EUROPEAN CLUSTER IN OPTICAL INTERCONNECTS

COOPERATION

Overview and Roadmap for European projects in Optical Interconnects

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http://phos-net.csd.auth.gr/

CERTH THE CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

Why is an overview needed ?

- *To identify possible synergies*
- *To understand the strategy of the EC R&D*
- *To identify possible "blank" or "uncovered" areas*
- *…and orchestrate all this into a coherent strategy with the final aim being:*
  - *a stronger European industry on OI*
  - *a stronger European R&D on OI*
  - *a more intense industry-academia collaboration*

Some history

SEVENTH FRAMEWORK

POLYSYS

On-board interconnects

polymer+InP

STReP, ~2.5M

RAM PLAS

Optical RAM

SOI+III-V

FET-STReP, ~2M

~11.7M

PhoxTroT

Photonics for High-Performance, Low-Cost & Low-Energy Data Centers, High Performance Computing Systems, Terabit/s Optical Interconnect Technologies for On-Board, Board-to-Board, Rack-to-Rack data links

All hierarchy levels

SOI+III-V+polymer

+glass+plasmonics+IC

IP, ~8.7M

Platon

...plasmonics "in-the-box"

On-chip interconnects

SOI+plasmonics

S... ...M

~8M

On-board interconnects

polymer+PhCrystals

STReP, ~3.4M

~7.3M

HISTERIC

Optical digital logic

InP-on-SOI +PhC

STReP, ~2.3M

NAVOLCHI

Chip-to-Chip

plasmonics

STReP, ~2.4M

mirage

Active Optical Cable

III-V+SOI+multicore

STReP, ~3M

<2010 **2011** **2012**

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Source: http://cordis.europa.eu/fp7/ict/photonics/projects-fp7_en.html

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Some conclusions

- ***Increasing interest between 2010-2012***
  - ***FP7 funding on OI projects increased from 7.3 to 11.7MEuro***
- ***Total EU contribution ~27 M€***
  - ***3 projects*** *funded under* ***Obj. "Disruptive Photonic Technologies"***
  - ***1 project*** *funded under* ***FET Open***
  - ***Only 4 projects*** *funded under* ***Obj. "Photonic Components"***

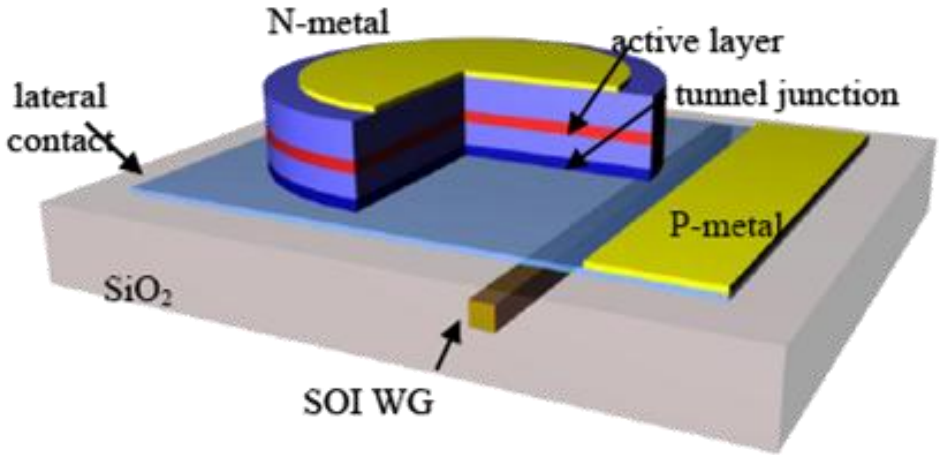
non-focused CfP, random approach

…and some technology

http://www.ict-historic.eu/

HISTERIC

coordinated by IMEC, Belgium



Heterogeneously integrated microdisk lasers on SOI.
(L. Liu et al, Nature Photonics, Jan 2010, DOI: 10.1038/NPHOTON.2009.268)

- ✓ *InP + SOI + PhC*
- ✓ *goal: flip-flops and digital circuits*
- ✓ *demonstrated low-energy, ultra-small, high-speed FFs*

POLYSYS

http://www.ict-polysys.eu/

coordinated by ICCS/NTUA, Greece

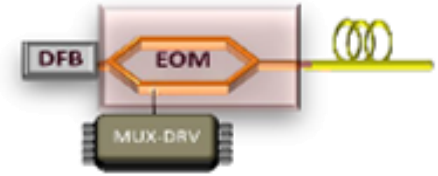
Serial 100 Gb/s optical transmission based on:

