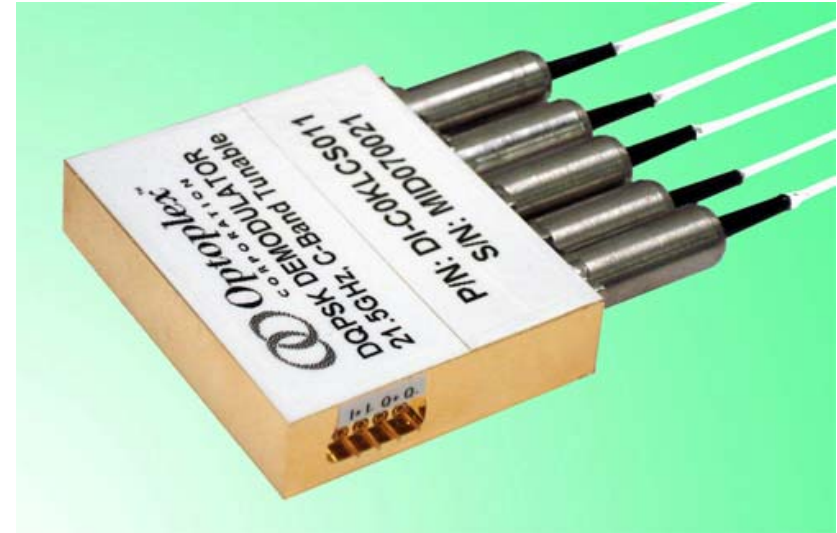
- Smallest form factor
- Custom FSR (12.5, 25, 40, 50, 66GHz)
- High FSR accuracy (<7 MHz for 50GHz)
- 1 ps delay accuracy
- Fixed or Tunable SFR



No#1 supplier, > 85% market share !!!

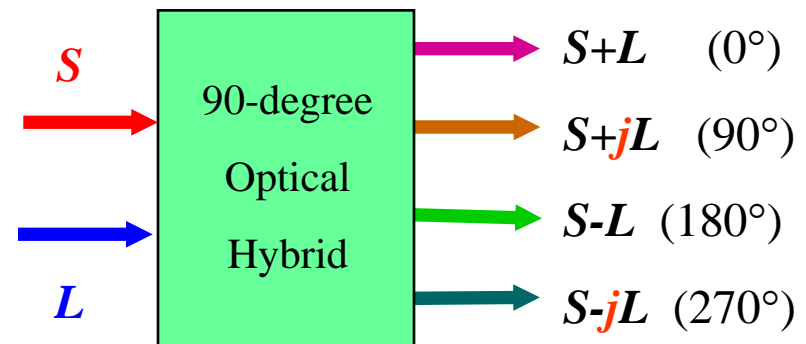
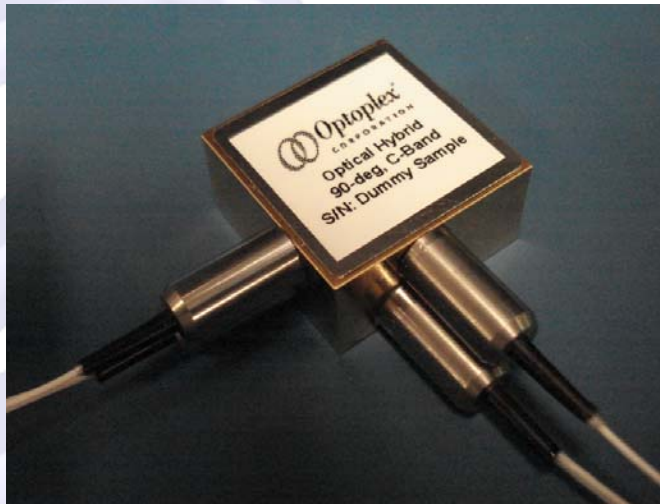
DQPSK Demodulators

- Fully integrated device (including free-space power splitter and two DPSK) is taking order now
- Smallest form factor (50x35x12 mm)
- Low power consumption (<1 W)
- Highly accurate FSR (customizable)
- Low PDF
- Easy to Integrate with photo-detector



In volume production !

