EPRC – 9 Project Proposal

Development of hybrid 3D stack and Demonstration of Optical Interconnects

24 August 2007

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Contents

1. Introduction
2. Optical Interconnect examples
3. Objectives and scope
4. Details of major tasks
5. Broad overview, challenges and advantages
6. Deliverables
7. Project inputs
8. Benefits from the project

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Introduction

• Electrical interconnects are reaching their fundamental limits at high data rate

Limitations of electrical interconnects

- Frequency-dependent loss
- High Power consumption
- Signal latency
- Crosstalk
- EMI/EMC

Properties of optical interconnects

- Inherent high speed transmission lines
- Scaleable architecture.
- Immunity from EMI

Ref: ITRS Roadmap 2004

Challenges in using optics

1. High speed optical modules need RF/high speed electronics design
2. New Technology – Requires architectural changes in data systems
3. Opto-electronic devices are large and require precise alignment methods

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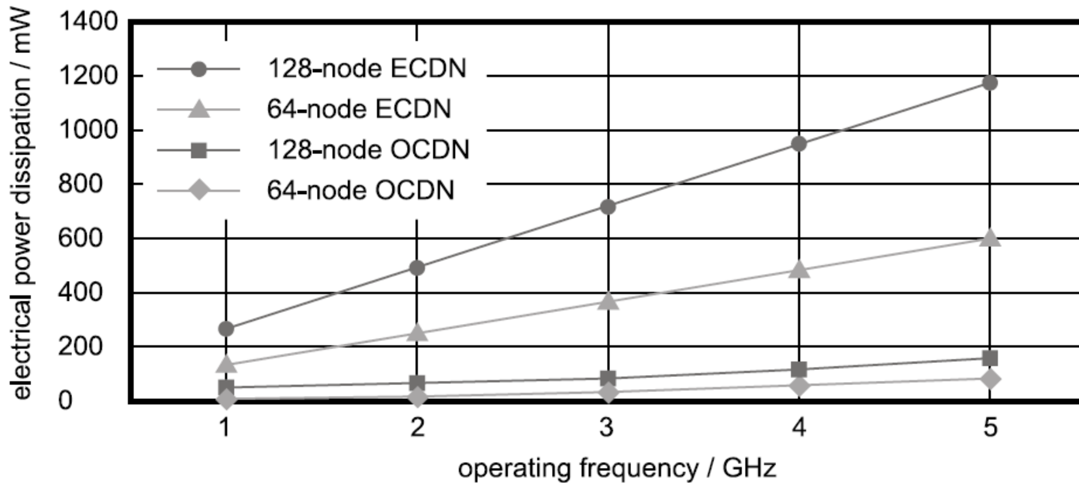
Comparison between Optical and electrical interconnects



Ref: Ian O'Connor and Frédéric Gaffiot

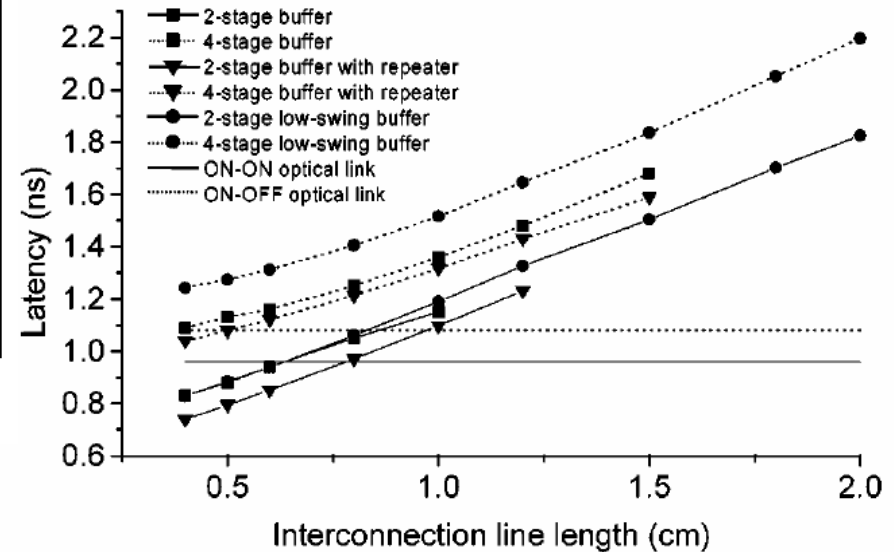


Fig. 2 Latency versus interconnection length for optical and electrical links.