EO polymers for high-speed modulation

InP for high-speed photodetection

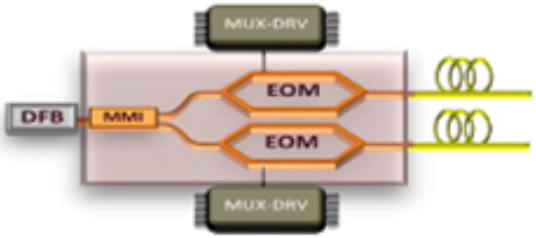
InP-DHBT for high-speed electronics

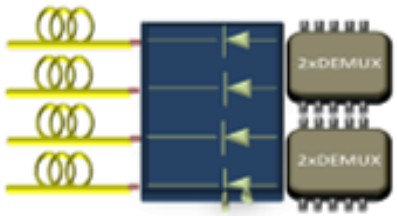
Hybrid integration, assembly, packaging



Scale the technology to higher capacity using arrayed components

2x 100 Gb/s and 4x100 Gb/s systems



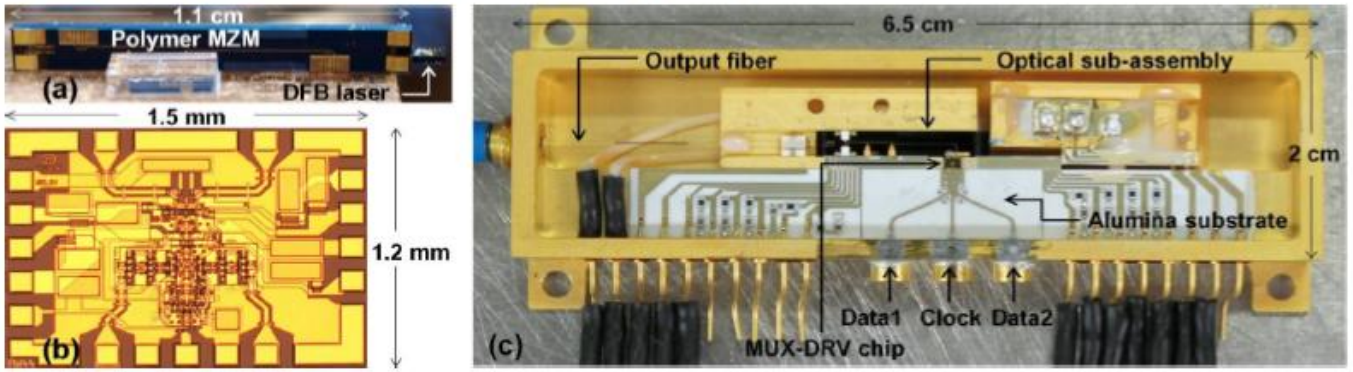


Applications in Telecom, Datacom and Computercom

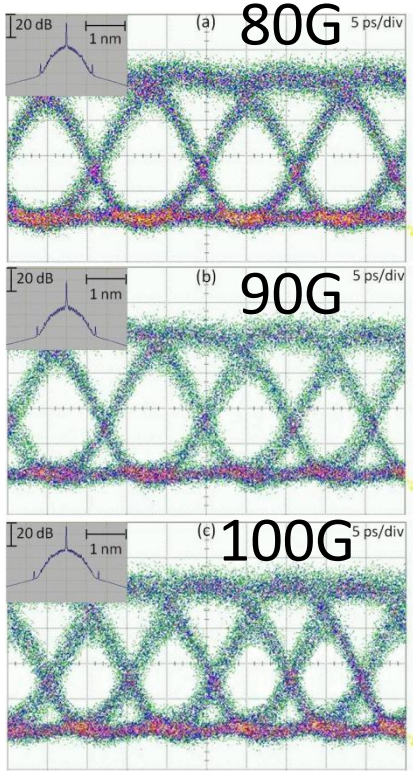
POLYSYS

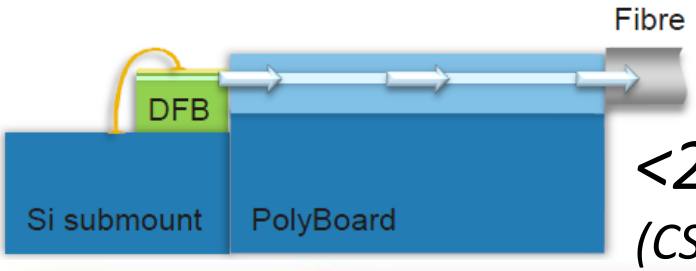
http://www.ict-polysys.eu/

Serial 100 Gb/s NRZ-OOK connectivity, ~ 80 mW/Gb/s



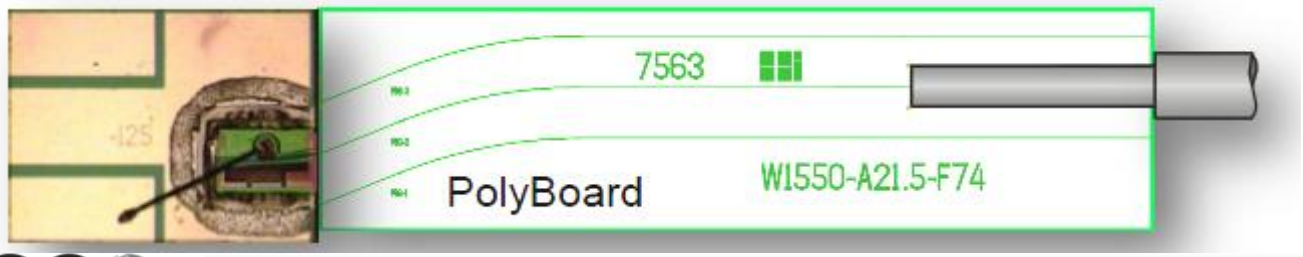
(V. Katopodis et al, ECOC2012, PDP Th3.B.4)





<2 dB coupling loss

(CSDFB+PolyBoard+SMF)



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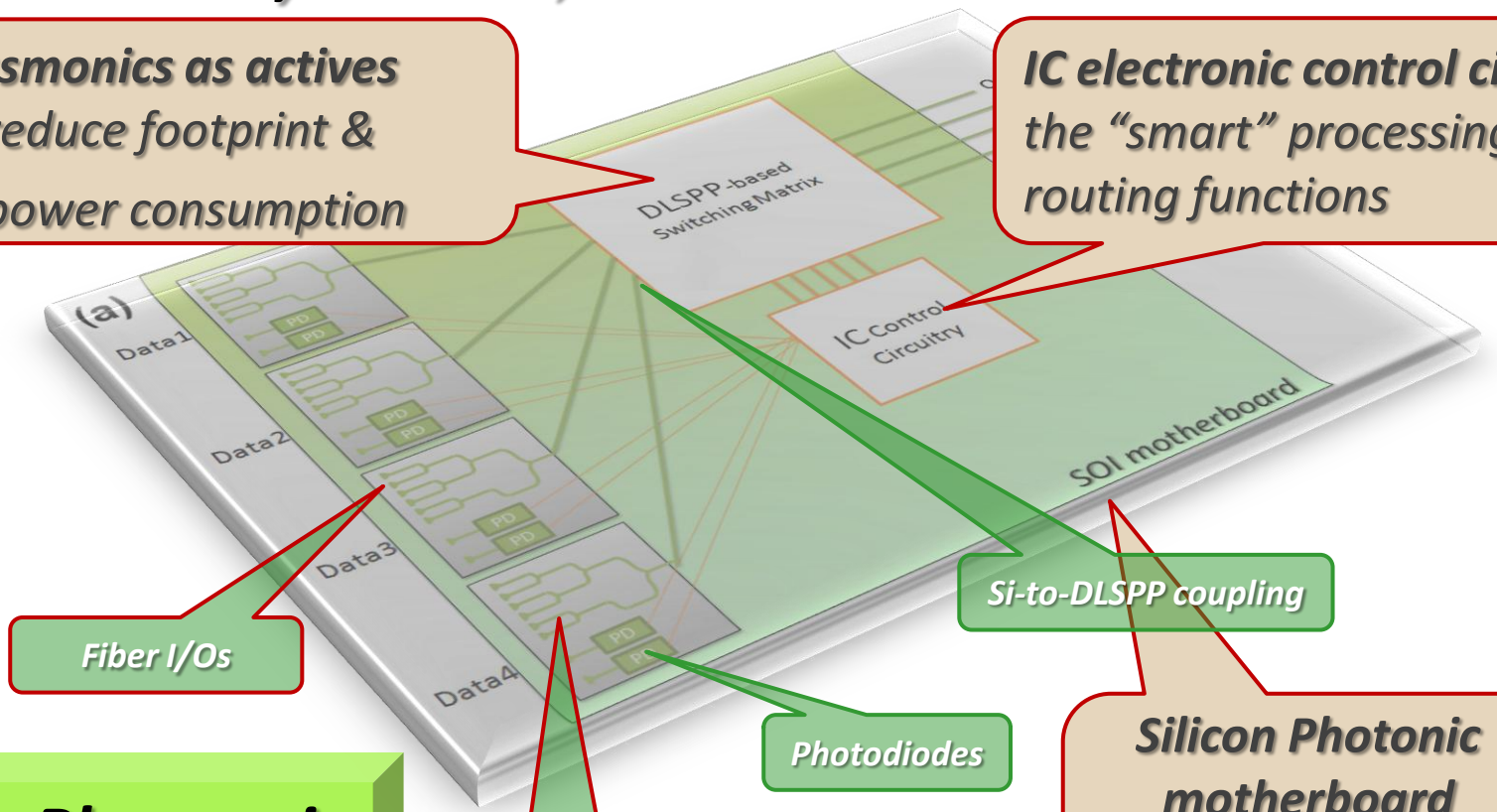
...plasmonics "in-the-box"

coordinated by CERTH, Greece

CERTH THE CENTRE FOR RESEARCH & TECHNOLOGY HELLAS

Plasmonics as actives
- ✓ reduce footprint &
- ✓ power consumption

IC electronic control circuit
the "smart" processing and routing functions



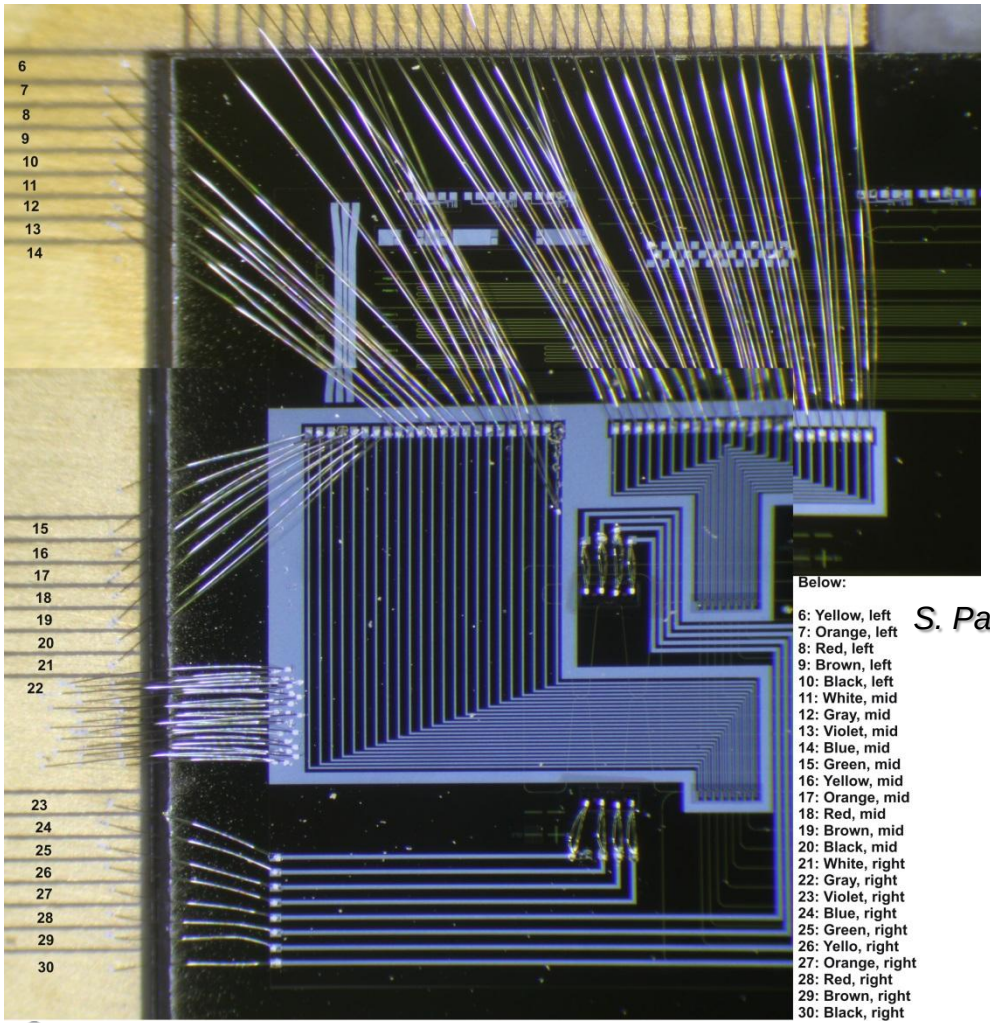
Silicon Photonic motherboard
low loss technology hosting platform

