

HIR Roadmap Workshop Presentation 2017

Heterogeneous Integration Roadmap
Presented by William (Bill) Chen

Presentation Agenda

1. Technology Roadmaps for the Electronic Industry

- The Beginning of ITRS
- A different world
- The end of ITRS

2. Heterogeneous Integration Roadmap (HIR)

- The re-invention of Technology Roadmap
- CPMT , SEMI, EDS, Photonics & ASME EPPD Collaboration
- HIR Mission Statement
- Technical Working Groups

3. HIR today and 2016 Schedule

4. Summary

Historical Transition Of ITRS

US Domestic

1991
Micro Tech 2000
Workshop Report

1992 NTRS

1994 NTRS

1997 NTRS

Odd Year: Major Revision
Even Year: Table Update

International

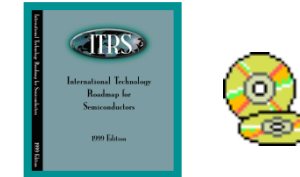
Update Version

2003 ITRS



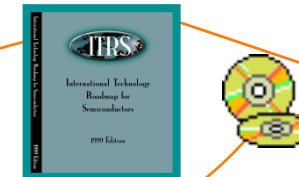
2002 Update Version

2001 ITRS



2000 Update Version

1999 ITRS

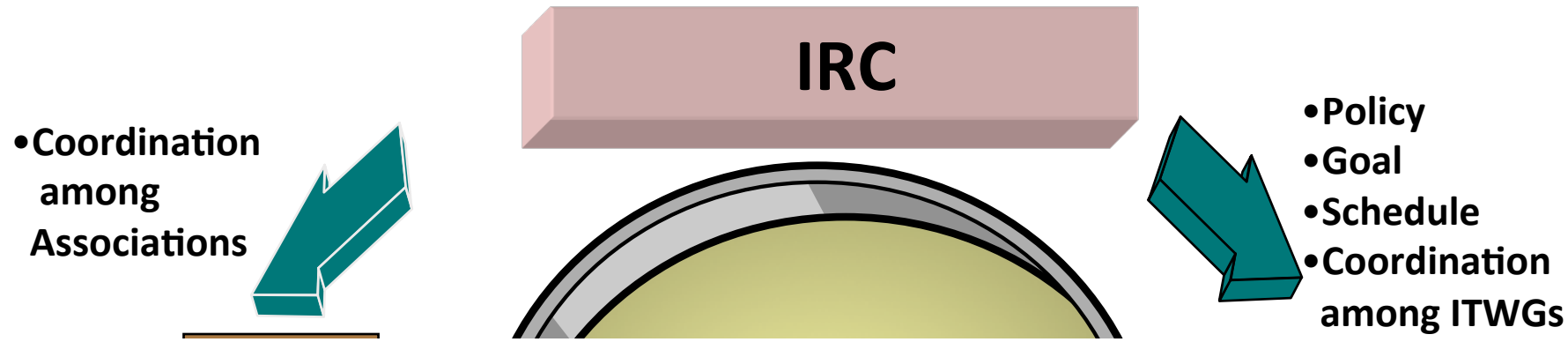


1998 Update Version

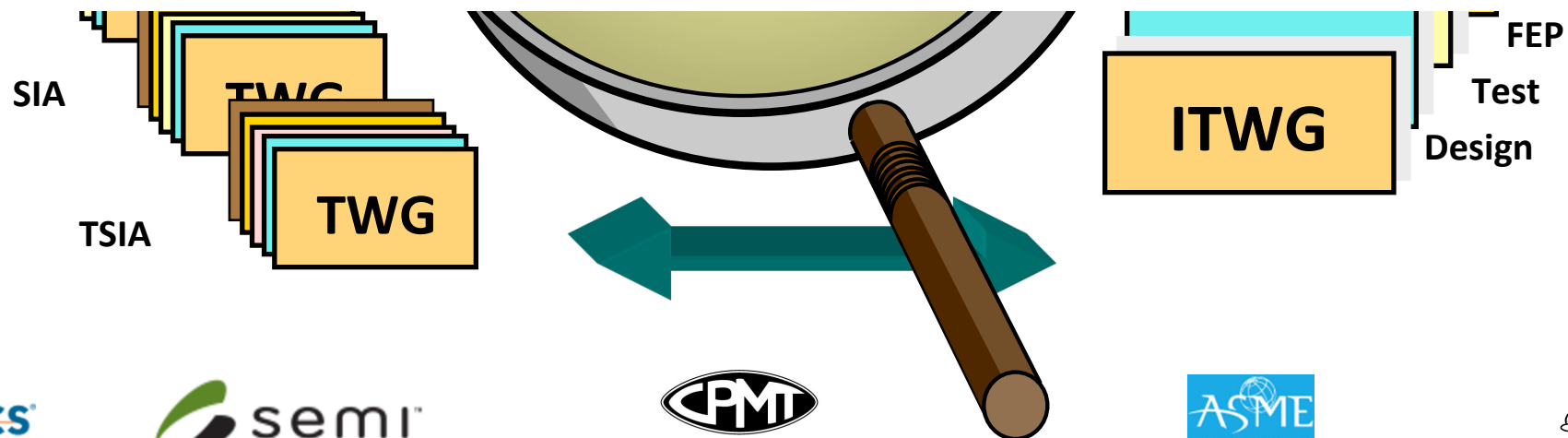
1998

World Semiconductor Council

ITRS Structure IRC & TWGs



In 2014 ITRS 2.0 was created to add an overlay of 7 focus teams. One of the Focus teams, Heterogeneous Integration, was tasked to address market changes.



Technology Roadmaps Proliferated

-- Shortly after the iNEMI Roadmap was established in 1994, a collaboration between iNEMI and the ITRS Assembly and Packaging Technical Working Group began, which continued through the 2015 edition of the ITRS

-- Jisso Roadmap, established in Japan in 2001, expanded the Technology Roadmap to cover a broader range of technology from design to systems

-- IPC established a roadmap in 2006

-- Many new roadmaps appeared with variations in focus ranging from the EPC Roadmap with RFID focus to MIT's Communications Technology Roadmap, and the NIST sponsored PSMC Roadmap.

23 years later...



....the world has evolved and is changing in ways never imagined.

World largest companies by market capitalization

Source: The Economist, September 17th 2016. Special Report Companies, page 5.