Ref: E.D. Kyriakis-Bitzaros, et al., Opt Engg

Power dissipation requirement
Electrical: 900 mW @ 4 Gbps
Optical: 150 mW @ 4 Gbps

Optical Interconnects offer lower power, faster and scaleable alternative while eliminating EMI and cross-talk

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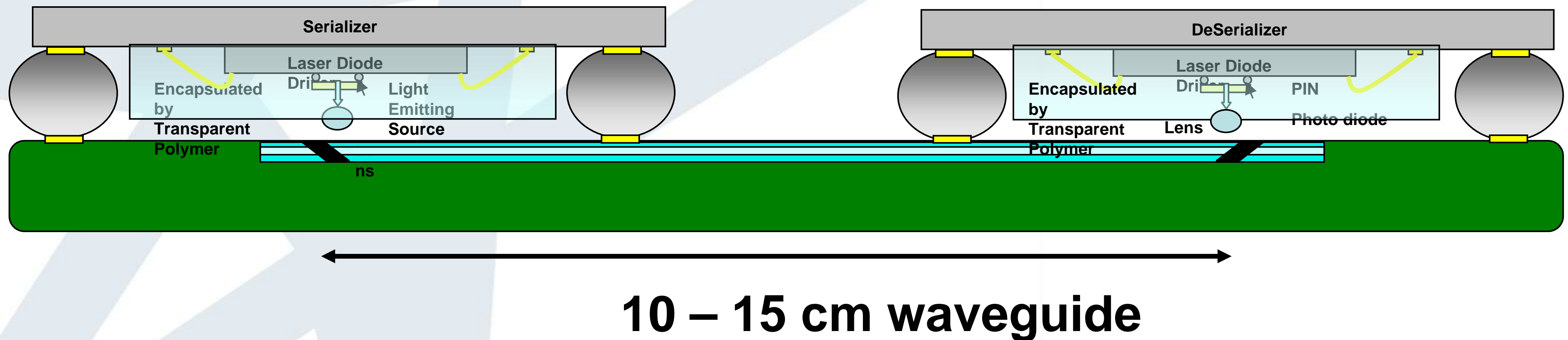
Proposed Project:
Development of hybrid 3D stack
and Demonstration of Optical Interconnect

Objective

To demonstrate high frequency interconnect at 10 Gbps on FR4 optical PCB with low form factor and low cost stacked dies



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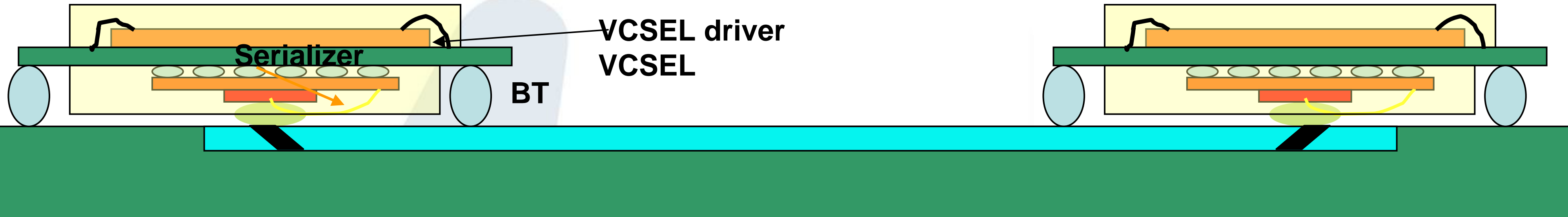
Proposed Architecture



Objective

To demonstrate 10 Gbps interconnect on FR4 optical PCB with low form factor and low cost stacked dies on organic substrate

Scope

1. Design of 3D stack with optical and electrical devices on organic substrate
2. Design and development of electrical interconnects and solder bumps
3. Design of High Speed Optoelectronics board
4. Design of methods of optical coupling between optical devices and waveguides
5. Process development for assembly of Optical devices and optical coupling elements
6. Optical PCB assembly
7. Development of characterization set-up and performance evaluation
8. Reliability Assessment