Silicon-Plasmonic Network-On-Chip

Platon

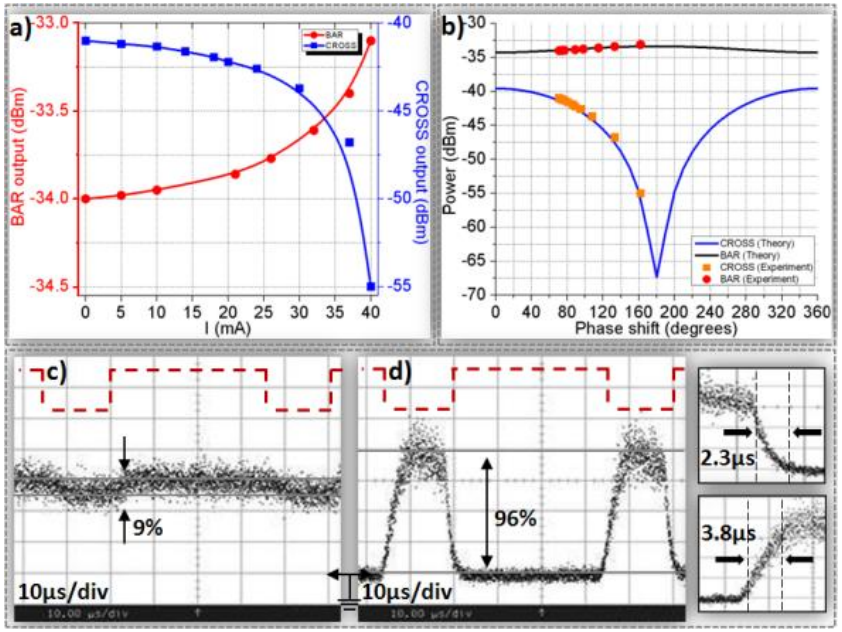
...plasmonics "in-the-box"

http://www.ict-platon.eu/



Below:

6: Yellow, left
7: Orange, left
8: Red, left
9: Brown, left
10: Black, left
11: White, mid
12: Gray, mid
13: Violet, mid
14: Blue, mid
15: Green, mid
16: Yellow, mid
17: Orange, mid
18: Red, mid
19: Brown, mid
20: Black, mid
21: White, right
22: Gray, right
23: Violet, right
24: Blue, right
25: Green, right
26: Yello, right
27: Orange, right
28: Red, right
29: Brown, right
30: Black, right



S. Papaioannou et al., Nature Sci. Rep. Article number: 652(2012)

- ✓ *3.8µs response*
- ✓ *13.1mW power cons.*
- ✓ *40Gb/s throughput*
- ✓ *Lowest Pxτ value*

ECO EUROPEAN CLUSTER IN OPTICAL INTERCONNECTS

Nikos Pleros

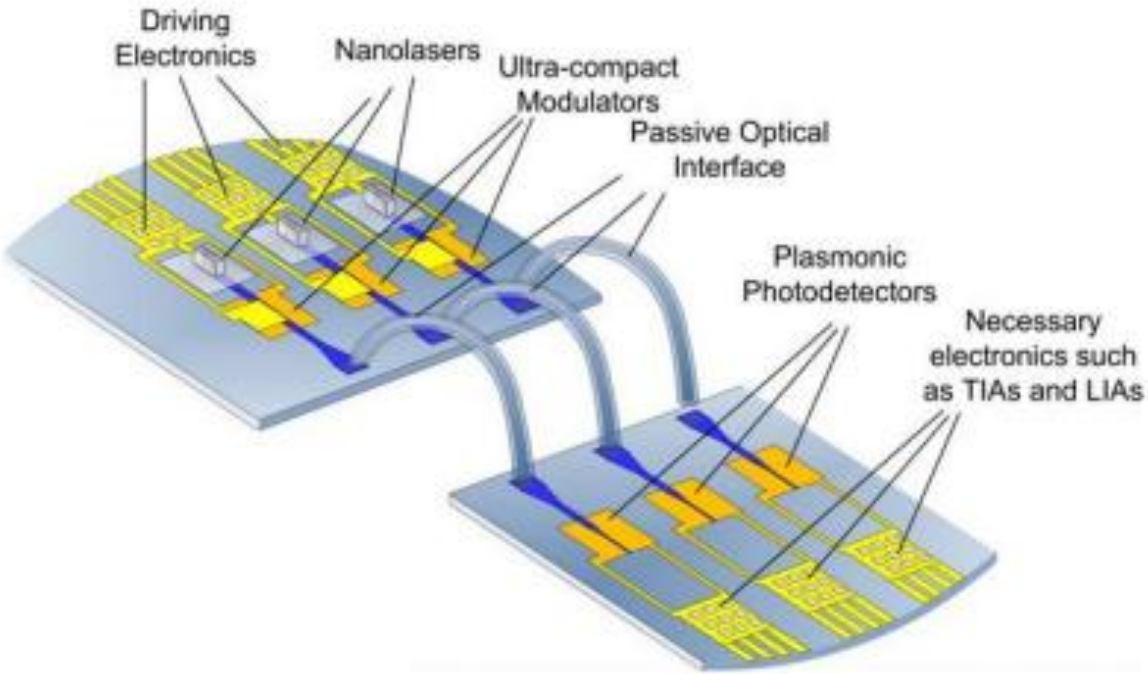
NAVOLCHI

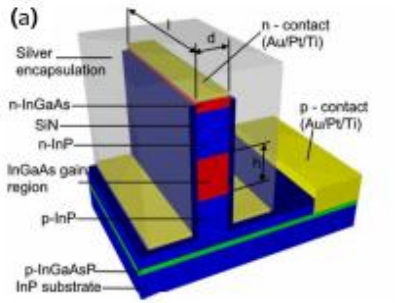
http://www.imt.kit.edu/projects/navolchi/index.html

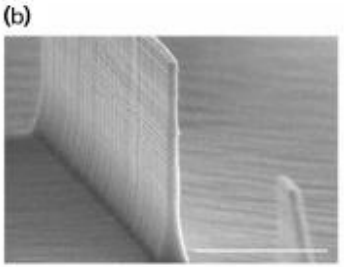
coordinated by KIT, Germany

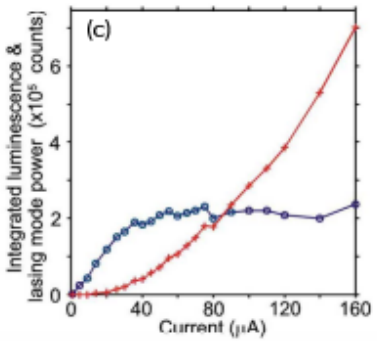
KIT Karlsruhe Institute of Technology

CMOS Chip-to-Chip interconnect









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leros

http://www.fp7-firefly.eu

FIREFLY

Multilayer Photonic Circuits made by Nano-Imprinting of Waveguides and Photonic Crystals

