

Photonic Integrated Circuit (PIC) Alternatives for 100GE

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100GE Cost, Schedule & Technical Feasibility

- **Cost:**

- Package bodies, TEC's, isolators, receptacles, are expensive parts of TOSA or ROSA
- Un-cooled optical multiplexing (mux and de-mux) will be the lowest cost solution for many applications
- O or E dispersion compensation will be costly and should be avoided
- The cost of ICs (TIAs, CDRs & Drivers) and the EC are estimated separately

- **Schedule:**

- Product needed in near future considering the usual development times
- ICs for ~20 Gbps will be available and cost effective (most likely)
- Hybrid PICs (mm-optic & Si multiplexers) available before monolithic InP PICs
- Baud \gg ~20 Gbps will require traveling wave components and not be practical & meet schedule

- **Spans to be considered \leq 40km, SM or MM fiber**

- Single mode sources with optical isolation can work with MM fiber
- PIC solutions can be cost effective in the <1km market



100GE

- **Performance Goals:**

- *Extrapolating from existing standards for span loss, there appears to be 3 applications: $\leq 40\text{km}$, $\leq 10\text{km}$, and $\leq 1\text{km}$ with span loss at $1.3\mu\text{m}$ of 22dB (11dB @ $1.5\mu\text{m}$); 9.4dB ; and most likely $\leq 5.8\text{dB}$.*
- *Ambient temperature is most likely going to be -5C to 85C .*
- *The transmission could be CWDM or DWDM (TDM too costly)*
- *{There is one special market - supercomputers - where the ambient temperature range is $\sim 30\text{C}$ and the span link is $< 100\text{m}$ point to point with span loss ~ 1 to 2 dB.}*

- **Optical Solutions:**

- *All above spans can be addressed economically with a $1.3\mu\text{m}$ PIC source (low chromatic dispersion penalty) & 40km could be a PIC $10 \times 1.5\mu\text{m}$ solution.*
- *Generalizing the optical mux, de-mux insertion loss (IL), one finds for each micro-optical an IL of 3dB or less, for Si waveguides $\sim 6.5\text{dB}$ (TOSA) and $\sim 5\text{dB}$ ROSA and for each monolithic AWG in InP $\sim 6\text{dB}$. Coupling loss to u-optical TOSA of 2dB must also be added.*

100GE

- ***Optical solutions then implies the following loss:***

Span Length	Source	Span Loss+IL in dB		
		u-optical	Silicon	InP AWG
40 km	1.5um	17	22.5	23
40 km	1.3um	28	33.5	34
10km	1.3um	15.4	20.9	21.4
1km	1.3um	11.8	17.3	17.8
0.1km	1.3um	8	13.5	14

- ***While ROSA have the following sensitivities (SOA at the input can improve these values):***

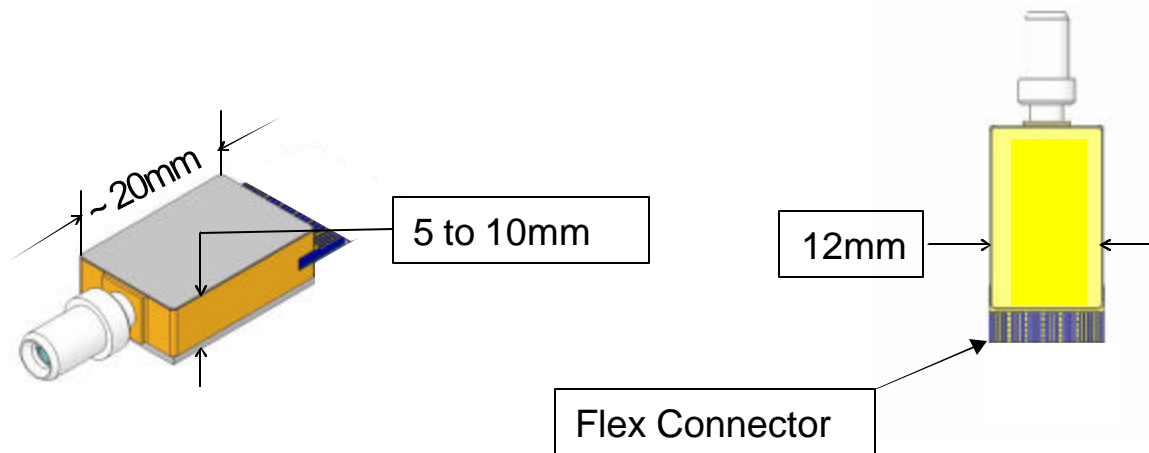
Detector	PIN/DFB	PIN/EML	APD/DFB	APD/EML
10 Gbps	-17	-19	-25	-27
20 Gbps	-14	-16	not available now*	

