Webinar: Highlights of the World Technology Mapping Forum

Link to webinar recording: http://bit.ly/2q0iqEs
(link is good for approximately 6 months after webinar)

Prof. Ton Backx
President, Institute for Photonic Integration at Eindhoven University of Technology

Thursday, October 18, 2018

Driving Photonics Manufacturing

IPSR-International 2018 Seminar Calendar

Thursdays at 11 AM EDT (1700 CET)

- Thursday October 18 Ton Backx: Highlights of WTMF Meeting
- Thursday November 1 Tom Brown: AIM Photonics Test, Assembly, Package Facility
- Thursday-Friday. November 29-30 IPSR-International Fall Meeting at MIT
- Thursday December 13 Prof. Kimerling *"Grand Challenges and Key Needs"*

- Future Presentations
  - Analogue RF AIG
  - Indium Phosphide & 3-5 Compounds TWG
  - Electronic-Photonic Design Automation TWG
  - Electronic-Photonic Test TWG
- For additional information
  - www.photonicsmanufacturing.org

Photonic Integration Technology Centre

Photon Delta

WTMF technical content and outcome

Ton Backx

Outline

- World Technology Mapping Forum
- Technical Content
- Outcome
- Next steps

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World Technology Mapping Forum - WTMF

The objective of the WTMF is to establish and sustain a trust based global network of partners who are working together on photonic integrated circuits and systems and jointly enable fastest possible technology and application developments in this emerging technology field

- Commonly agreed vision and problem definitions
- Collaboration in creation of solutions
- Bring Ecosystem requirements into the Lab environments

World Technology Mapping Forum - WTMF

Lionel Kimerling perfectly summarized the key success factors for meeting market requirements during the coming decades where exponential growth with high growth rate factors in various application domains is foreseen

- Establish an environment of mutual trust and collaboration
- Enable scaling of performance and production capacity
- Map current needs on existing technologies and create the roadmaps mapping future requirements on next generation technologies (R&D)

World Technology Mapping Forum - WTMF

Lionel Kimerling concluded following:

- Scaling of performance and production capacity will be governed by:
  - ***Universal Parallelism*** as the key word in scaling of photonic integrated circuits and systems
  - Very disciplined development of application specific ***cross-market platforms*** and creation of ***standard functional modules*** as basic building blocks for creation of any functionality
- Map current needs on existing technologies and create the roadmaps mapping future requirements on next generation technologies (R&D)

World Technology Mapping Forum - WTMF

The WTMF has been initiated by PhotonDelta in 2016 to have major developers of Photonic Integrated Circuits and Systems technology and applications from all over the world meet and discuss roadmaps

- Structured outlook on technology requirements in (near) future
  - Specific technology related
    - Design
    - Photonic Integrated Circuit manufacturing
    - Integration of Photonic-Electronic circuits
    - Testing
    - Packaging
    - Connections (electric, light)
    - Systems assembly
  - Specific application or application domain related

World Technology Mapping Forum - WTMF

During the WTMF meeting June 20-22, Twente, The Netherlands agreement was achieved on the structure and the agenda for the Integrated Photonics Systems Roadmap – International (IPSR-I):

- Outlook on technology requirements in (near) future structured as follows:
  - Monolithic Silicon Integration
  - Indium Phosphide & 3-5 Compounds
  - Electronic-Photonic Packaging
  - Electronic-Photonic Connectors
  - Substrate
  - Electronic-Photonic Assembly
  - Electronic-Photonic Test
  - Integrated Photonic Sensors
  - Electronic Photonic Design Automation

Outline

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Technical content

Merger towards IPSR-I in Spring 2019

2019

Technical content

Current starting point are separate documents –IPSR and WRIP- established with a high level of collaboration and interaction

- WG leaders have strongly collaborated the past year
- New insights and knowledge developed during the process have been integrated in both roadmaps
- Structures of the documents have much similarity but significant differences still exist

Technical content

Progress has been made in establishing the team of Technology Working Group leaders; we still are looking for additional people though