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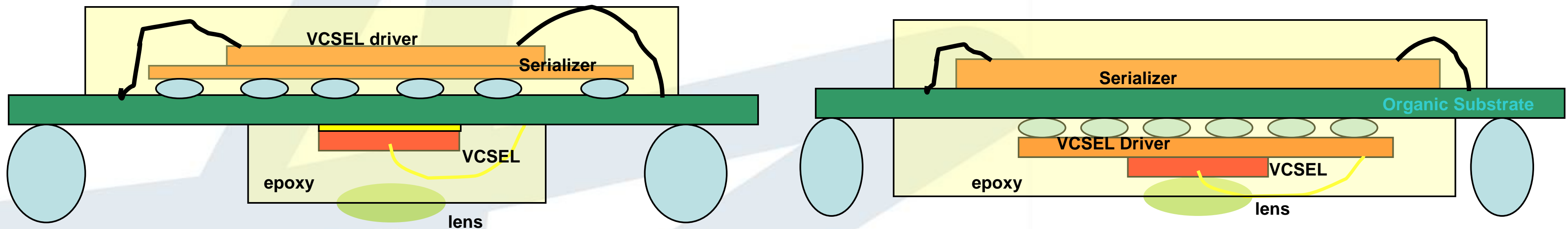
Two Options for Package

Serializer / Deserializer: 3.3 V, 2.5 W, 2.5 W/cm2
VCSEL driver: 3.3 V, 0.35 W, 6 W/cm2
VCSEL: 2.2 V, 33 mW, 16 W/ cm2



Package 1:
Electrical ICs on the Top Layer
VCSEL/ Pin on bottom layer

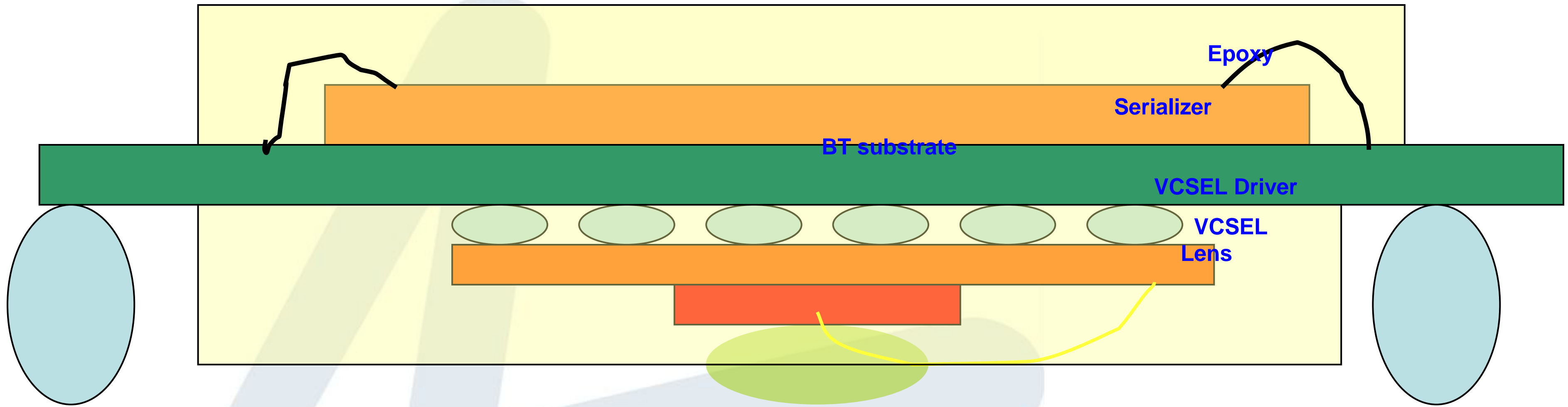
1. Better for thermal performance
2. Challenging for electrical performance
3. 10 Gig signal takes longer path
4. Easier to control VCSEL heat dissipation

Package 2:
Low frequency IC on top layer
High frequency devices on bottom layer

1. Better for electrical performance
2. Challenging for thermal performance
3. 10 Gig signal takes shorter path
4. VCSEL and driver heat dissipation

It is decided that Package 2 will be studied first for implementation.