2006 DEC 31st

- Exxon Mobil
- General Electric
- Gazprom
- Microsoft
- Citicorp
- Bank of America
- Royal Dutch Shell
- BP
- Petro China
- HSBC

2016 Aug 24th

- Apple
- Alphabet (Google)
- Microsoft
- Berkshire Hatheway
- Exxon Mobile
- Amazon
- Facebook
- Johnson & Johnson
- General Electric
- China Mobile

Companies in the in the Increasingly Connected World

Source: The Economist, September 17th 2016. Special Report Companies, page 5.

2006 DEC 31st

- Exxon Mobil
- General Electric
- Gazprom
- Microsoft
- Citicorp
- Bank of America
- Royal Dutch Shell
- BP
- Petro China
- HSBC

2016 Aug 24th

- Apple
- Alphabet (Google)
- Microsoft
- Berkshire Hatheway
- Exxon Mobile
- Amazon
- Facebook
- Johnson & Johnson
- General Electric
- China Mobile



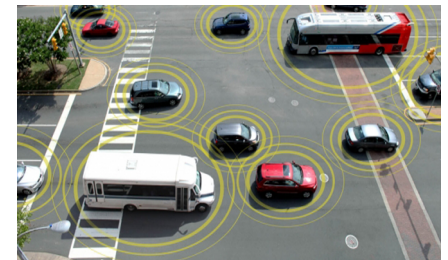
IoT to IoE

**Smart devices
everywhere**



**Data to the
clouds**

**Future Automotive
a reality**



The End Of The ITRS

-- The brave new connected world, IoT/loE, Smart Devices & Migration to the Cloud can no longer be paced by Moore's Law Scaling of CMOS

-- SIA announced in fall of 2015 that ITRS will be brought to closure with the 2015 Edition. The final ITRS edition was published July 8th 2016.

-- IEEE CPMT Society started planning for the Heterogeneous Integration Roadmap (HIR) Initiative to fill the void in 2015. Discussions ensued with EDS & SEMI to reinvent the Technology Roadmap for today's market & technology needs and look ahead 15 years into the future.

Heterogeneous Integration Roadmap

Re-inventing the Technology Roadmap for the Electronic Industry

Focused on System Level Integration of Diverse Components for the world of IoT/loE, Smart Devices and migration to the Cloud

Semiconductors-Sensors-MEMS-Photonics-Systems

IEEE CPMT Initiative to Continue Heterogeneous Integration Roadmap Mission

-- The CPMT Society believes it is important to continue this Heterogeneous Integration Roadmap function for the profession, industry and the entire technical community.