Technical working group	Co-chair	Co-chair	Co-chair
Monolithic Silicon Integration	Abdul Rahim (IMEC)	Lionel Kimerling (MIT)	Ajey Jacob (Global Foundries)
InP & 3-5 Compounds	Meint Smit (TU/e)	Gloria Hoefler (Infinera)	Mike Wale
Silicon Nitride	Sami Musa (Vision & actions)	Lionel Kimerling (MIT)	
Novel Materials	Felix Betschon (Vario optics)	Michael Lebby (Lightwave Logic)	
Foundry Integration for Photonics	Huub Ambrosius (TU/e)		
Heterogenous integration	Abdul Rahim (IMEC)		
Electronic-Photonic Packaging	Peter 'O Brien (Tyndall)	Bill Bottoms (3MTS)	
Substrates	Peter Maat (Astron)	Terry Smith (3M)	
Electronic-Photonic Assembly	Paul van Dijk (LioniX-International)	Yi Quan (MRSI Systems)	Dick Otte (Promex Industries)
Electronic-Photonic Testing	Tom Brown (U of Rochester)	Dave Armstrong (Advantest)	Sylwester Latkowski (TU/e)

Photonic devices content

Photonic devices group	Co-chair	Co-chair	Co-chair
Integrated photonic components and devices	Paul van Dijk (LioniX-International)		
RF Photonics	Arthur Paolella (Harris)	Paul van Dijk (LioniX-International)	
Electronic-Photonic Connectors	John MacWilliams (US competitors)		
Integrated Photonic Sensors	Ben Miller (U of Rochester)	Anu Agarwal (MIT)	
IPSR Cost Emulators	Arjen Bakker (Synopsis / Phoenix)	Randolph Kirchain (MIT)	Elsa Olivetti (MIT)
Electronic Photonic Design Automation	Twan Korthorst (Synopsis / Phoenix)		
Process Design Kits	Arjen Bakker (Synopsis / Phoenix)		
Product standardization and structure			

Product content

Product emulator group	Co-chair	Co-chair	Co-chair
Datacenter / Telecom	Richard Pitwon (Seagate), Bob Pfahl (iNEMI)	Michael Robertson (Huawai)	Michael Lebby (Lightwave Logic)
Internet of Things and Industry	Christophe Py (CNRC)	Rich Grzbowsky (Macom)	
Automotive	Domenico D'Agostino (Aptiv)	Bob Pfahl (iNEMI)	
Aeronautics	Rolf Evenbleij (Technobis)		
Bio Photonics and medical	Thierry Robin (Thematys)	Bob Pfahl (iNEMI)	Anu Agarwal (MIT)
Agrofood	Rick van der Zedde (WUR)		
Defence	Dan Hermansen (MyDefence)		

