Optical Integration for 100G Interfaces

Market Focus
ECOC 2013

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Evolving 100G Component and Modules

Platform Technologies

10G – historical perspective

100G Line side

100G Client side
Introductory remarks

- Optical Transmission Transition
  - Once in a decade change

- Evolution of optical technology
  - 1-3 year evolution becoming clear
    - LH, Metro: Line card (discrete component) solutions → CFP, CFP2
    - Client: CFP → CFP2, CFP4, QSFP28
    - iTLA/LN modulator → monolithic InP devices
    - Higher Baud rates
    - Multi-component integration
Platforms for Photonic Integration

Indium Phosphide (InP)
- Lasers
- Modulators
- Receivers

Silica on Silicon Passive Lightguide Circuits (PLC)
- AWGs
- Coherent Mixers
- Pol Mux

Lithium Niobate (LiNbO₃)
- Modulators

Gallium Arsenide (GaAs)
- VCSELS
Tunable XFP functional integration drives:
- 85% smaller size
- 75% less power consumption
- Cost reduction

JDSU T-XFP technology replaces:
- Fixed XFP’s in 2009
- Metro/Regional transponders in CQ3 2010
- Long Haul transponders in CQ1 2011

Shipped >>100,000 Tunable XFP’s
10G Tunable – Further transition

- Tunable market consolidating on T-XFP in near term
- The smallest, lowest power dissipation (T-SFP+) will be most widely adopted over longer term

T-XFP
Zero chirp, PiN

T-XFP
Negative chirp, APD

T-XFP
High Power Negative chirp, APD

T-SFP+ 2W
NC, APD, Linear

T-SFP+ 1.5W
NC, APD, Linear

T-SFP+ 2W
NC, APD, Limiting

T-SFP+ 1.5W
NC, APD, Limiting

T-SFP+ 2W E-temp
NC, APD, Limiting

Smaller Size & Lower Power Dissipation
Monolithic Integration for 100G Line Side Transmitters
Monolithic Tunable Laser 100G Coherent Transmission

- **SGDBR Laser Design**
  - **Benefits:** cost, monolithic integration
  - **BUT:** linewidth broadening due to current injection

- **Requirements for Coherent Systems**
  - **Narrow Spectral Linewidth**
    - QPSK – < 500KHz
    - 16QAM – < 300KHz
  - **High output power**
    - > +16dBm
  - **Low power dissipation**
Thermally tuned SGDBR Laser

- Thin-film micro-heaters for mirror and phase sections
- Thermal tuning eliminates tuning-induced loss which degrades linewidth and power conversion efficiency
- Thermal isolation between thermally tuned sections and substrate for reduced power dissipation
Thermally Tuned Laser Efficiency

Significantly improved slope efficiency compared to previous generation current-injection device.
Thermally Tuned Laser: Linewidth and SMSR

- <300kHz worst case linewidth and >40dB SMSR
100G Integration for Size and Power reduction

Smaller size, lower power dissipation

OIF Transponder
5" x 7"
100W

CFP
ASIC inside

CFP2
ASIC outside

InP
Laser/Modulator

Compact PLC Rx
Packaging options for InP I/Q modulators

C-band laser + SOA/VOA

- Locker & power monitor + Coupling optics
- Micro optics pol MUX and power monitors + VOA

DP-IQ modulator

- Locker & power monitor + Coupling optics
- Micro optics pol MUX and power monitors

Performance, cost, power and size advantages to monolithic integration
InP MZ for 28Gb/s OOK, 100Gb/s DP-QPSK, 200Gb/s QAM

2D Normalized output power, dB 1.4 mm MZ

- Traveling wave electrode design; shallow ridge technology
- Vpp = 1.8V/side for QPSK

30Gb/s Electrical Input

MZM = 1.4mm long; Vpp = 0.9V/arm
Lithium Niobate Technology Evolution

- Lithium Niobate Nested MZ Modulators are used in the most 40G and 100G coherent systems today
  - Pure Phase Modulation
  - Highest Bandwidth Available
  - Low voltage operation (< 3V)

- Future
  - Will continue to enable very high performance links
  - Higher baud rates for 200G applications
    - Lower Density constellations for improved OSNR (longer reach than QAM)
      - 43 Gbaud 8PSK
      - 64 Gbaud QPSK
Hybrid Integration for 100G
Client Side Interfaces
Hybrid Integration for client optics

100G LR4 TOSA
- 4 EML devices on carriers
- AWG MUX with integrated taps
- Integrated PD monitor array

100G LR4 ROSA
- 4x25G PIN array bonded on carrier with quad TIA
- PLC de-multiplexer
  - High Δn AWG design

Compact solution compatible with CFP2/CFP4/QSFP28
100G TOSA EML based TOSA performance

- Meets LR4 and ER4 requirements
- Driver power dissipation ~200 mW/channel

ER>5dB, MM>40%, Vpp=1.2V

ER>9dB, MM>40%, Vpp=1.5V

100G TOSA @ 28Gb/s PRBS $2^{31}$-1
100G LR4 CFP2 Transceiver Module

- Support line rates of 103.125 Gbps or 111.81 Gbps
- Operating temperature range of up to -5°C to 70°C
- Low power dissipation
- MM > 15% at 27.9525 Gbps/Channel
Optical Integration has enabled cost, size, power savings for tunable 10G interfaces

We are beginning to see a migration to integrated solutions in 100G applications which are necessary to enable CFP, CFP2, CFP4, QSFP28

Optimized solutions require a mix of monolithic and hybrid integration