-- The Board decided to bring the Heterogeneous Integration Roadmap function and activities into CPMT, with the intention of expanding the collaboration to include other IEEE Technical Societies and others organizations that shares the vision.

-- In March 2016, CPMT Board formally endorsed launching the Heterogeneous Integration Roadmap.

HIR Collaboration

- SEMI has a long history of collaboration with CPMT. SEMI decided to join in collaboration of the Heterogeneous Integration Roadmap Initiative in April, a month after the vote of the CPMT BoG.
- IEEE Electron Devices Society (EDS) Board & Photonics Society Boards voted to join in the HIR collaboration.
- Last month ASME Electronic & Photonics Division (EPPD) voted to join in HIR collaboration

Today five organizations CPMT, SEMI, EDS , Photonics & ASME EPPD are working together in collaboration to deliver this Heterogeneous Integration Roadmap to serve our profession, industry, academia, and research institutes, to meet the challenges of this new world of rapid market disruption and bold technology innovation.

Heterogeneous Integration Defined

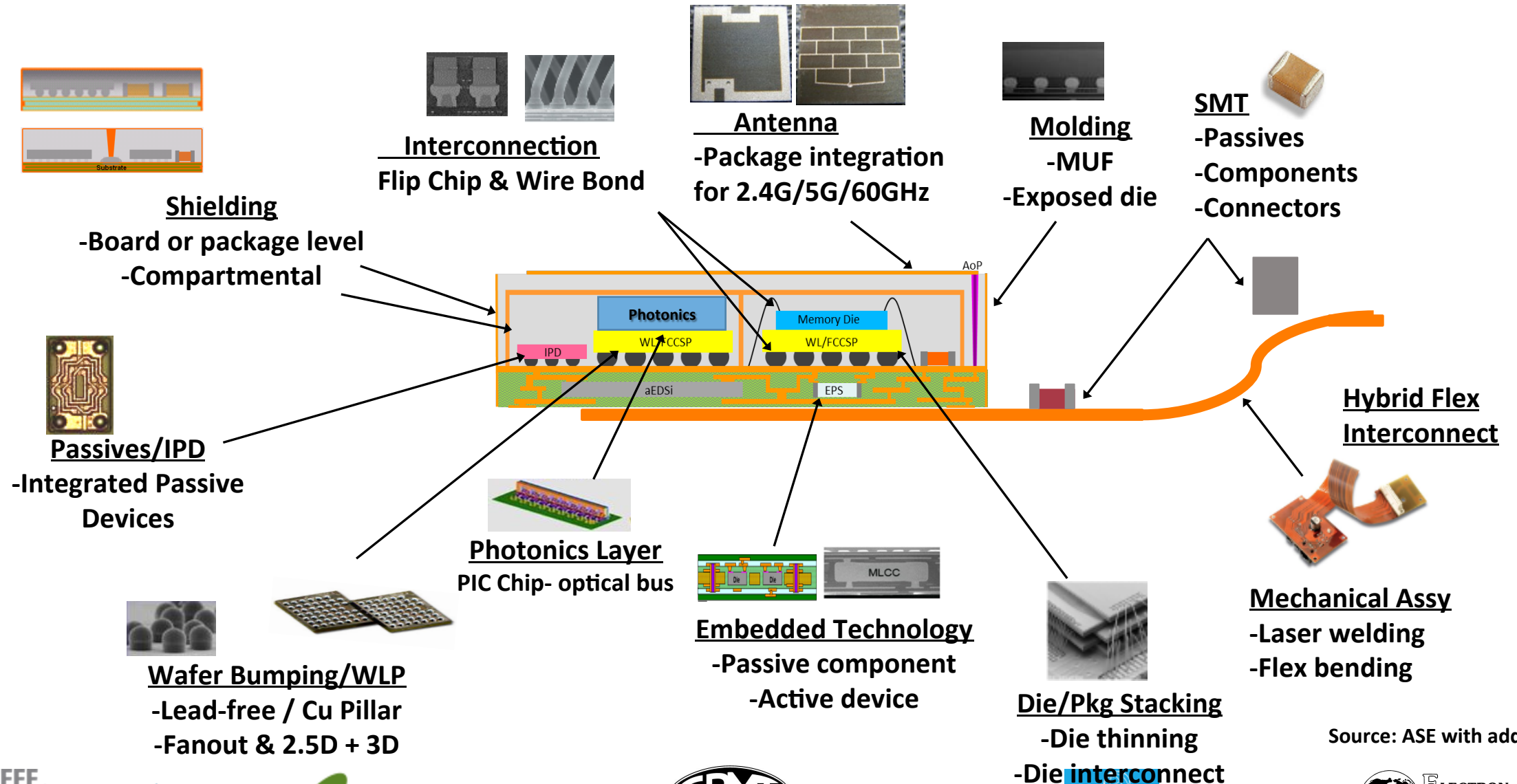
Heterogeneous Integration refers to the integration of separately manufactured components into a higher level assembly (SiP) that, in the aggregate, provides enhanced functionality and improved operating characteristics.