Technical content

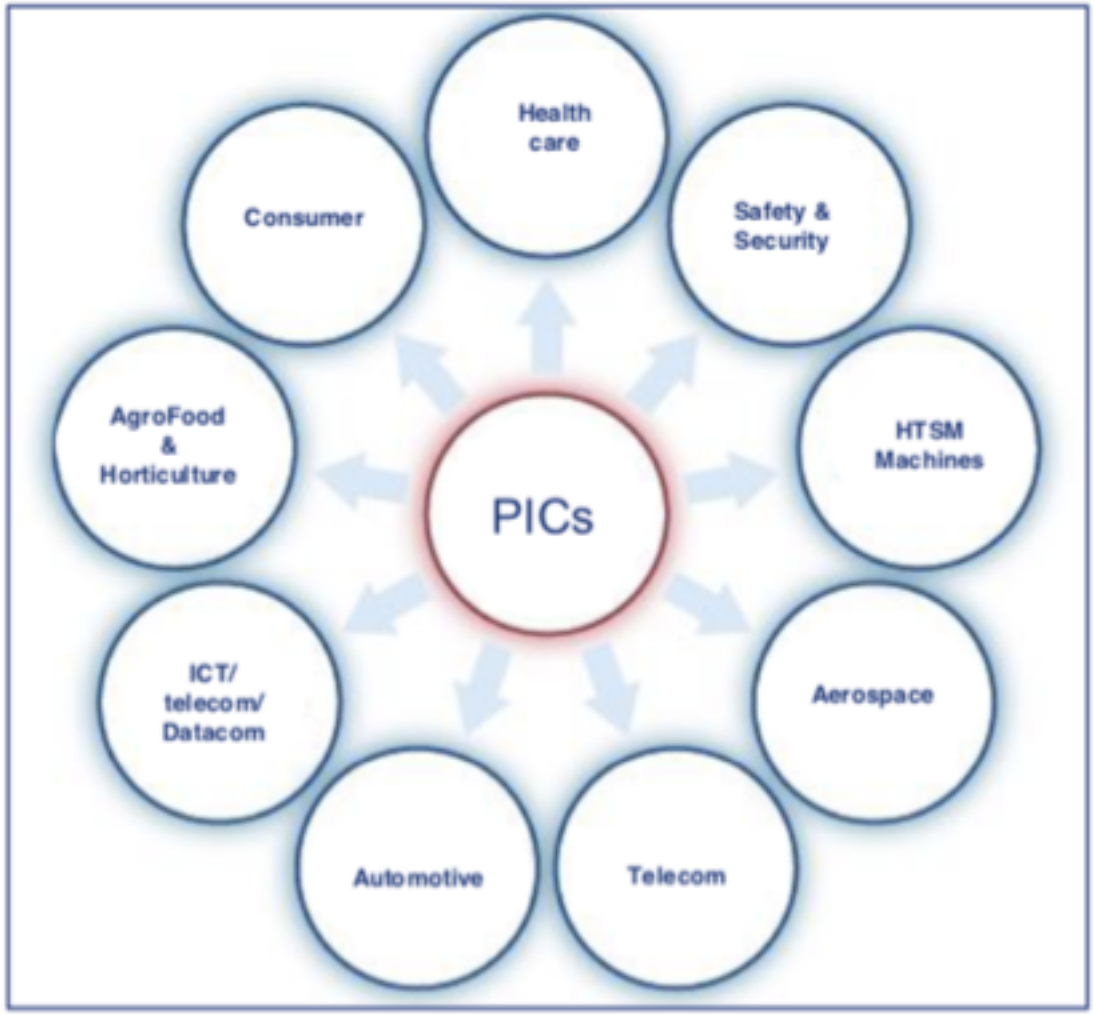
Photonic Integration Technology Centre

High Volume – Low Cost

- Datacom (Next generations Datacenter architectures)
- Telecom (5G and next generations)
- Consumer products