Detailed tasks



- Design
  - 3D stack design
  - Organic substrate design
  - Solder bump development
  - Optical PCB design with 3D stack
  - Optical coupling design
  - Lens design and tolerancing
  - Thermal optimization
- Fabrication
  - Waveguide fabrication
  - Organic substrate fabrication
  - Optical PCB fabrication
  - Optical mirror formation
- Assembly
  - 3D stack assembly
  - Optical board assembly
- Performance Testing
  - Optical and electrical performance
- Limited Reliability Assessment

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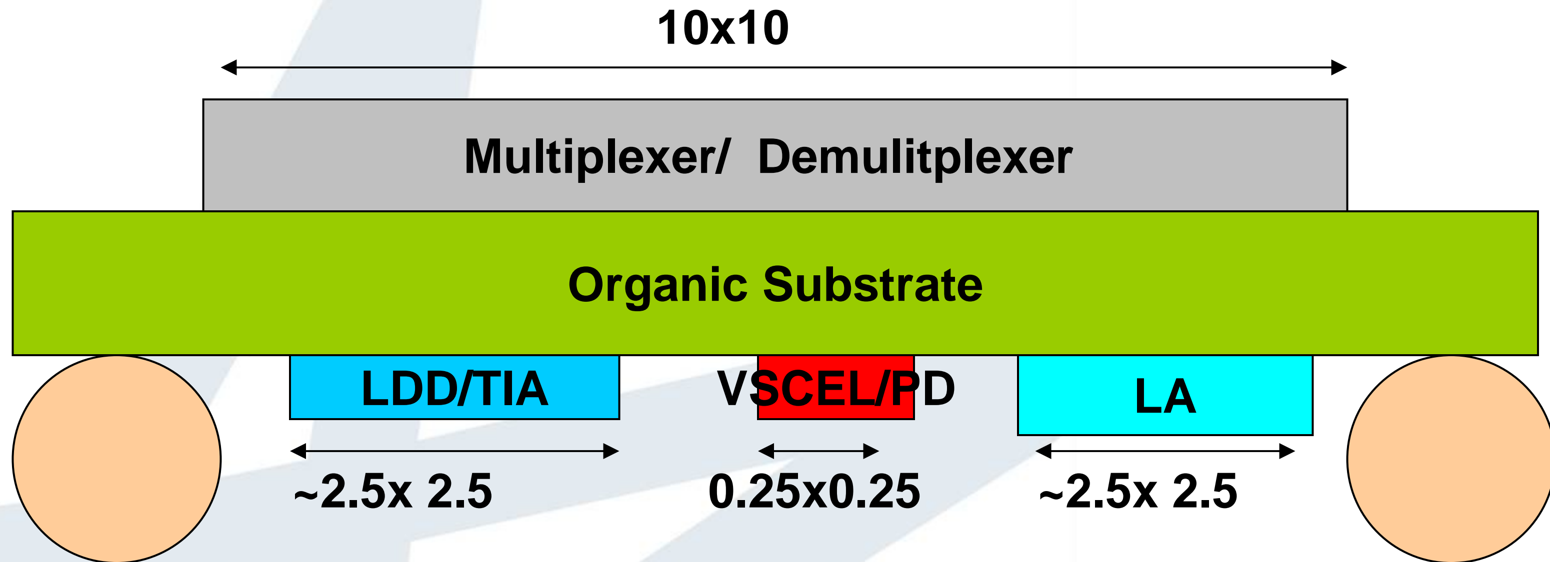
Alternate Proposal for Module



Note: the LA is for receiver only, which we have not taken in to consideration earlier. The position of the components are for illustration only.

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Benefits to members

The consortium members will get the following benefits from the project

1. Development results of hybrid 3D stack for Optical PCB
2. Methods of achieving high frequency communications for Optical Interconnect applications
3. Results of design and process studies on epoxy based optical elements to improve optical output
4. Optical coupling methods between the stack die and waveguide
5. high frequency data transmission using optical waveguide
6. Results of reliability assessment of Optical PCB

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Deliverables

- Progress reports periodically detailing design and process methods
- Final Technical Report containing
  - Low cost 3D stack on organic substrate with optical device and electrical ICs
  - Electrical, optical and thermal design methodology
  - Methods of optical coupling between stacked die and WG
  - Process methodology for 3D Optical stack
  - Design details of optical PCB
  - Performance and reliable assessment results
  - design, simulation, process and test results

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