

Background:

Fiber Optics has traditionally been best suited for telecom outside plant and inside plant network cabling. With the advent of ‘Big Data’, including the development of large data centers, each comprising thousands of servers, the need for faster circuitry has materialized. As circuit speeds exceed 40G fiber optics has begun to be employed to connect server racks, switches and routers in both public and private data centers. The market for these and other applications, including stand-alone, mid-range, enterprise servers and scientific computers exceeds \$50B not including infrastructure costs. The Big Data portion of this market is growing $\geq 20\%$ /year.

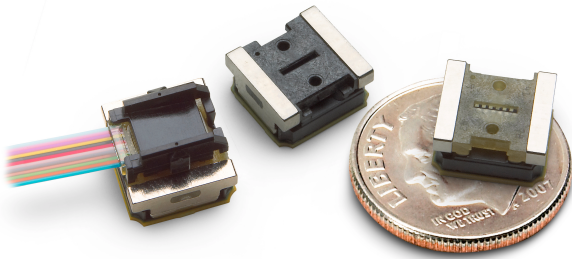


Figure 2: Avago MicroPod transceivers

Beyond 40G and certainly beyond 100G photonics circuitry and data communications will be required both internal and external to equipment, replacing many cu interconnects and cables at the board level. IO ports, as well as rack-to-rack, top-of-rack and in network pipelines that can exceed 1Tbps.

Many pieces of this puzzle have not yet been fully developed. The number of domestic fiber optic connector companies is small, (< than 5 major suppliers), and the technology has a steep learning curve. System packaging work-arounds include the use of discrete photonic components and cables, while the ultimate goal has to be one of integrating photonic silicon from the device outward in order to reduce cost and accept high speed signals beyond 40G. The focal point of this development will be mid-board logic modules containing electro-optical

conversion circuitry, and discrete fiber optic interconnect. In many cases, the challenge is one of extending existing technology, (singlemode connectors and cables are in use, but not yet in these applications), while other product technologies will require new developments. In most cases developments are a matter of matching market needs with development and tooling costs for future high volume manufacturing (HVM). In a few cases, more basic RDE is needed to overcome technology roadblocks.

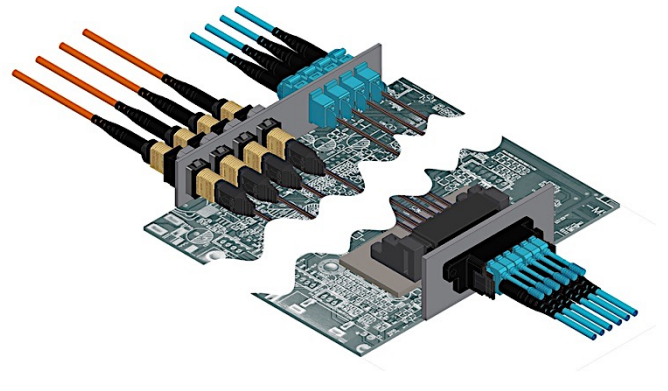


Figure 1: MXC Connectors, blind mated w/MT Ferrule

These include single mode interconnects closest to the chip. Where a transition from um dimensions of on-chip/in-package embedded silicon or glass waveguides - to out-of-package mm round optical fiber interconnects. This is a major challenge, but doable. Optical ferrule technology, the device that aligns and connects fibers with minimum loss, is at the forefront of these developments.

The small number of domestic fiber optic connector manufacturers is worrisome, but [Figure 3 USconec Pri](#) manageable with an existing global [Ferrule](#) supply chain. But, as of mid-2016, the majority of fiber optic connectors (60%) are assembled in China.

Project Proposal:

In late June, 2016, at the MIT Microphonics Spring Conference, the Interconnect TWG was asked to conceptualize intermediate (1-3 year) and longer

term (3-5 year) application needs for advanced cloud computing/data center applications. Seamless SM interconnect technology in support of 400G to beyond 1T is the goal.

The shorter term “Low Hanging Fruit” in the Interconnect TWG’s session was defined as singlemode multi-fiber ferrule technology having expanded-beam capability. This single-mode optical interconnect technology, (ferrule, connectors and cable assemblies), would be co-developed to provide de-mateable connections to mid-board transceiver modules, IO ports, disaggregated server, memory, storage, networking functions and other subsystems. Module interconnect to optical backplane/midplane or frontplane rack-to- rack interconnect were viewed as concomitant to optical transceiver development.

Longer term we identified embedded polymer waveguide technology vs existing fly-over cables as an overdue technology that has been at least partially developed, but not in use – or with characteristics needed for future high bandwidth applications.