TNO

Tyndall National Institute

TE connectivity

imec

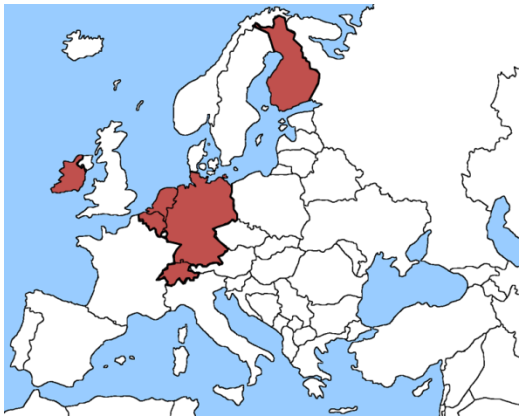
IBM

Universiteit Utrecht

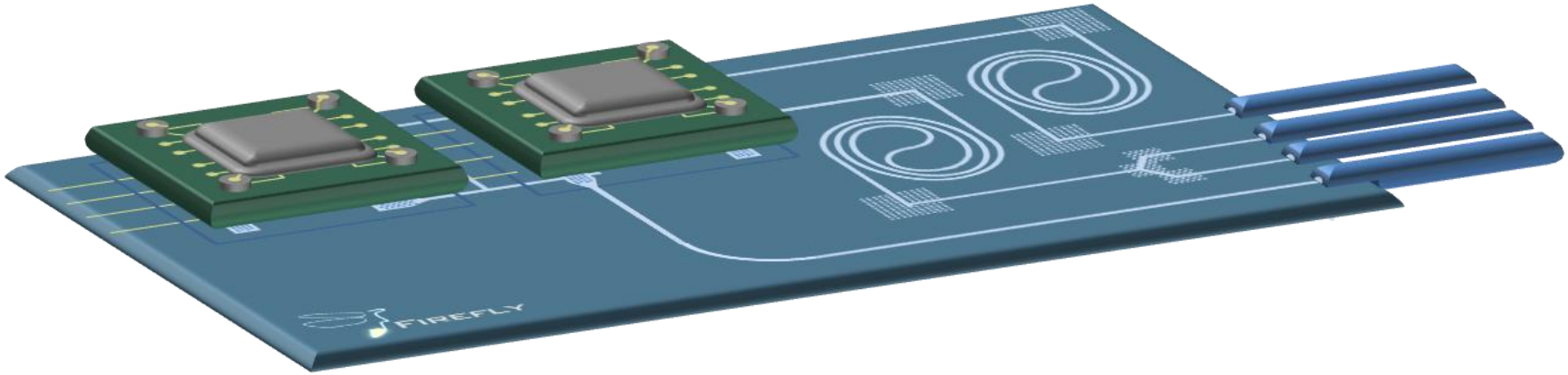
MOMENTIVE™

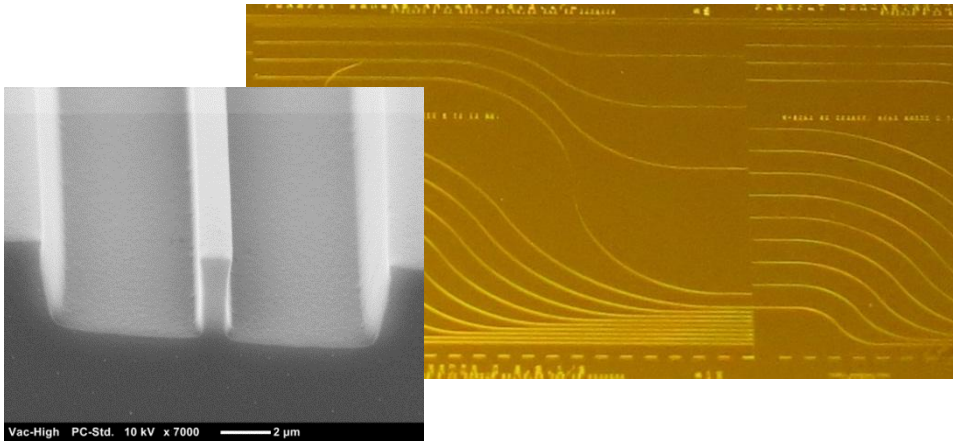
VTT

VERTILAS®

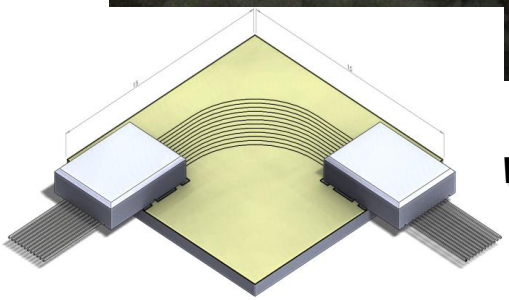


- Develop polymeric, SM waveguides and PhC structures for optical data transfer
  - based on 3D structured nano-materials
  - manufactured using new cost effective production processes
  - suitable for large scale manufacturing
- Develop new optical components (VCELS, Waveguide-fibre coupling)
- Develop new integration concepts

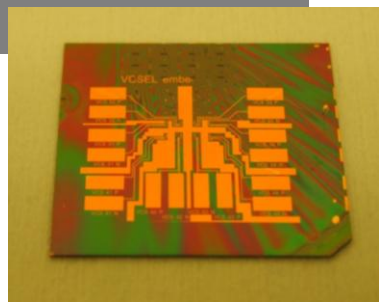




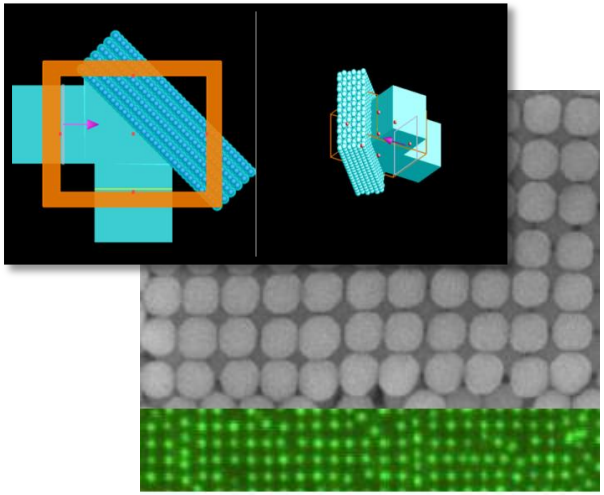
Inverted waveguides imprinted in siloxane polymer



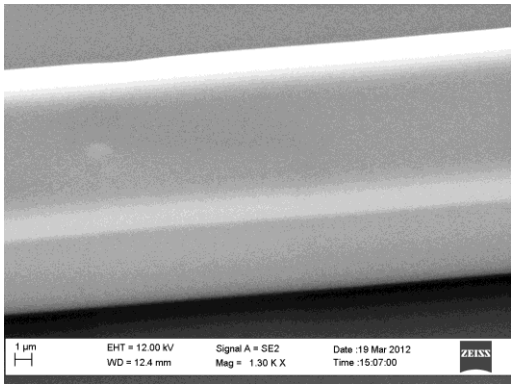
Waveguide to fiber coupling device



Integration of long wavelength VCSELs



Multilayer colloidal crystals

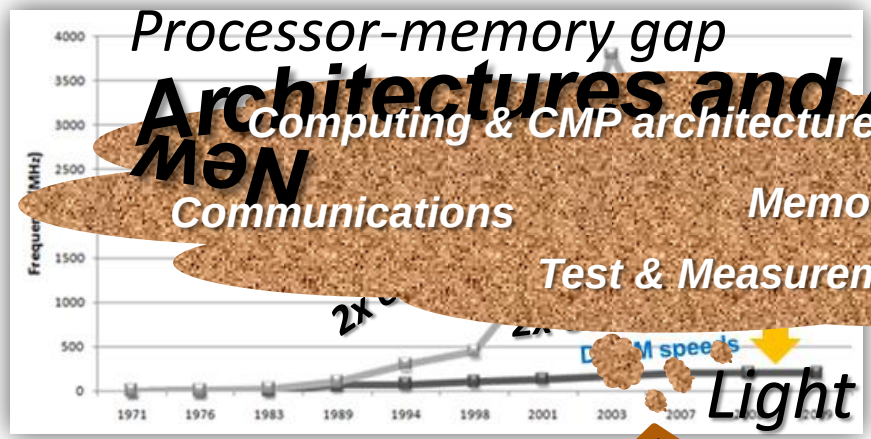


Waveguide defined by laser direct write photolithography

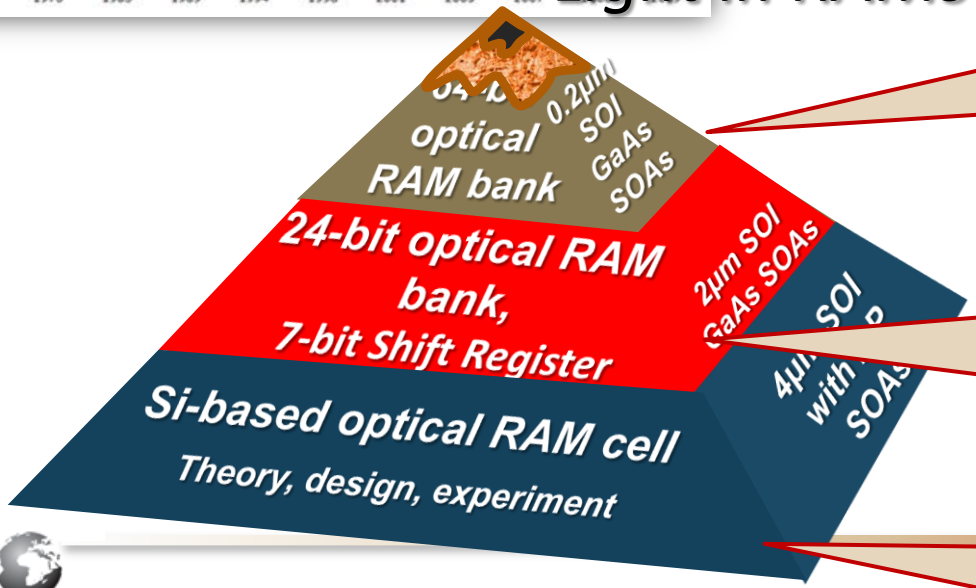
RAM PLAS

http://www.ict-ramplas.eu/

coordinated by CERTH, Greece



Light in RAMs?