In this definition, components should be taken to mean any unit whether individual die, MEMS device, passive component and assembled package or sub-system that are integrated into a single package. The operating characteristics should also be taken in its broadest meaning including characteristics such as system level performance and cost of ownership.

HIR Mission Statement

The mission of this Heterogeneous Integration Roadmap is to provide guidance to the profession, industry, academia and government to identify key technical challenges with sufficient lead time that they do not become roadblocks preventing the continued progress in electronics. That progress is essential to the future growth of the industry and the realization of the promise of continued positive impact on mankind. The approach is to identify the requirements for heterogeneous integration in the electronics industry through 2031, determine the difficult challenges that must be overcome to meet these requirements and, where possible, identify potential solutions.

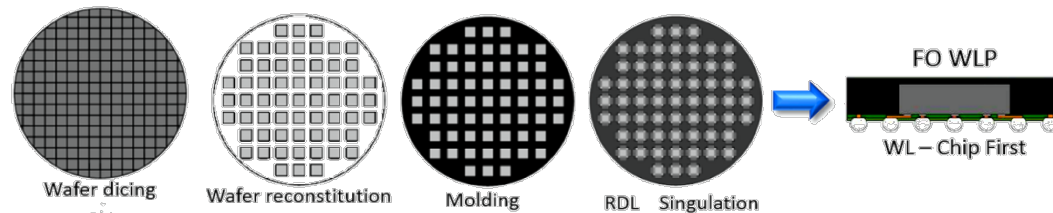
Electronic/Photonic SiP through Heterogeneous Integration



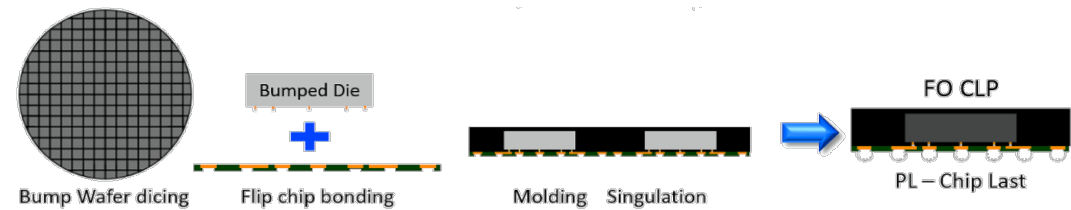
Source: ASE with additions

Fan Out SiP

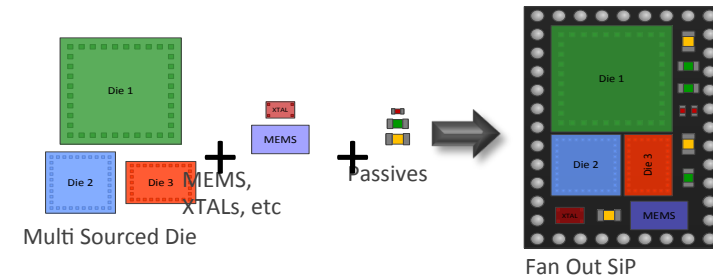
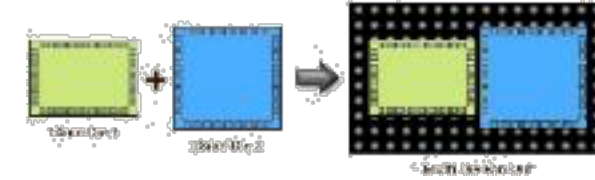
- Heterogeneous Integration
 - Multi-die, Passives, MEMs/Sensor
 - System in Package (SiP)
 - Chip First and Chip Last



FO Chip First (eWLB Like)