90° Optical Hybrid for QPSK Detection

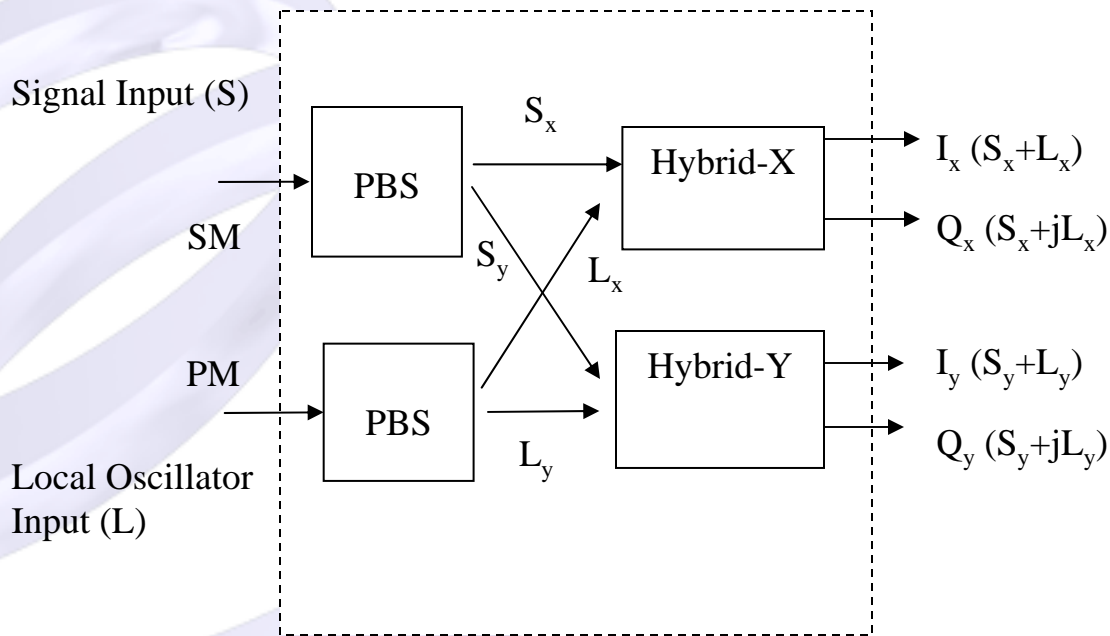


- Key component for QPSK coherent detection
- Passive and colorless
- Small volume production now

For 100Gb/s

In small volume production !

Polarization Diversified 90° Mixer



- Includes PBS and polarization diversity with $S+L$ and $S+jL$ outputs for both polarizations
- Passive and colorless
- Small form factor (48x50x10.5 mm)

For 100Gb/s Applications

Prototypes developed & being evaluated by several Tier-1 customers

Production in Q3/2009 !