- ✓ *Higher functionality*
- ✓ *Higher Integration densities*
- ✓ *Higher Speeds*
- ✓ *Lower Footprint*
- ✓ *Lower Power consumption*
- ✓ *>40GHz speeds*
- ✓ *On-chip optical RAM*

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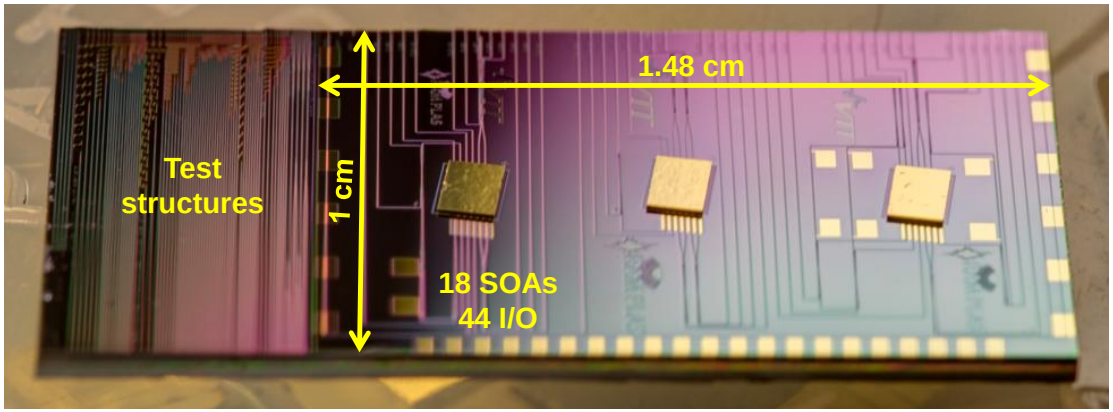
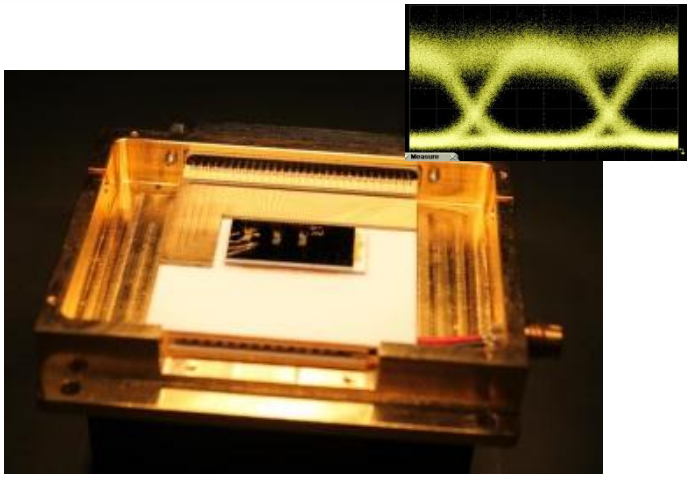
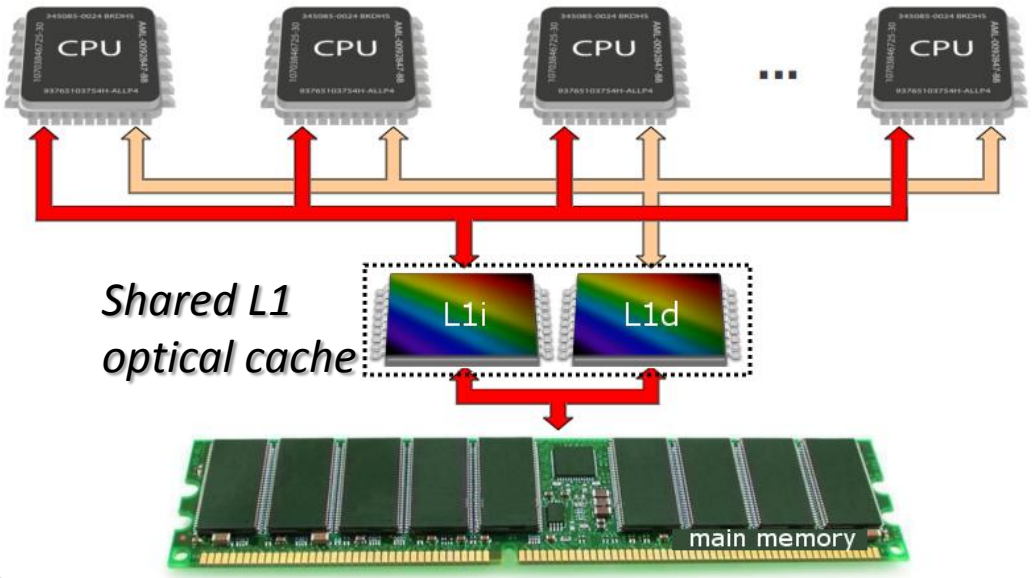
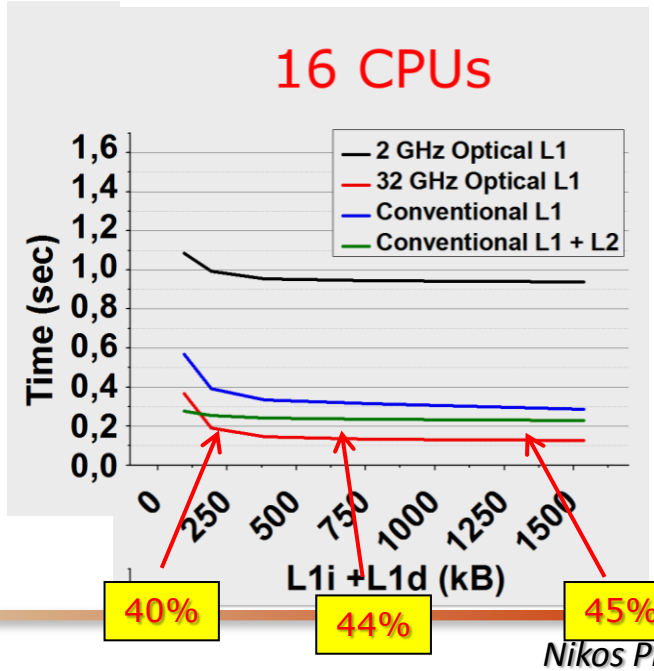
RAM PLAS

http://www.ict-ramplas.eu/









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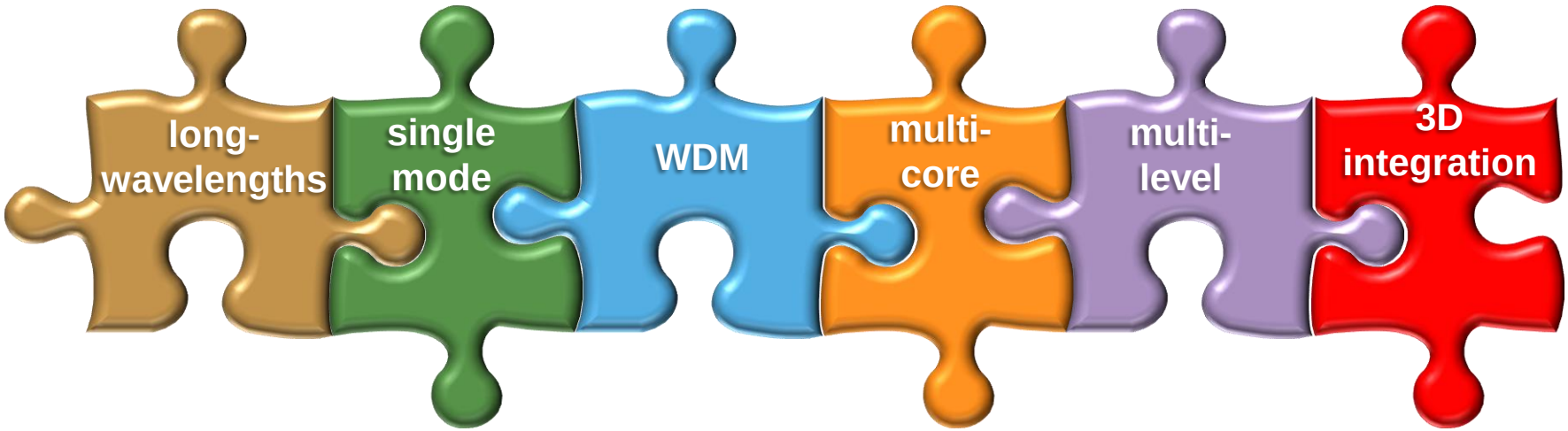
http://www.ict-mirage.eu/

coordinated by ICCS/NTUA, Greece

Multi-coRe,multi-level,WDM-enAbled embedded optical enGine for Terabit board-to-board and rack-to-rack parallel optics