FO Chip Last Package FOCLP



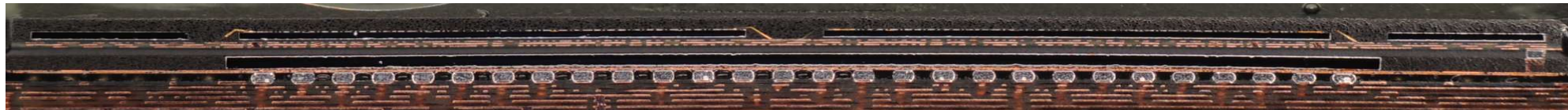
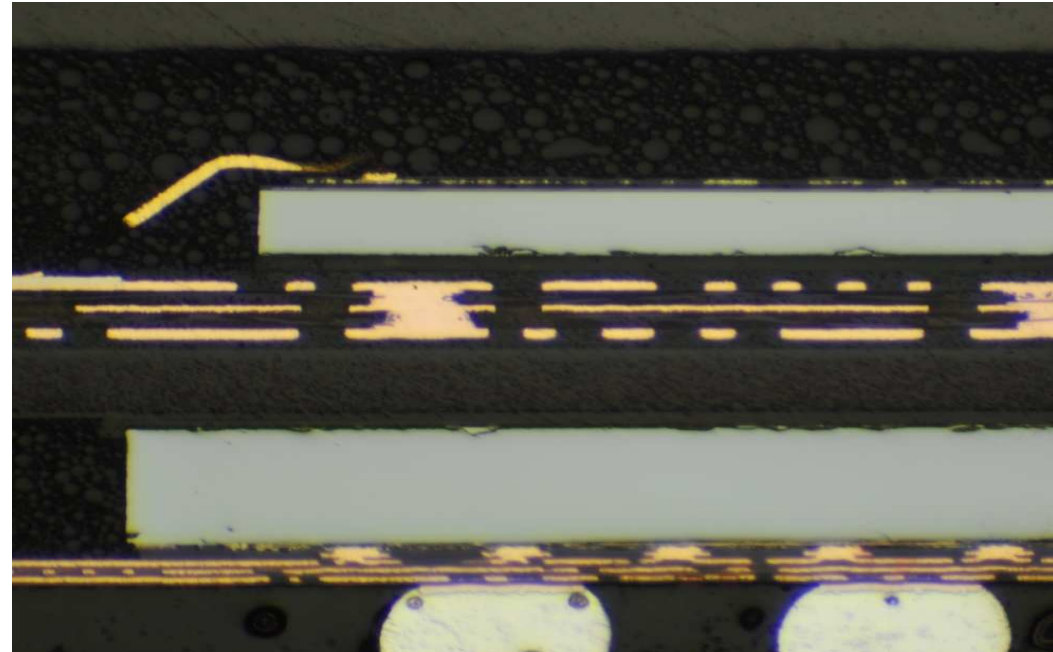
iPhone 7 Processor – Memory Heterogeneous Integration

