100G and Above Interconnects: The Need for Speed

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The ever increasing demand for data transfer and storage is driving technology in several different areas. The server and datacenters markets require massive amounts of data processing on- and off-board. With the continued improvement in processor speed and computational power, data transfer and transport speeds are increasing. Currently, copper interconnects dominate inside the server, but there has been continued movement to more optical interconnect technology off-board, on-board and off-chip. What is the crossover point where optical interconnects are preferred and how can this be achieved? What technology changes are required to make optical more pervasive inside the box. To address these questions the OIDA is holding a one day forum on this topic.

The topic areas to be discussed are:

- The markets for high performance computing, servers, data centers, storage and interconnects.
- Chip to Chip, Board to Board, and Rack to Rack serial and parallel interconnects. The requirements for optical and electrical interconnects and the current bottlenecks. For intra-chip see the forum following this event.
- The technology constraints for the server and component companies to implement >100Gbit/s interconnects.
- How will interconnects need to develop to address the increasing speed requirements? Will there be both Optical and Electrical solutions?

The forum will address the following:

- The market and demand/cost for high speed interconnects in the server and data center.
- The implementation challenges for optical waveguide printed circuit boards. The issues of proprietary and standards solutions for signaling.
- The technology issues for active/passive optical and copper interconnects for next generation high performance computers, servers and data centers.

The outcome expected from the forum is a roadmap for industry, government and academia on the markets and future direction of >100Gbit optical and electrical interconnects. The forum is looking to identify commercial and technical barriers for these areas and understand the direction of the electrical and optical interconnect companies. The forum will outline the state of play today, the issues going forward, and the new requirements that need to be addressed.

The forum will include presentations by industry experts representing the full spectrum of technological, industrial and application developers and users. These will include but are not limited to Industrial companies, university research organizations, start-up companies and commercial organizations.
The forum will be a one day event, in which presentations by distinguished experts will be provided. In addition, a discussion panel and breakout sessions will provide focus for aspects of the roadmap requirements.
Optical Interconnections at the PCB level

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12 countries
30 research labs
333 researchers

6,4 M Euro
Network Funding
Providing Europe with the food chain of micro-optics

Mastering and Prototyping Technologies

Applications for the Quality of Life

Measurement and Instrumentation

Modelling and Design

Low-Cost Replication

Assembly, Integration and Packaging
Outline

• Rationale
• Options
• Waveguided Optical Interconnections
• Optical coupling
• Where do we go from here?
• Conclusions
Optics have proven their potentials for

- high density
- long distances

Introduction of optics into short distances:

- coupling technology is challenging
- optical technology should be compatible with existing technology
Open any consumer electronic system and what will you see?
A printed circuit board (PCB)...

Optical interconnections at this level ► integrated with PCB...
First generation:
Discrete optical fiber interconnects

Second generation:
Flexfoil interconnects

Third generation:
Embedded optical & Free-space

Interconnect density (Gbps/mm²)

1990 2000 2010

BPA «OPTICAL BACKPLANES: A global market and technology review 2000-2005 », Report #762
Options

• Optics on PCB-level
  ▪ fibers
    - glass fibers
    - polymer fibers
  ▪ waveguides

Fibers require:
- length for ‘re’-cleaving
- min. $R_{\text{curvature}}$
Fiber-based

- Fibers in flex
In-board optical interconnections

- substrate: FR4, Ceramic, Glass, Si,...
- waveguiding material: ORMOCER, polymers, SU8
  Sol-Gel, Fibers, glass, ....
- coupling structures: Ablated, gratings, LIGA-inserts,
  DLP-inserts, Laser-writing, Glass inserts....
Waveguide-based

\[ y = 0.1069x + 1.9053 \]
\[ R^2 = 0.7483 \]

@850 nm

Truemode, laser-ablated WG

Truemode, UV-Litho WG
Truemode with ablated cavities (UG) + DLP inserts (VUB)

UG: FR4-substrate + Truemode layers
   waveguides – UV-defined
   laser-ablated end-facets & cavities

► VUB: fabrication of DLP-inserts
       mounting
       characterisation
Truemode with ablated cavities (UG) + DLP inserts (VUB)

UG: FR4-substrate + Truemode layers
waveguides – UV-defined
laser-ablated end-facets & cavities

► VUB: fabrication of DLP-inserts
mounting
characterisation

Optical coupling - Inserts

Source MMF

DLP out-of-plane coupling component
Optical coupling
Optical coupling
NEMO parallel optical interconnect demonstrator

- To demonstrate 4-channel optical interconnect on FR-4 board with integrated waveguides and fully passive alignment assembly
- Based on VTT’s demonstrator with 4-channel 10Gb/s/ch transmitter and receiver modules integrated on LTCC substrates

Where do we go from here?
Where do we go from here?

NEMO parallel optical interconnect demonstrator

Passives

VCSEL / PIN array, (flip-chip)

Driver / Receiver IC

Microlens arrays

Top-cladding

Waveguide core

LTCC

PWB

BGA
Where do we go from here?

Multimode waveguides

► Singlemode waveguides
Where do we go from here?

Single layer

► Multiple layers

Level switch

Level switch + turn
Where do we go from here?

Rigid substrate

► Flex substrate
Conclusions

• Optics in PCB’s
  ▪ Fibres: proven - Waveguides: to be investigated

• Optical coupling
  ▪ Micro-optical parts required
  ▪ Inserts or in-layer fabrication
  ▪ Coupling to OE or connectors

• Optimise technologies for optical interconnections
  ▪ Compatible with FR4-processing

• Watch out: costs can be extremely high