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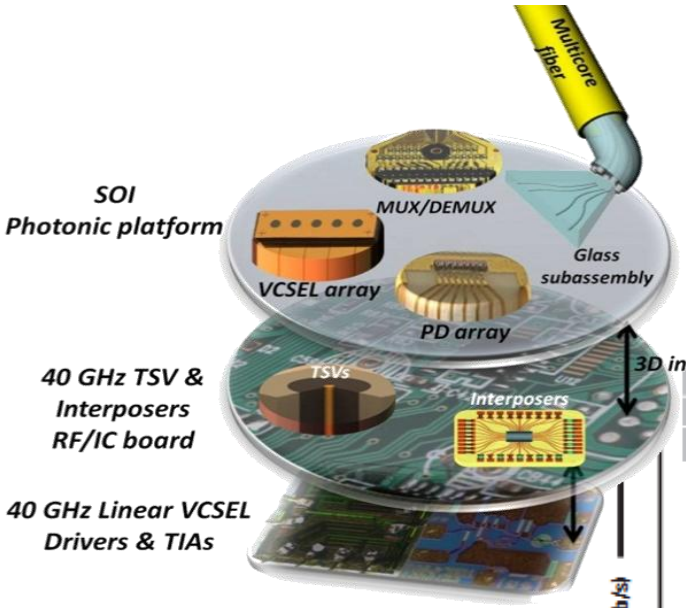
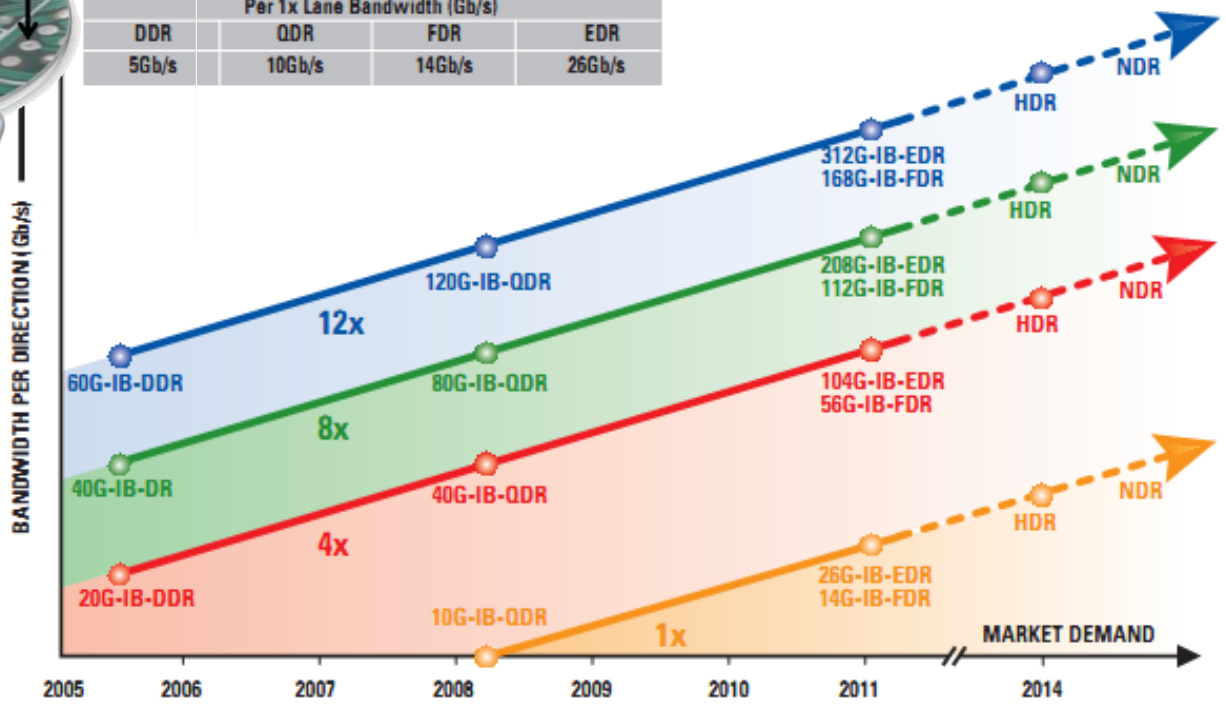
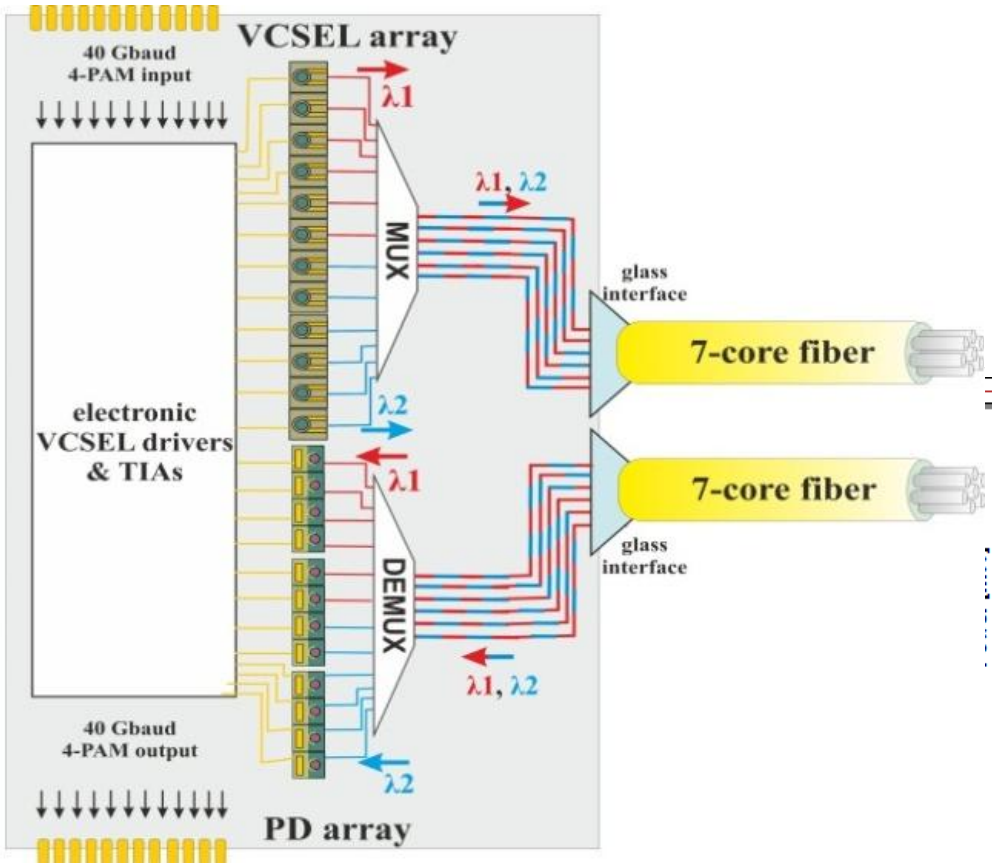
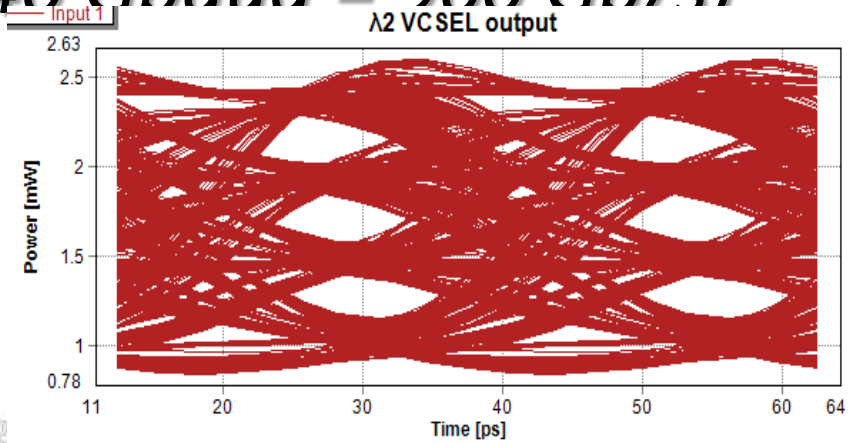