Source: Prismark Partners

916.6/193bp

APPLE A10 FUSION

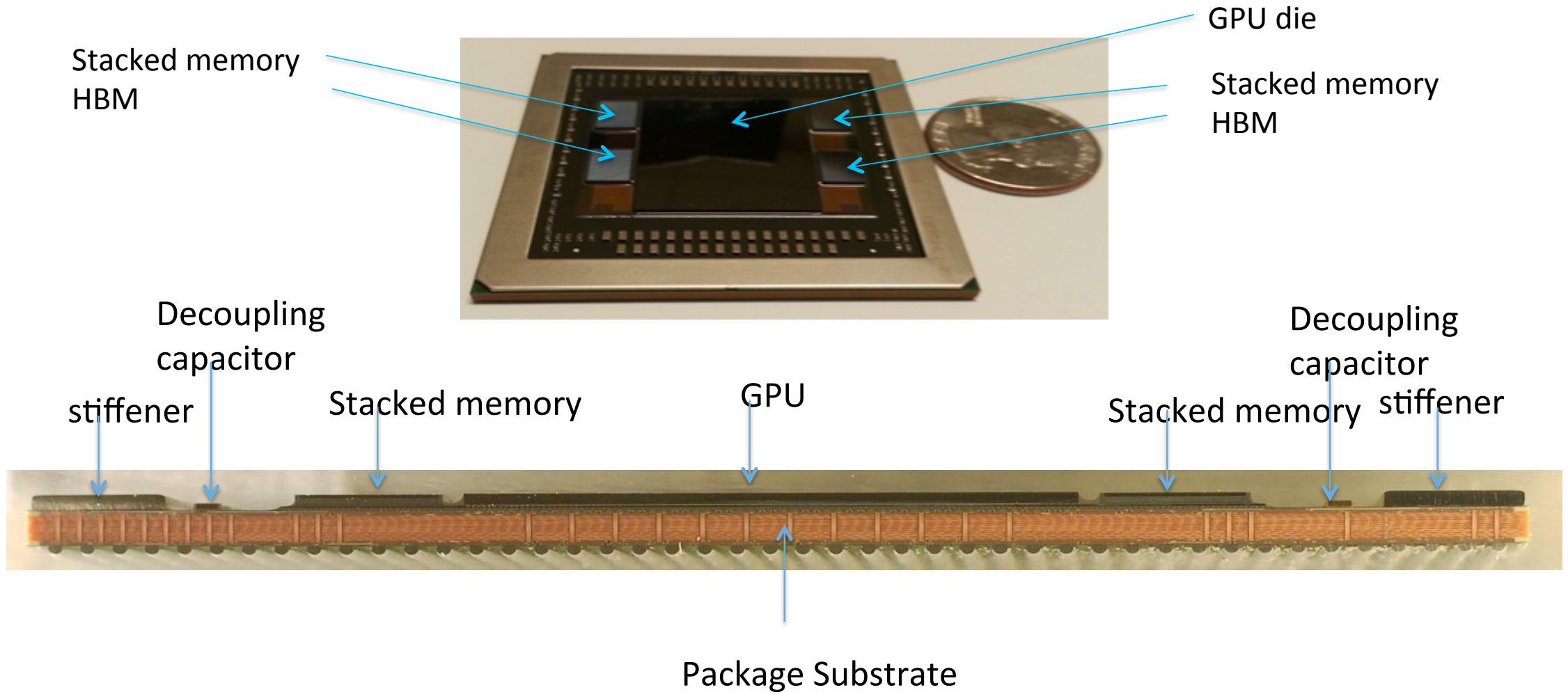
- 14.4 x 15.5mm InFO PoP Package
 - ~1300 balls at 0.4mm pitch
 - 825 μ m package height
- Memory package with 5 die (4 shown)
 - Die Thickness: 105 μ m
 - 170 μ m EMC thickness over die
 - 3L substrate; 100 μ m thick
 - 386 balls at 0.3mm pitch
 - Underfill between packages
- Processor : 11.6 x ~10.8mm
 - 165 μ m thick; 12 μ m “top coat”
 - 50 μ m thick 3 Layer RDL



Photos source: Prismark/Binghamton University

AMD Fiji (2.5D) Package

Source: ASE



HIR TECHNICAL WORKING GROUPS (TWGs)

Heterogeneous Integration Components

1. Single Chip and Multi Chip Packaging (including Substrates)
2. Integrated Photonics
3. Integrated Power Devices
4. MEMS & Sensors
5. RF and Analog Mixed Signal

Cross Cutting topics

6. Materials & Emerging Research Materials
7. Emerging Research Devices
8. Interconnect
9. Test

Integration Processes

10. SiP
11. 3D +2.5D
12. WLP (fan in and fan out)

Packaging for Specialized Applications

13. Mobile
14. IoT, Wearable & Consumer Electronics
15. Medical and Health
16. Automotive
17. High Performance Computing

Design

18. Co-Design & Simulation – Tools & Practice

Device, package, subsystem & system levels

HIR is adding a Supply Chain TWG focused on pre-competitive requirements with Leadership from Intel

From ITRS to HIR

ITRS: 1991 - 2015

- Precompetitive
- 15 years outlook & 25 years for emerging materials & devices
- Sponsored by five global semiconductor associations. Appoint IRC & approve governance
- Volunteer driven
- Free access
- CMOS “Moore’s Law” node driven
- 17 Technical Working Groups

HIR: 2016 --

- Precompetitive
- 15 years outlook & 25 years for emerging materials & devices
- Sponsored by IEEE technical societies & organizations with similar outlook. Appoint IRC & approve governance
- Volunteer driven
- Free access
- Systems & application driven
- 19 Technical Working Groups

Heterogeneous Integration Roadmap

- Roadmap Web Link

<http://cpmt.ieee.org/technology/heterogeneous-integration-roadmap.html>

- Background
- Mission
- Purpose
- Committee
- Scope
- Schedule

- Roadmap Committee

- William Chen , W. R Bottoms, Tom Salmon, Subu Iyer, Amr Helmy, Ravi Mahajan

How do we get HIR off the Ground ?