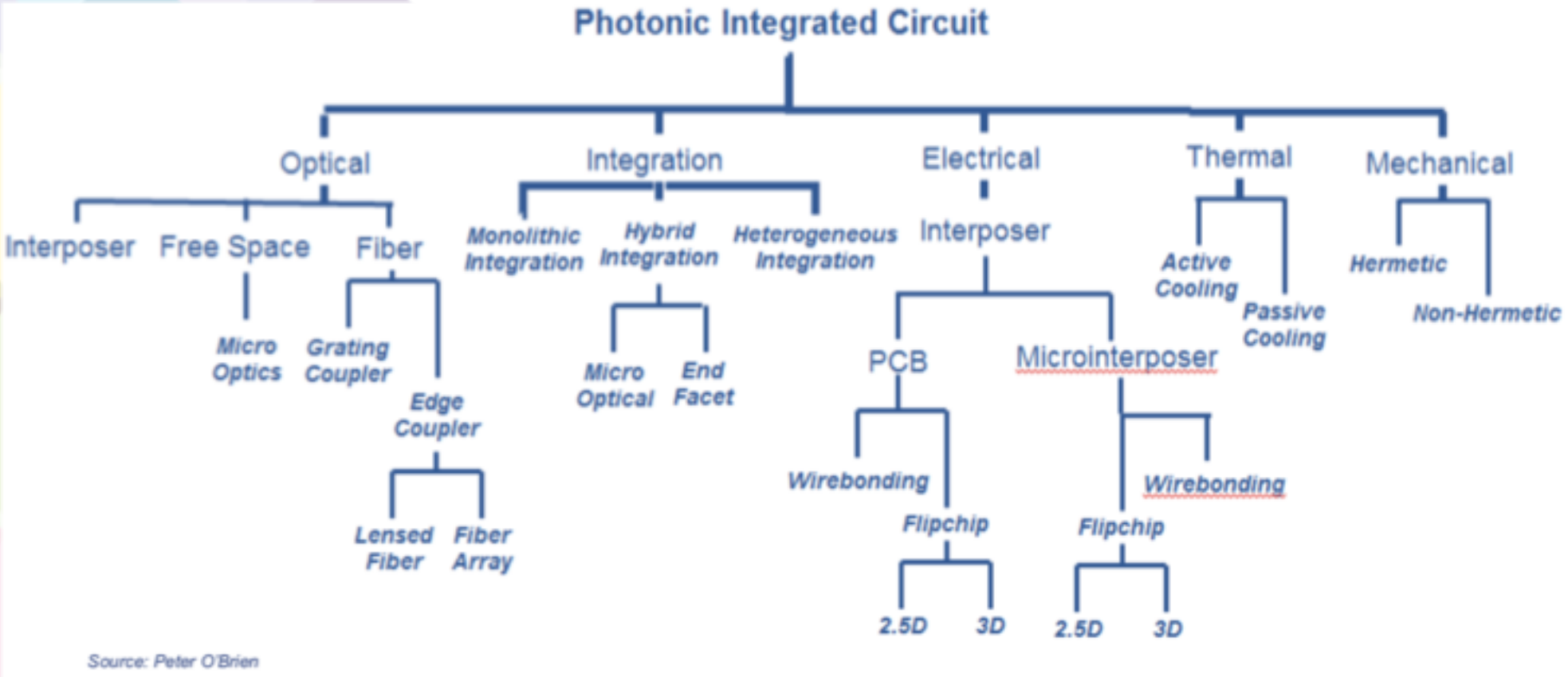
Low Volume – High Value

- Health cure and care
- Aerospace
- Automotive
- Agrofood & agriculture
- Safety & security
- High Tech machine building



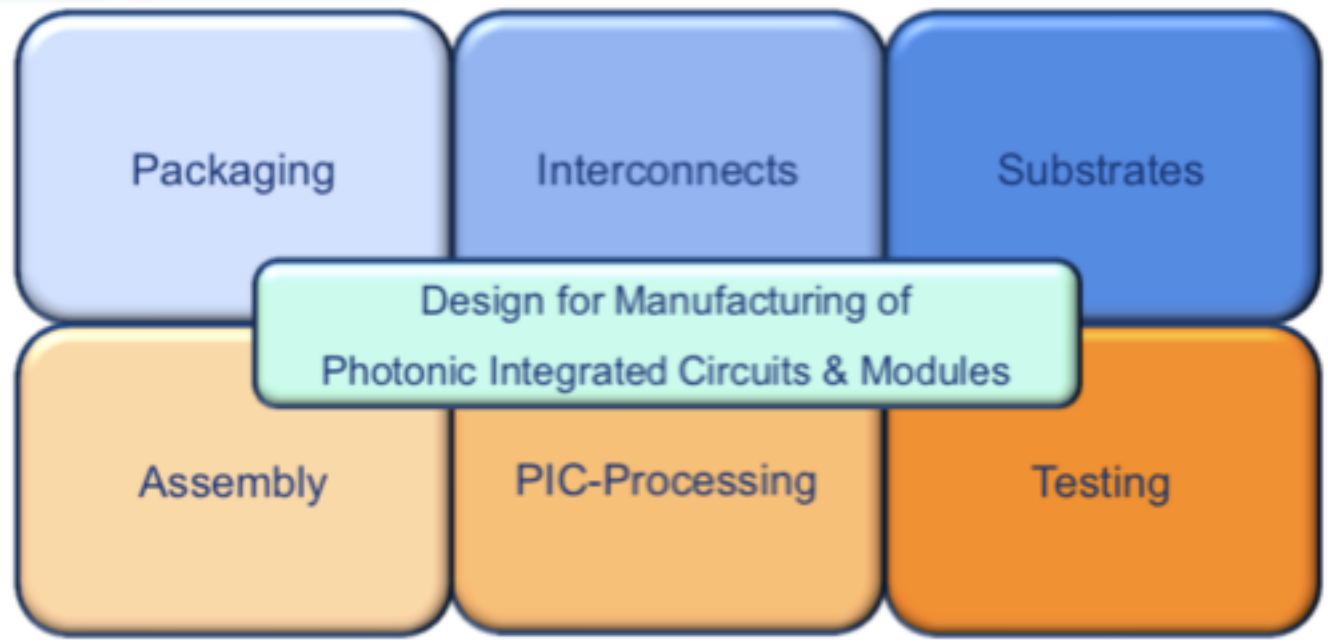
Technical content

Packaging is going to require short term attention



Technical content

Scalability of manufacturing requires focus on ***Design for Manufacturing*** of Photonic Integrated Circuits and Systems