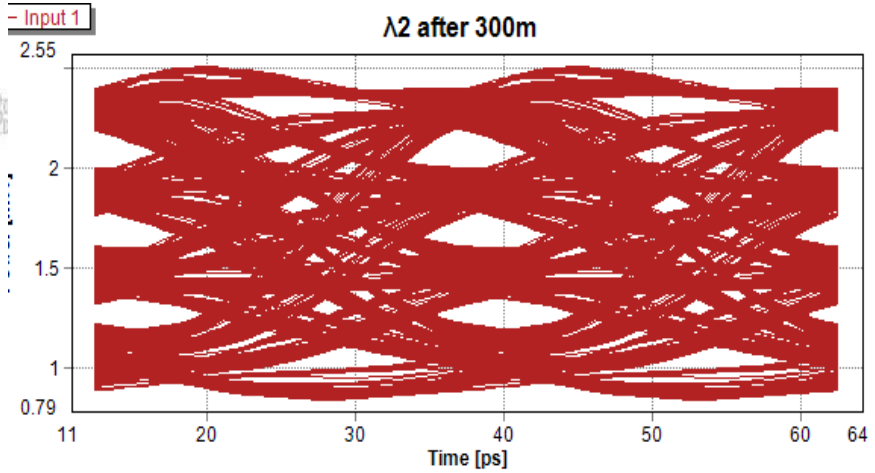
Per 1x Lane Bandwidth (Gb/s)			
DDR	QDR	FDR	EDR
5Gb/s	10Gb/s	14Gb/s	26Gb/s



CXP AOC (6 cores x 2 λs x 40 Gbaud = 960 Gb/s)

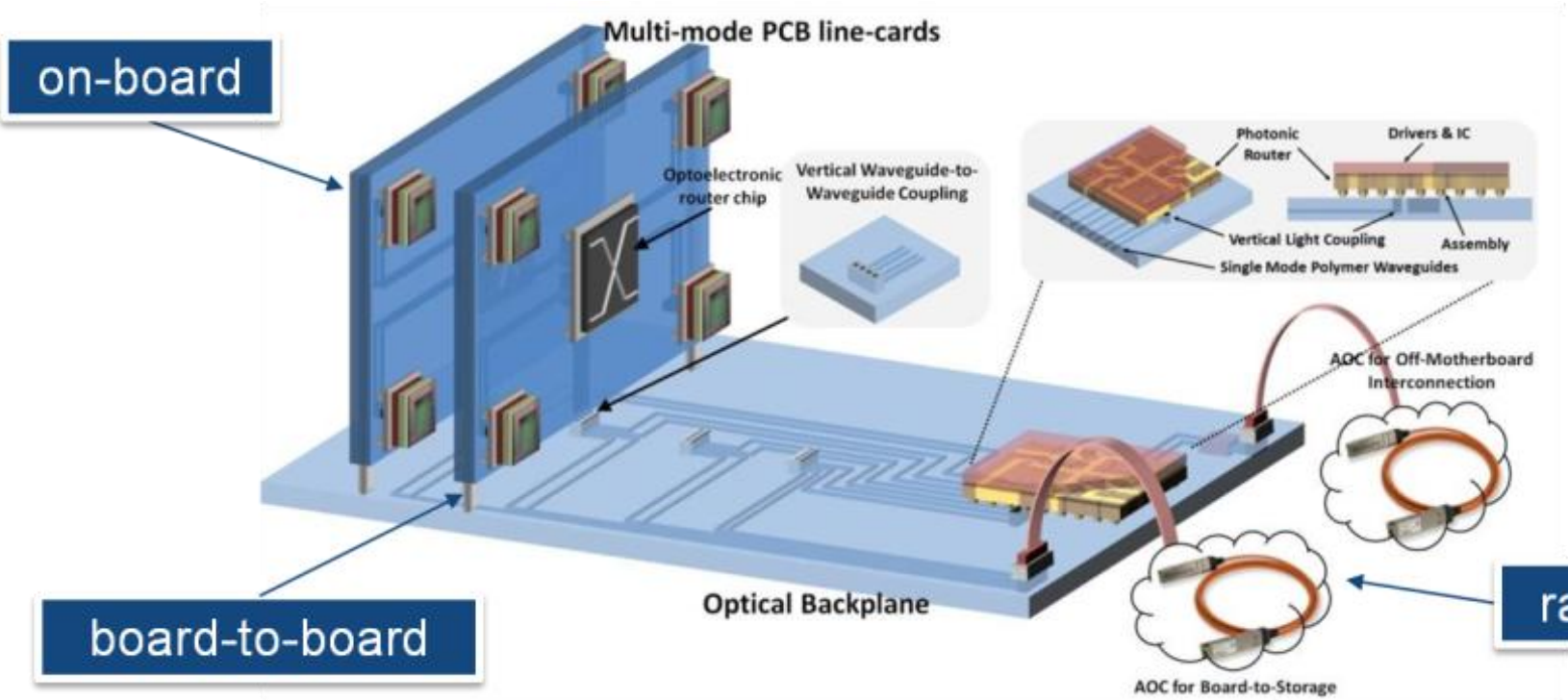






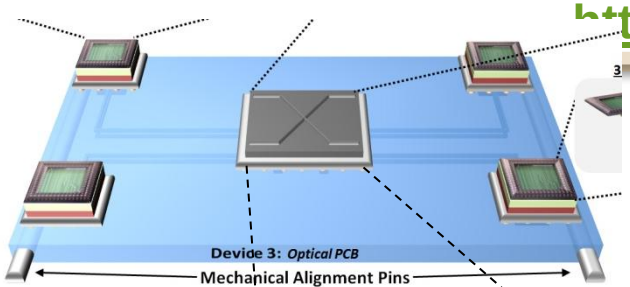
IP, coordinated by Fraunhofer IZM, Germany