Global Technical Conferences & Chapter workshops to meet face to face with the technical community and interested contributors worldwide

Calendar Of HIR 2016 Events

1. [ECTC + ITherm](#) Las Vegas, NV USA 05/31- 06/04
2. Palo Alto Workshop before SEMICON WEST, July 10th 2016
3. [SEMICON WEST](#) San Francisco, CA USA, July 11th, July 11th , 2016
4. Japan August 9th, 2016 at the Nagase R&D Center in Tokyo
5. Taiwan at ITRI August 12th, 2016
6. ICEPT in Wuhan, China August 16th, 2016 <http://www.icept.org/en/>
7. [ESTC](#) Grenoble, France September 13th , 2016
8. IEMT-EMAP Penang, Malaysia September 20th, 2016
9. [ELECTRONICS PACKAGING SYMPOSIUM](#) Binghamton, NY USA October 5th , 2016
10. [IMPACT](#) Taipei, Taiwan October 26th , 2016
11. [ICSJ](#) Kyoto, Japan November 7th, 2016
12. MEPTEC Heterogeneous Integration Roadmap Symposium, Holiday Inn, San Jose, Ca. November 14th , 2016
13. [EPTC](#) Singapore November 30th , 2016
14. [IEDM](#) San Francisco December 2016

HIR Conference Presentations 2016

- ConFab CPMT Session Las Vegas June 14th - Bill Bottoms
- 3D PEIM Conference NC State June 14th – Bill Chen
- ASME InterPack Workshop June 21st – Bill Chen
- MIT Microphotonics Center June 25th – Bill Bottoms
- SEMICON West July 13th – Bill Bottoms & Bill Chen
- IEMT-EMAP Conference, Penang, Sept 20th – Bill Chen

**These presentations are resulting in many groups engaging
in collaboration with HIR**

HIR 2017 Planned Events

1. [ICEP 2017](#) (JIEP) Yamagata Japan 4/19-22
2. [ECTC](#) Orlando, FL, USA 5/30-6/04
3. Palo Alto Workshop before SEMICON WEST, Palo Alto, CA, USA 7/9
4. [SEMICON WEST](#) San Francisco, CA USA 7/10
5. InterPACK (ASME) San Francisco, CA, USA 8/29-9/1
6. [ELECTRONICS PACKAGING SYMPOSIUM](#) , Niskayuna NY, USA 9/19-20
7. IEEE PHOTONICS CONFERENCE, Lake Buena Vista, FL, USA, 10/1-5
8. [IMPACT](#) Taipei, Taiwan 10/25-26
9. [ICSJ](#) Kyoto, Japan 11/20-22
10. [EPTC](#) Singapore 12/3-5
11. August Asia workshops under planning
 - A. [ICEPT](#), Harbin China 8/16-19
 - B. ITRI in Hsinchu, Taiwan
 - C. Tokyo workshop with CPMT Japan, JIEP & SEMI Japan

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HIR Roadmap Collaborations & Global Outreach