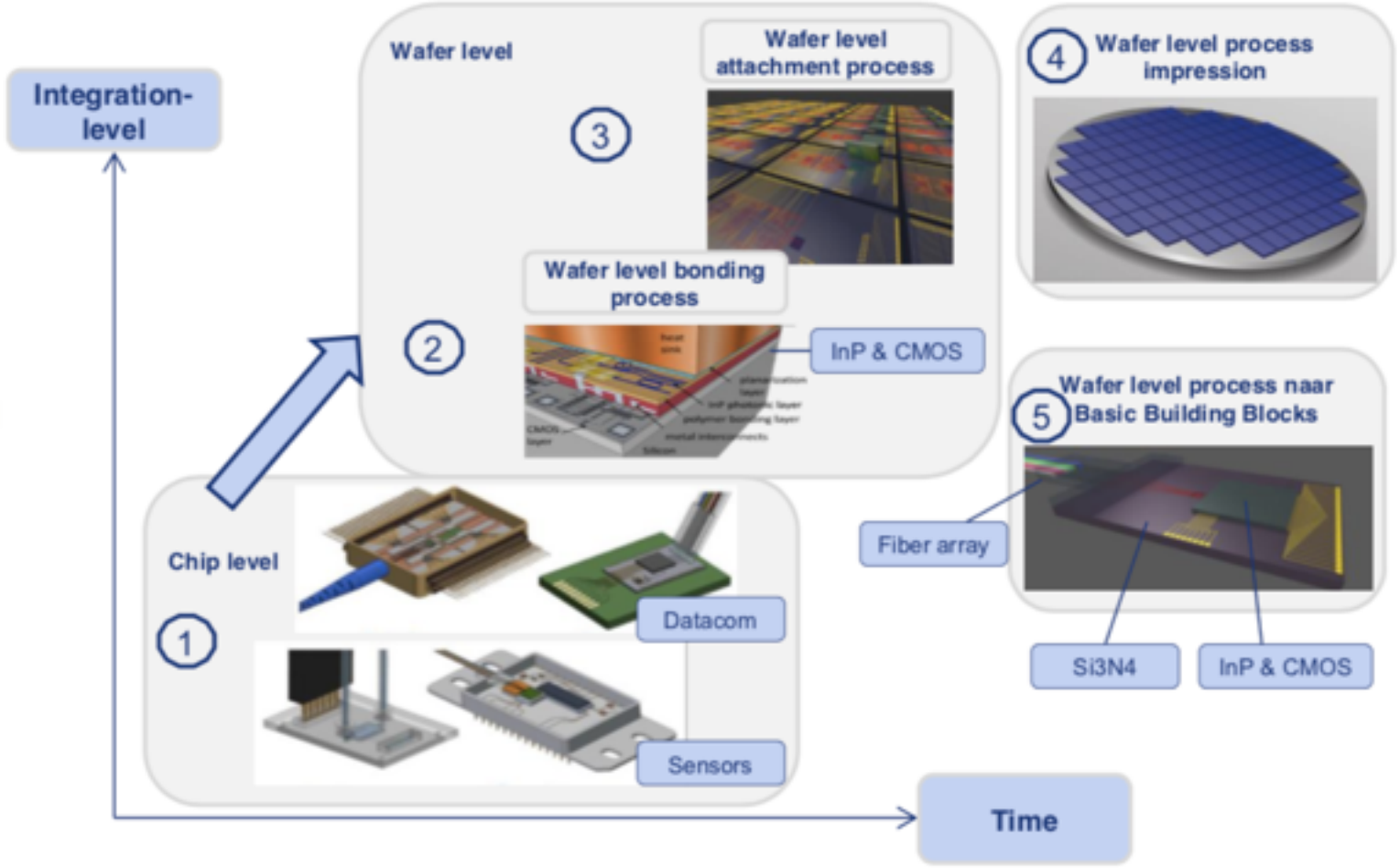
Courtesy: Paul van Dijk, Yi Quan, Erik Teunissen