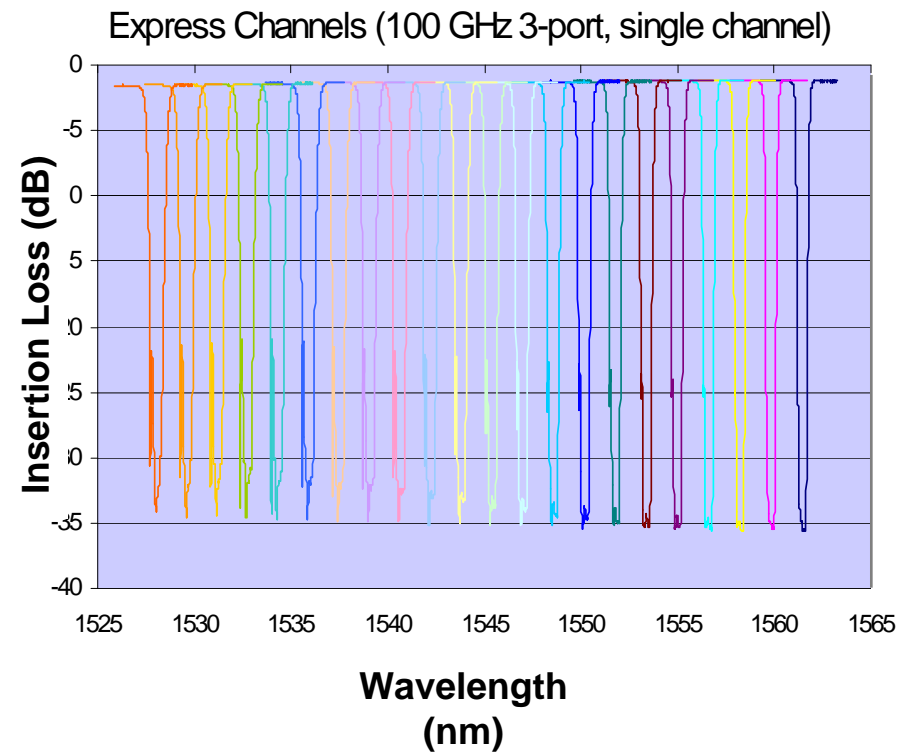
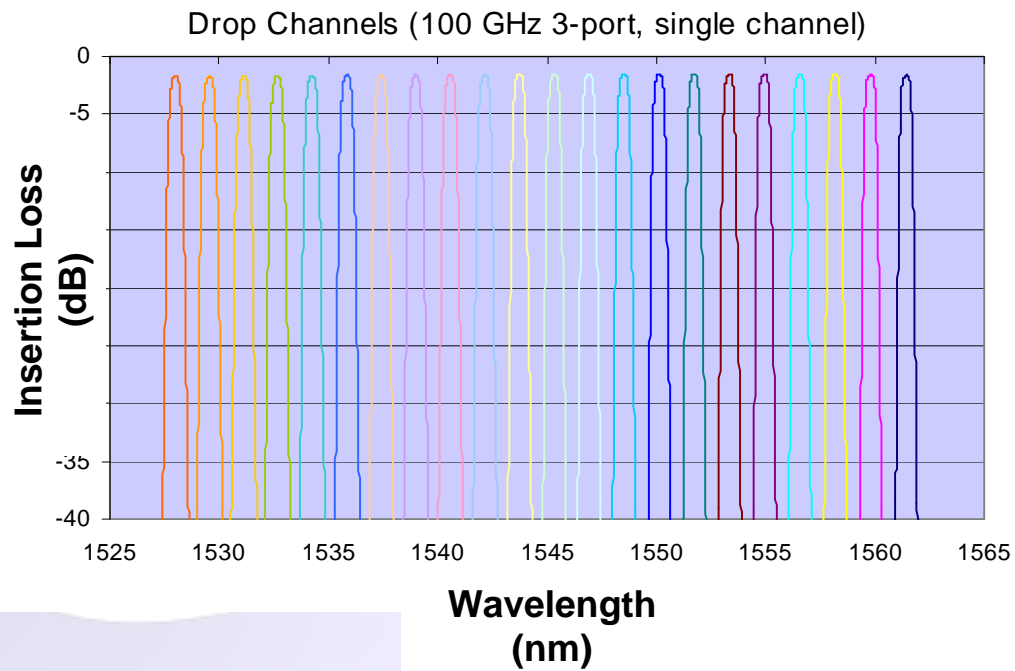
Tunable Filters/ROADM



US Patent No.
6,909,549

- Sole supplier of 3-port TOADM (shipping devices now)
- Current platform can be extended to 4-port TOADM
- Best performing and most cost effective 2-port devices in the market
- Latching, low power consumption, plug-and-play (customers do not need to develop the control system), low cost
- Pre-calibrated to ITU channels
- Athermal, wide and flat passband for 2.5 and 10 Gb/s systems, wide tuning range, low polarization dependence

ROADM Performance



Optical Channel Monitor (OCM)



Features:

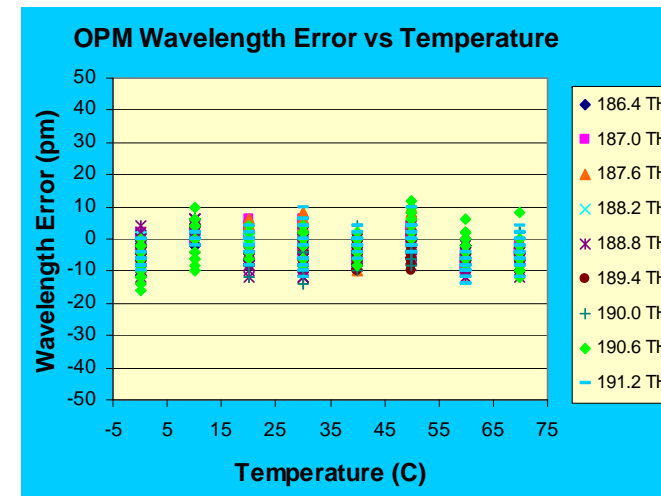
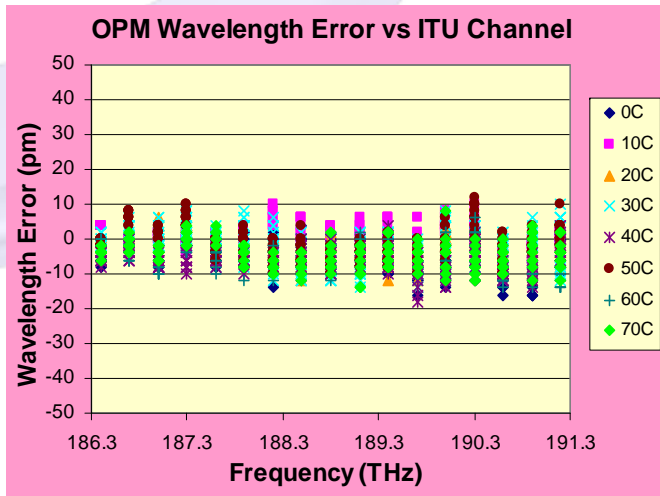
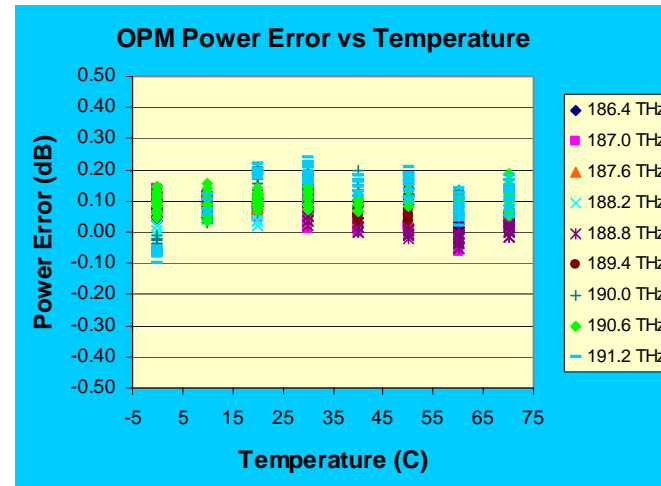
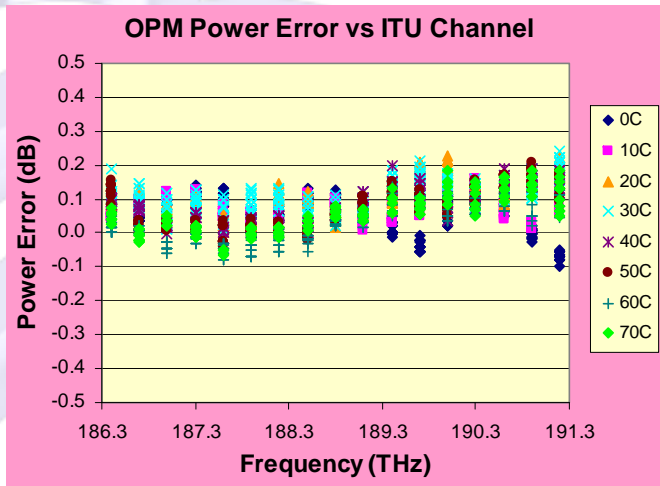
- High accuracy (better than 30 pm) based on >4000 data sampling
- Full function — Measure power, channel wavelength and OSNR accurately
- **Capability to measure 10G, 40G, or mixture of 10G/40G signals**
- **Capability to measure DPSK modulated signals**

Applications:

- Performance monitoring of DWDM system
- Add/drop monitoring and diagnostics
- Power and/or OSNR monitoring for remote gain equalization
- Optical Spectrum Analyzer
- System alarms or error warnings

- One of the Major suppliers
- Design-in with several Tier-1's
- Growing market share

OCM Performance



Portable OSA/Spectrometer Engine



Applications:

- DFB-LD TOSA Characterization
- Telecom field applications
- Optical instrumentation
- Labs and R&D