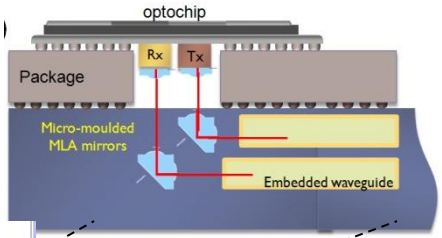
Fraunhofer IZM



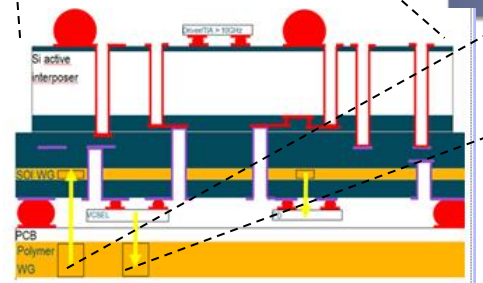
http://www.phoxtrot.eu/

- *Optical PCBs*

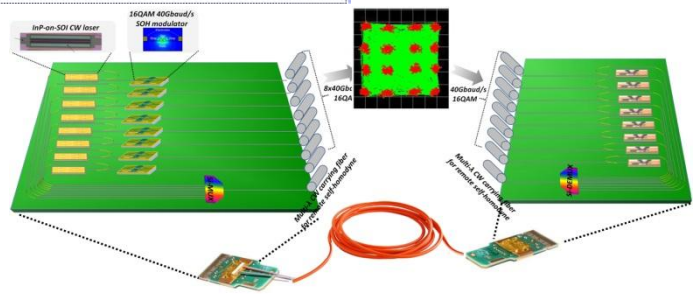




- *Optochips & interfaces*



- *1.28Tb/s, 16-QAM SOI AOC*

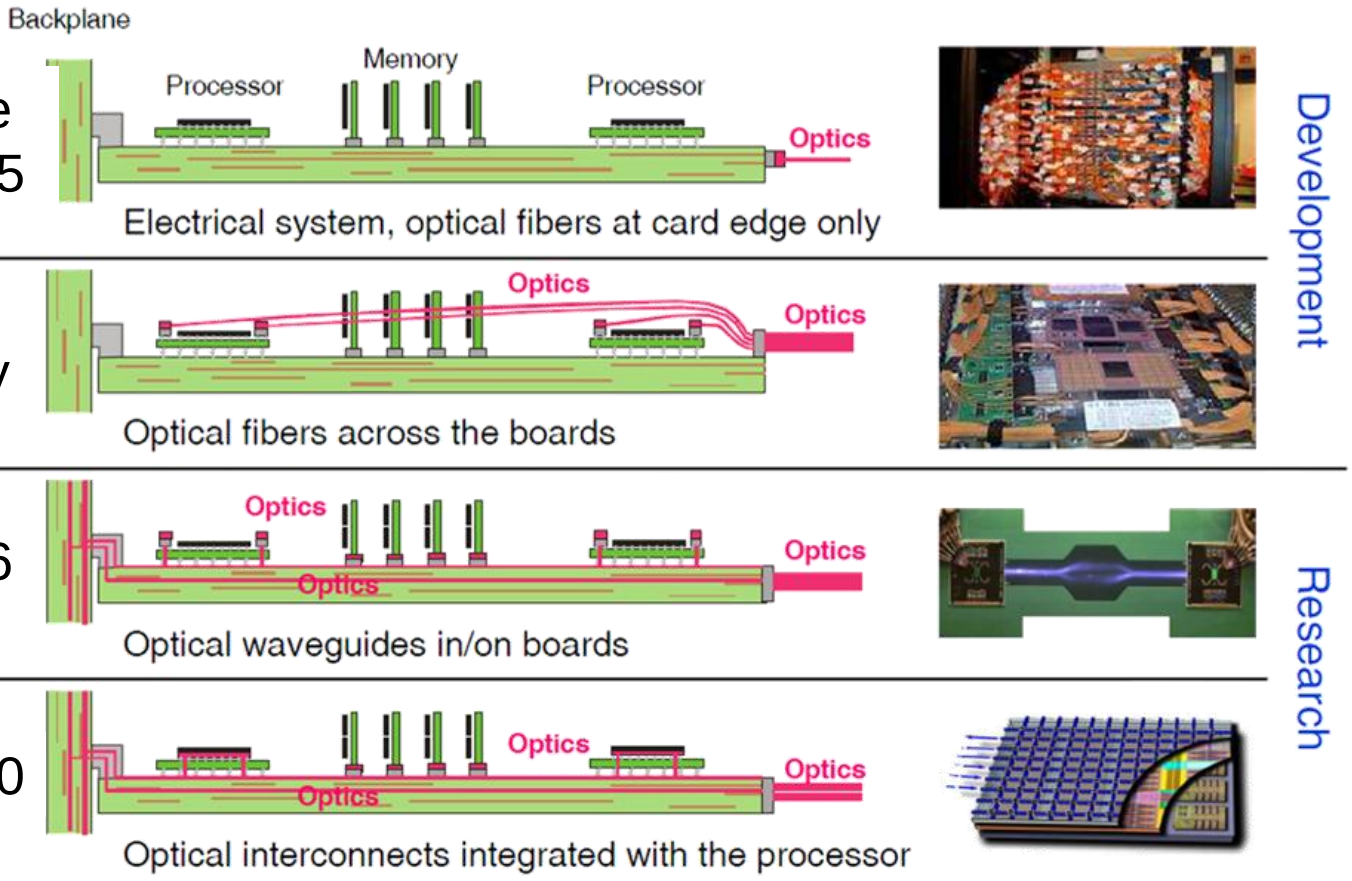


- *…"blending" many photonic technologies (SOI, III-V, polymer, glass, plasmonics, electronics)*

Which hierarchy level ?

8 projects

3 hierarchy levels (chip-, board-, rack-level)



Source: IBM, B. Jan Offrein, "Silicon Photonics Packaging Requirements", Munich 2011

Why it matters

- ***More projects targeting R&D >2020 (on-chip)***
- ***Only a few (and new) being on today's closer-to-the-market areas (AOC and optical PCBs)***
  - *while US had already started by 2005 (IBM TeraBUS)*
- ***Much effort relies on more "disruptive" technologies (plasmonics, PhC, RAMs..)***
  - ✓ *Forward-looking, more open-ended reseach*
  - ✗ *Given the small total number of projects, , he closer-to-the-market areas are under-supported*

cannot support a focused interconnect technology sector

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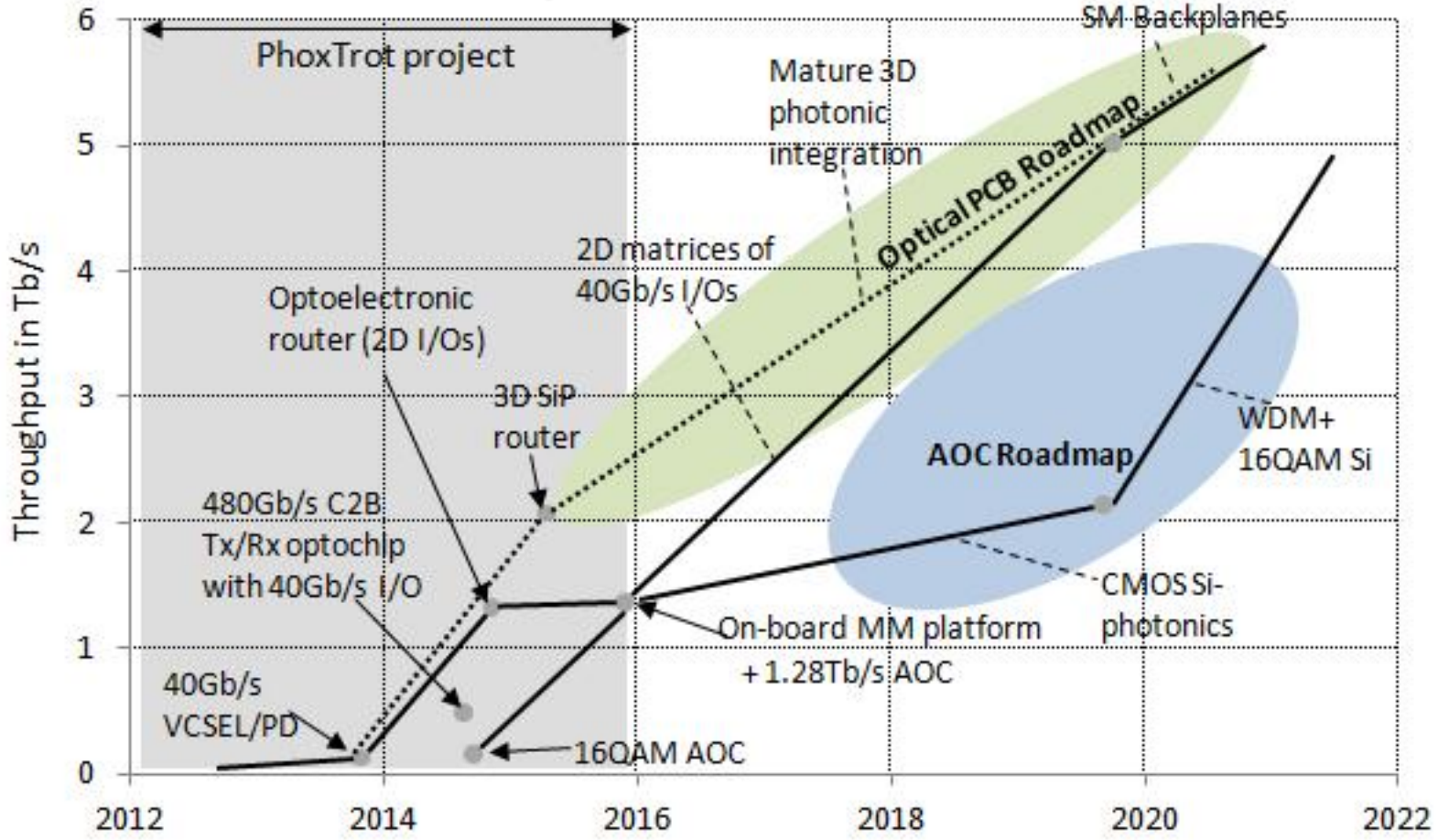
How should this be done?

PhoxTrot's roadmap

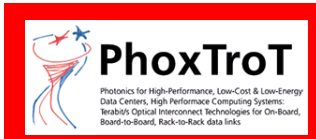


Possible Actions

- *Push Photonics21 for more balanced CfPs targeting all OI hierarchical levels*
- *Strengthen synergies between architecture- (i.e. Lightness, Cosine etc) & technology-oriented projects*
- *Bring together people from different technological sectors (like III-V, SOI, polymer, glass, systems, end-users etc.)*
- *…additional ideas more than welcome !!*

THANK YOU

Upcoming events



Technology Workshop
"Optical Interconnect in Data Centers"

18-19 March 2014
Berlin, Germany
Held in conjunction with Laser Optics
www.laser-optics-berlin.de

1st European Summer School on
"Optical Interconnects"

3-6 June 2014
Thessaloniki, Greece
Co-organized by FP7 PhoxTrot and ECO cluster

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