Technical content

Photonic Integration Technology Centre

Level of Integration: Platforms

- Chip level integration(1)
- Wafer level integration
  - Bonding of wafers (2)
  - Attachment of circuit elements (3)
- Impression of PICs on wafer (4)
- Easily connectable Building Blocks architectures (5)



Technical content

Photonic Integration Technology Centre

Technical content

PLATFORMS	INP	SI3N4/TRIPLEX	SOI	GAAS	POLYMEREN
Operating optical window (nm)	1300 - 2000	400 - 2350	1300 - 2000	700 - 1000	400 - 1000
Wafer Size	3" - 4" - 5" - (6")	4" - 6" - (8")	4"- 6"- 8" -12"	3" - 4"- (6")	spinning on any substrate
Index & (contrast %)	3,4 (10 %)	1,8 (25 %)	2,5 (>100%)	3,2 (10%)	1.8 (< 10%)
Bending radius	100 µm	> 50 µm	>10 µm	100 µm	> 500 µm
Attenuation (dB/cm)	2,5	< 0,1	3-4	5	< 0,1
Birefringence	< 1 x 10-4	< 1 x 10-4	> 1 x 10-3	< 1 x 10-4	nvt

PLATFORMS	INP	SI3N4/TRIPLEX	SOI	GAAS	POLYMEREN
Footprint (typical PIC size)	200 x 300 µm	2.000 x 4.000 µm	200 x 300 µm	-	3.000 x 4.000 µm
CMOS compatibility	no	yes	yes	no	yes
Fiber chip coupling	accurate align-ment via edge coupling	very good edge coupling	accurate align-ment via grating couplers	-	easy
PIC Cost	moderate	Good	moderate	-	low
Packaging Cost	challenging	Good	challenging	-	low

PLATFORMS	INP	SI3N4/TRIPLEX	SOI	GAAS	POLYMEREN
Applicaties	datacom, inter-connects, Tunable lasers, optical switches, trans-ceivers, optical amplifiers, WDM devices, receivers	datacom, intercon-nects, visible light sensors, anten-na's, OCT, lab-on-chip, hybrid lasers with InP, 5G, RF analogue links	datacom, inter-connects, sen-sors, receivers, WDM devices	datacom transcei-vers, high power lasers	optical intercon-nects

Technical content

Topics morning	Co chair 1	Co chair 2	Moderator
Ecosystems	Peter van Arkel	Bob Pfahl	Peter van Arkel
Tele/datacom	Michael Lebby	Michael Robertson	Wouter Verbeek
Agri, Health, Industry	Thierry Robin	Ben Miller	Niki Lintmeijer
Auto, Aero, Defence	Domenico D'Agostino	John Mckaay	Paul Pietersma
EPDA/PDK/Building Blocks	Twan Korthorst	Paul van Dijk	Martijn Röfenkamp
Front-end	Meint Smit	Lionel Kimmerling	John Eisses
Back-end	Peter O'Brien	Dick Otte	Erik Teunissen
Testing	Sylwester Latkowski	Anna Nikiel	Emmy Hertogh

Topics afternoon	Co chair 1	Co chair 2	Moderator
Tele/datacom 1 (Short haul)	Michael Lebby	Boudewijn Doctor	Martijn Röfenkamp
Tele/datacom 2 (Wireless)	Peter Maat	Sami Musa	Wouter Verbeek
Tele/datacom 3 (Long haul)	Michael Robertson	Paul van Dijk	Paul Pietersma
Healthcare	Thierry Robin	Peter Harmsma	Niki Lintmeijer
Automotive	Domenico D'Agostino	Twan Korthorst	Emmy Hertogh
Industrial equipment	Christophe Baum	Frank Shephard	Peter van Arkel
Agri-food	Rick van der Zedde	Aura Higuera Rodriguez	John Eisses
Defence/Aerospace	Dan Hamerson	John Mckaay	Erik Teunissen