* APDs at 20 Gbps require traveling wave designs

Suggested Package Configuration

- *Assumptions*

- *TOSA and ROSA should be in small, practical, hermetic packages*
- *12mm width allows Xenpak footprint and can accommodate 5 channels*
- *For practical flex connection to package recommend contact & space $\geq 0.2\text{mm}$. This allows up to ~ 28 contacts on back edge to child board.*
- *~ 28 contacts allows external drivers & single-ended connection to TOSA*
- *~ 28 contacts allow TIAs to be inside ROSA package with differential leads.*



Cost of Optical Solutions - 100GE

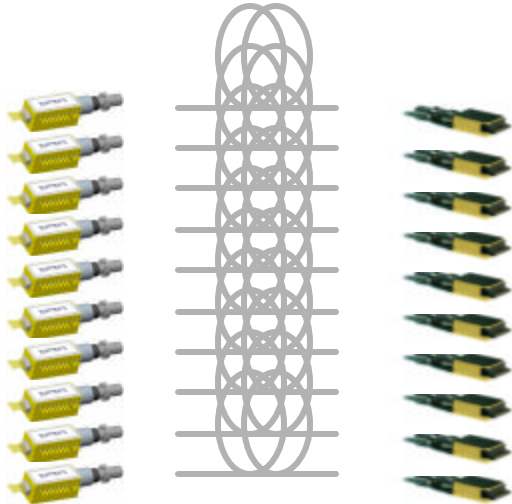
<i>Link</i>	<i>TOSA</i>	<i>ROSA</i>	<i>When</i>	<i>Est. Vol. Costs</i> (ICs & EC excluded)
$\leq 1\text{km}$	1.3um 10Ch 10Gb 1dBm	PIN w PLC	To	Unit <\$0.86X
5.8dB	1.3um 5Ch 20Gb 4dBm	PIN w AWG or PLC	To+1yr	Unit <\$X/2
10km	1.3um 10Ch 11Gb 6dBm	PIN w PLC	To	Unit <\$0.93X
9.4dB	1.3um 5Ch 22Gb 8dBm	PIN w AWG or PLC	To+1yr	Unit <\$0.57X
40km	1.5um 10 Ch 11Gb 4dBm	PIN w PLC	To	Unit <\$X
22dB	1.3um 5 Ch 22Gb 3dBm	PIN SOA AWG PLC	To+1yr	Unit <\$2X/3

- **Link loss will be similar to existing standards**
- **PLC will be used for multiplexing and may be lower cost than u-optic. An issue is the process yield on the PLC. Low favors PIC, high favors PLC**
- **DFB extinction is ~ 6dB while EML extinction ~ 9dB**
- **Cost of ICs at ~20Gbps will be comparable to ICs at ~10Gbps by To + 1yr. The ICs and the EC can add up to \$0.1X to above costs.**

Recommendation for Spans $\leq 1\text{km}$

- Cost for very short reach spans can compete with VCSEL solutions, especially when the fiber ribbon is included in the cost.
- Edge emitting reliability is well documented (CyOptics alone has reported >120 billion device hours with >4 million lasers in the Telecom field).
- We strongly recommend that it is technically feasible to include edge-emitting PICs for these short spans, not just for 10km (or 40km).

VCSEL+ Fiber Ribbon Solution



Photonic Integration