State of the Technology:



Multimode ferrule technology has been developed and is in production at US Conec, Raleigh, NC, a joint venture between Corning, Fujikura and NTT. Their goal in this project is to develop a singlemode expanded beam MT

(Prizm) ferrule in 18 months. This will provide the singlemode connector alignment mechanism needed for the proposed mid-board module application. Parallel to the ferrule development will be the appropriate singlemode connector and fly-over passive cable assemblies. The MXC connector is one possible choice, and a range of electro-optical

backplane connectors are also available from several suppliers.

IPSR TWG Leader Discussion on Sept 6:

Dr. Terry Smith of 3M, Austin discussed the single mode expanded-beam module proposal exposed at the Spring Meeting. He believes that a connector for this application could be developed in an 18-month project. The advantages include reduced alignment tolerances. It will require a single-mode expanded-beam connector ferrule, e.g. US Conec, and a silicon photonics provider such as Luxtera. Bill Bottoms said that the same connector should be both at the package and the board. Bob Pfahl suggested that a group of customers like those involved with COBO could help describe the needs. Bill Bottoms supported pursuing this and having more than one supplier at each level. Bob Pfahl indicated that he had listed this proposal as a subject for our October meeting. Terry Smith said that he would need John MacWilliams’s help to push the proposal and seminar. Terry said the open issue is the package and assembly work. The open question is whether funding is needed. Terry said that it depends on who signs up. Bill Bottoms suggested that some OSATs are working in the packaging area. Molex possibly could do the assembly or the Rochester packaging facility. If Rochester is to get involved, Tom Brown would be the appropriate contact.

It was generally agreed that, given the proprietary culture in the fiber optics space, IPSR should be in position to reach beyond the roadmap process, and actually pursue projects through its TWG fora. This mid-board interconnect project is already being discussed and should involve a manageable few chip and transceiver manufacturers, Server and switch/router OEMs, and participants in the fiber optic connector space. Thus, this would include multiple industry stakeholders in the roadmapping activity. The challenge will be to get a critical mass of interested parties together in a ‘mini-consortium’ effort.

Terry discussed the need for prototype silicon photonic modules to do the interconnect project. Macom might be able to do this.

Mid-Board Interconnect Working Group:

Our goal is to form a new working group targeting mid-board, system interconnect and IO port photonic connectorization for these future high performance server/data center applications. The process includes:

- Enlist company support: connector manufacturers, Big Data OEMs, COBO end user support and input: (see list)
- Define objectives: SM MT ferrule w/ expanded beam technology, initial 4 rows of 4 SM, end point 4 rows of 16 SM fibers, with ‘top-of-hat’ interconnect from chip package; pre-terminated SM 6, 12, 18, 24, 32, 64” connectors/cables for mid-board module, backplane electro-optical, blind made connectors; IO port; 7mm max mated ht.; design for automated assembly; maximum ergonomic cable characteristics
- Define specifications. $\geq 0.5\text{dB}$ loss per connection; X bend radii for 16-64 fiber cables; Y Mated Ht.; standard pre-terminated cable lengths
- Work with Si Integration, Packaging and Assembly TWGs on interconnect needs.
- Have individual companies to do their own research and development within the parameters set forth in the TWG.
- Cause to be activated a SiPh test bed for mid-board modules utilizing the SM expanded beam MT Ferrule with 16-32 ports as needed.

This group will define the technical specifications, publicize specifications through IPSR, AIM Photonics and other venues in support of US manufacturing; encourage product development of the various connectors, cables, backplane connector

systems; test prototype circuitry through an OEM partner - and create dialog on low cost manufacturing techniques. Our OEM partners in the mid-board optical interconnect TWG will work with us on chip, package and IO port interconnect.



Figure 4 Intel Si Photonic Transceivers

Potential Project Participants :

- 3M: Terry Smith, Co-Chair
- Bishop Assoc.: John MacWilliams, Co-Chair
- iNEMI: Bob Pfahl, Facilitator
- Macom: Rich Grzybowski
- Promax Industries: Dick Otte
- USConec: Darrell Childers
- Corning: Alan Evans
- Molex: Tom Coughlin, Tom Marrapode
- TE Connectivity: Terry Bowen
- 3MTS: Bill Bottoms
- Samtec: Marc Verdiel
- Microsoft-COBO: Bradley Booth
- COBO: Yuki Nishiguchi
- Intel
- Cisco Systems; Kal Shastri
- HP
- IBM: Marc Taubanblatt
- Luxtera: Subal Sahni
- Celestica: Irene Sterian
- University of Rochester, Tom Brown
- PLC Connections: Mike O'Brian