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Outcome

- Full agreement has been achieved on true integration of the established US and European initiatives ⇒ IPSR-I
  - First Global Roadmap release at Spring meeting 2019
- The process for getting integration of the various roadmaps and international contribution and contributors is agreed
- Agreement is achieved on the structure of the IPSR-I document
- The meeting schedule for the *IPSR-I* is agreed and confirmed
- **Detail left to be resolved**: ***Long term financing of Roadmap development activities***

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Next steps

- Merge working groups to deliver their results timely to meet the tight schedule.
- Create a formal governance structure for IPSR International.
- Consultants of Berenschot will assist the merger process
- Merge IPSR and WRIP by:
  - Setting table of contents
  - Discuss and set template with Working group leaders, chapter by chapter
  - Merge working groups and documents, paragraph by paragraph
  - Gap and overlap analysis (with full team)
  - Validation & editorial

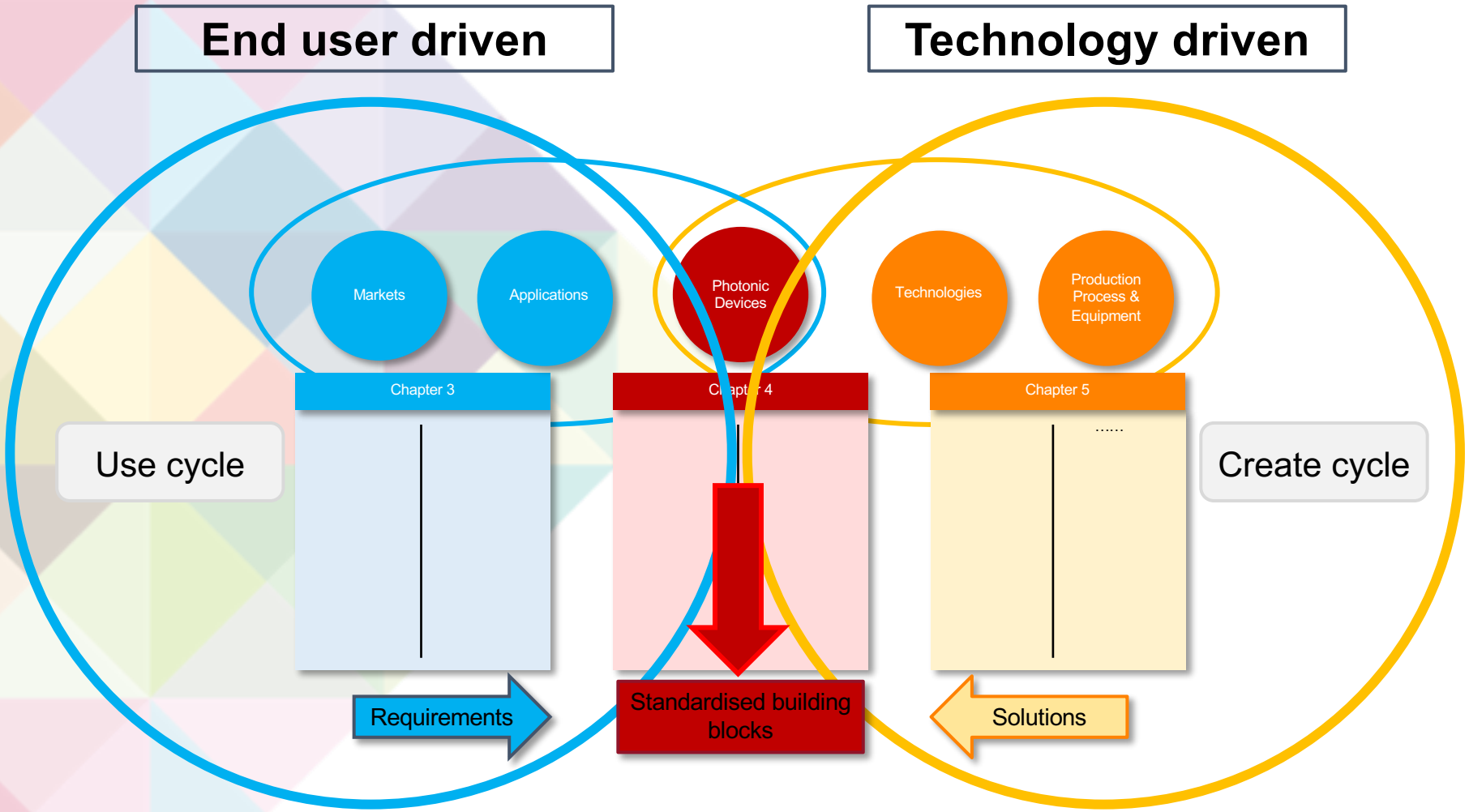
Time schedule merger

Activity	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Discussions on template												
Merge working groups												
Gap and overlap analysis												
Validation & editorial												
Publication												
Make a glossy version												
Meetings					Fall		Winter		Spring			WT MF

Time schedule

- Status, Progress and Consolidation meetings
  - Fall Meeting MIT, Boston, USA - Nov 29-30, 2018
  - Winter Meeting AIST, Tsukuba or Tokyo, Japan - January 2019 (exact place and date will be announced)
  - Spring meeting, California, USA – 20th – 21st of March 2019
  - Summer meeting Heinrich Hertz, Berlin, Germany - June 12-14, 2019
- Draft versions of IPSR-I to be discussed in Fall Meeting (Boston) and Winter Meeting (Japan)
- Release of first IPSR-I document during the Spring Meeting

Create and use cycle of the Basic Building Blocks “Library”



Use cycle

The application builders use the standardised building blocks in new applications for the end customers. This will generate new demands from the market side.

Create cycle

The PIC producers and designers constantly develop new standardised building blocks which are fully tested and validated.