Technical Organizations



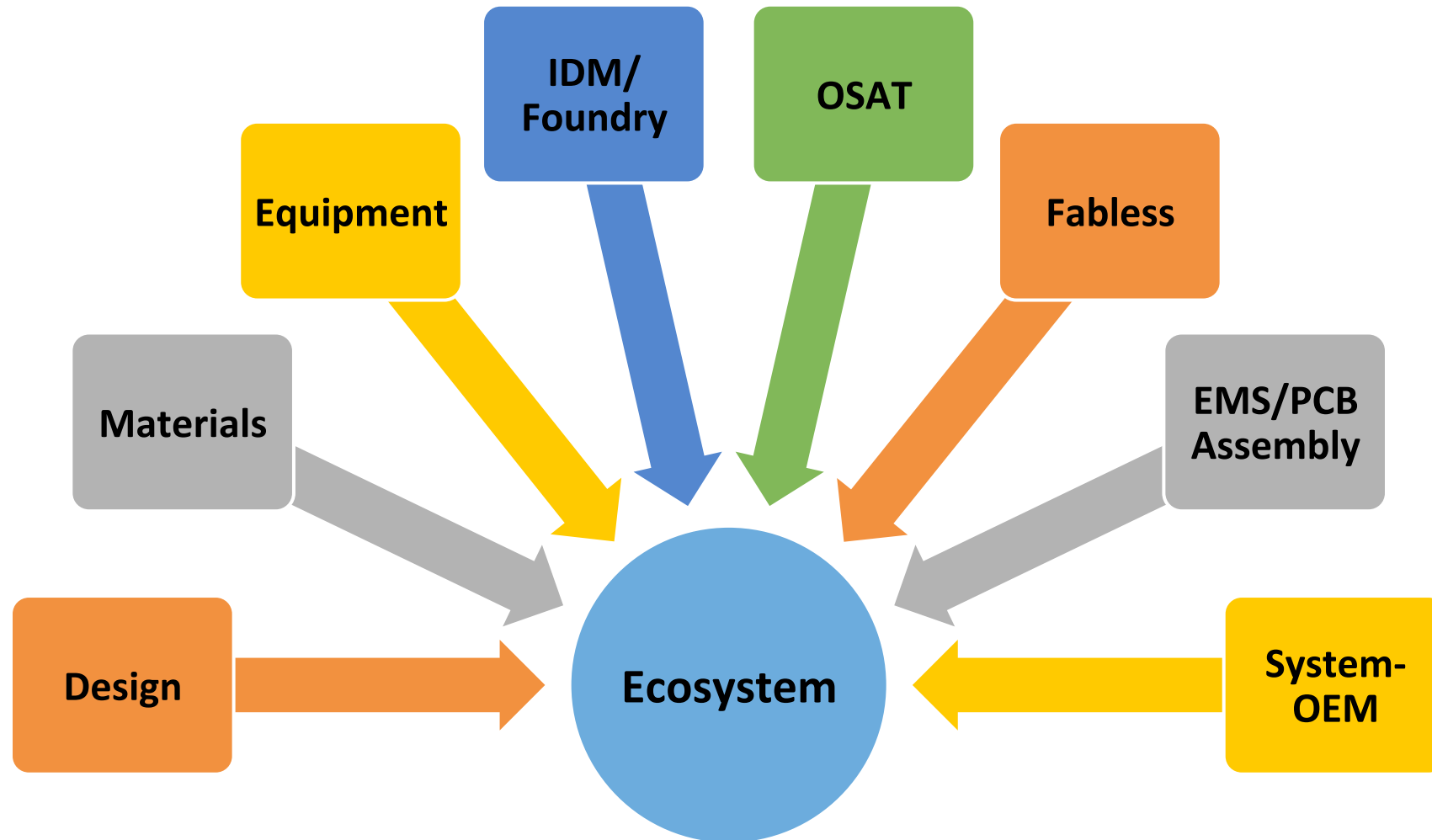
- MEPTEC
 - Joint Heterogeneous Integration Symposium at San Jose Holiday Inn November 14th, 2016
- IEEE Power Electronics Society
 - Joint planning and cooperation ongoing.
- IEEE Nanotechnology Council
 - Discussion initiated
- ITRI (Taiwan)
 - Workshop Sponsor August 11, 2016
 - Discussion ongoing

Technology Roadmaps



- International Electronic Manufacturing Initiative (INEMI) Roadmap
- PSMR
 - NIST, AIM Photonics, MIT Photonics & INEMI
- IRDS
 - IEEE Standards Association
- Wide Band Gap Semiconductor Devices
 - IEEE Power Electronic Society

HIR: Full Ecosystem Collaboration



Face To Face Workshops July 2016

Other participants on WebEx Connection



Face To Face Workshops August 2016



Tokyo, Japan August 9, 2016
110 Participants

Face To Face Workshops August 2016



Hsinchu, Taiwan August 11, 2016
102 Participants

Face To Face Workshops August 2016



Wuhan, China August 12, 2016
70+ Participants

Summary

- In this era of IoT quickly becoming IoE, big data & analytics to the Cloud, and smart devices everywhere, the roadmap must be reinvented to meet the needs of our profession, industry, academia, and research institutes.
- The Heterogeneous Integration Roadmap (HIR) brings together the total ecosystem from system to device, from equipment to material, from design to manufacturing, and from research to industry.
 - Identifying difficult challenges
 - Proposing potential solutions where possible

**Projecting a 15 year horizon for most areas,
with 25 years for emerging research topics**

Thank You

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