Features:

- Single detector -> low cost
- High performance - Multi-cavity high isolation thin film filter
- Precise, low-cost wavelength reference
- Hand-held or portable, good for field applications

- New product
- Several major projects going on
- Non-telecom applications as well

Telecom Customers



Defense/Aero-space / Government Customers



Market Potentials

Wintergreen Research: (April 2006)

Worldwide Optical Components for Telecom:

\$2.9B @2006

\$7.6B @2012

CIR Reports (August 2008)

Transceiver/Transponder Modules (CIR, August 2008)

\$1.5B @2008

\$4.8B @2013

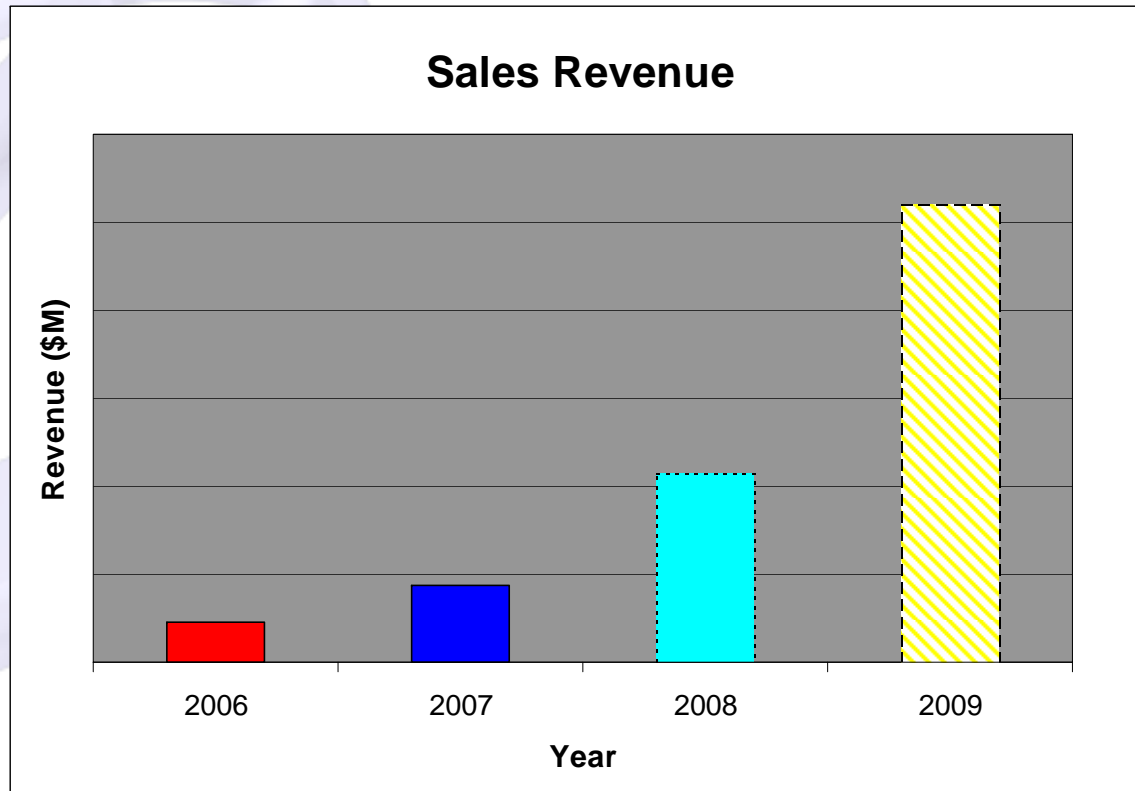
Components for 40G Transponders: \$500M @2012

WDM: \$1.8B @2008

PON: \$2.4B @2013

Optoplex's Growth

More than > 100% growth in past three years



Expect > 100% growth in 2009, too !

Summary

- Traditional optics for high speed telecom system applications (with proprietary technologies)
- No# 1 supplier of DPSK and DQPSK for 40Gb/s
- Front-runner of QPSK for 100Gb/s
- High-end interleaver supplier and the first for hitless interleaver in the market
- Revenue growth > 100% in 3 consecutive years and expect the 4th year too
- Ready to take-off with the 40/100Gbps market



THANK YOU !

(Q & A)