TOC proposal

Photonic Integration Technology Centre

- Product Emulator Groups (PEGs)
  - Data Center/Telecom
  - Internet of Things
  - Automotive
  - Aerospace
  - Bio photonics and medical
  - Agrofood
  - Defense
- Photonic devices (PEGs and TWGs)
  - Integrated photonic components and devices
  - RF Photonics
  - Electronic-Photonic Connectors
  - Integrated Photonic Sensors
  - Cost Emulators
  - Electronic Photonic Design Automation
  - Process Design Kits
  - Product standardization and structure
- Technology Working Groups (TWGs)
  - Monolithic Silicon Integration
  - Indium Phosphide & 3-5 Compounds
  - Silicon Nitride
  - Novel materials
  - Foundry Integration for photonics
  - Heterogenous Integration
  - Electronic-Photonic Packaging
  - Substrates
  - Electronic-Photonic Assembly
  - Electronic-Photonic Test

Start-point template for TWG chapters

Photonic Integration Technology Centre

- Executive Summary (~1page of highlights)
- Introduction (2 or 3 pages)
- Situation (Infrastructure) Analysis (5-10 pages)
  - Manufacturing Equipment
  - Manufacturing Process
  - Materials
  - Quality/Reliability
  - Environmental Technology
  - Test, Inspection, Measurement (TIM)
- Roadmap of Quantified Key Attribute Needs (3 to 5 pages)
- Critical (Infrastructure) Issues (3- 6 pages)
- Technology Needs: (6-15 pages)
  - Prioritized Research Needs (> 5 years result)
  - Prioritized Development & Implementation Needs (< 5 years result)
- Gaps and Showstoppers (2-5 pages)
- Recommendations on Potential Alternative Technologies (2-4 pages)
- Contributors (~1page)

Discussion

Thank you for your attention!

During the first nine months of the MOU between IPSR and Photon Delta

- Combine their Roadmapping activities into a single activity.
- Publish a merged roadmap by March 2019.
- Develop a more formal governance structure for IPSR International.
- Hold four international Roadmapping workshops
  - Fall 2018 IPSR-I Meeting, November 29-30, MIT Samberg Meeting Center, Cambridge, MA
  - Winter 2019 IPSR-I Meeting; January 31-February 1、2019, University of Tokyo
  - Spring 2019 IPSR-I Meeting, March 20-21 2018, Sunnyvale California
  - Summer 2019 IPSR-I Meeting, June 12-14, Berlin, Germany

www.photonicsmanufacturing.org

IPSR INTERNATIONAL

For additional information:

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