HETEROGENEOUS INTEGRATION ROADMAP

Heterogeneous Integration Roadmap

Mobile TWG

Presenter: Benson Chan

HETEROGENEOUS INTEGRATION ROADMAP

Mobile TWG Team Members

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Smart Phone – Human- Machine - Environment Interface

- Smart phones continues to be the major human-machine interface devices with its 5bn units & growing installed base.
- More functions & intelligence added to interact with human, machine and environment in the Global Digital Society

OLED Display

Dual Camera

5G

AI

3D Sensing

AR/VR

Smart Phone & Global Trade

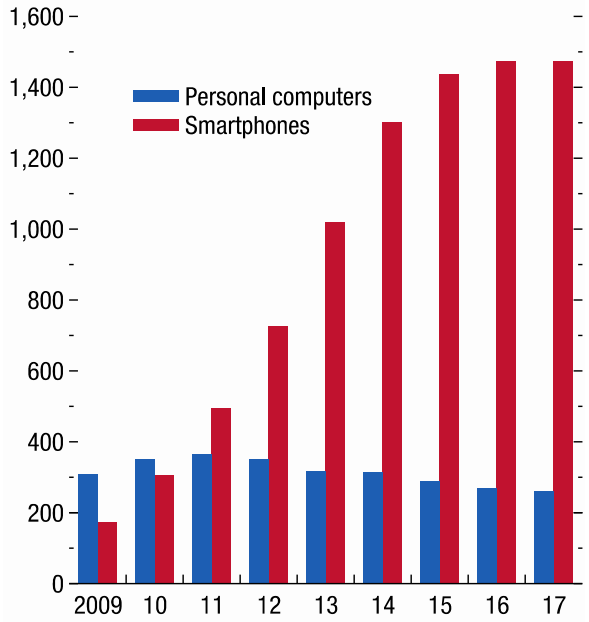
Source: World Economy Outlook IMF April 2018

"In 2017, global smartphone sales reached close to 1.5 billion units—one for every fifth person on earth (Figure 1.1.1). Demand has been driven by the increasing use of smartphones as the main computing platform across the world, substituting in part for personal computers. Mobile technology and services are estimated to have contributed $3.6 trillion (4.5 %) to 2017 global GDP (GSMA 2018)."

"Smartphones contributed about one-sixth the estimated growth rate of global trade in 2017.1 This growth was driven mainly by an increase in value added per unit, rather than units sold, which declined for the first time on record."

Source: IMF World Economy Outlook April 2018 page 34.

Figure 1.1.1. Global Sales of Personal Computers and Smartphones
(Millions of units)



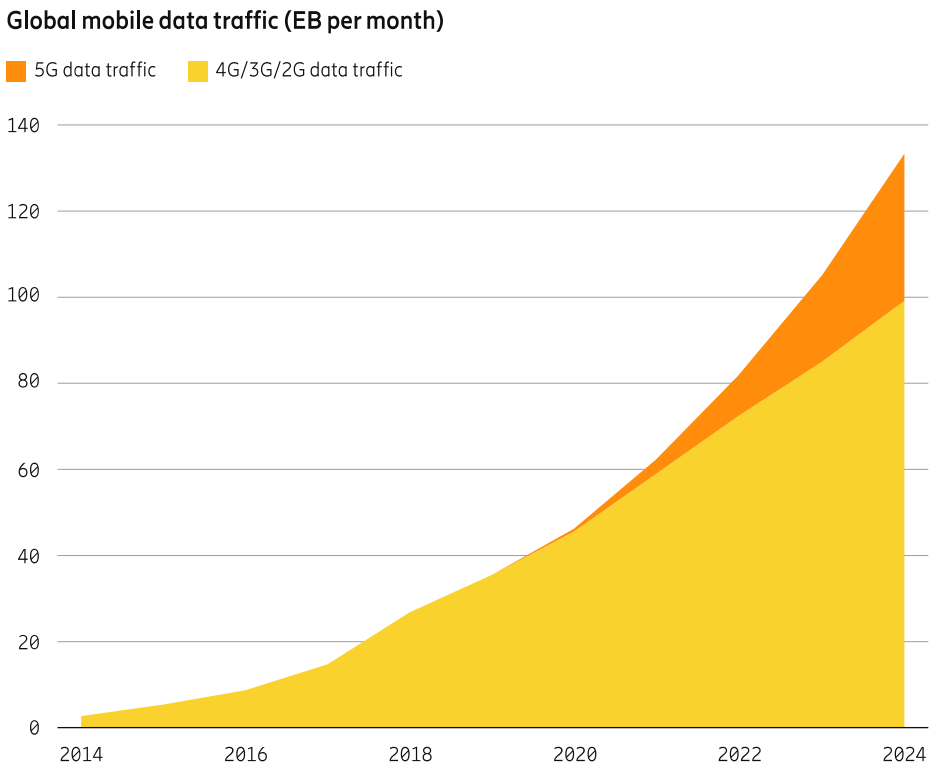
Source: Gartner; and IDC.

Smart Phone & Mobile Data Traffic

Ericsson Mobility Report World Economic Forum January 2019

"Close to 90 percent of total mobile data traffic is generated by smartphones today a figure which is projected to reach 95 percent at the end of 2024. As monthly usage per smartphone continues to increase, total mobile data traffic is predicted to rise at a compound annual growth rate (CAGR) of 31 percent over the forecast period, reaching 136 exabytes (EB) per month by the end of 2024.

It is expected that 25 percent of mobile data traffic worldwide will be carried by 5G networks at that time. This is 1.3 times more than the total traffic today. "



GLOBAL MARKET

Mobile industry contribution to GDP

4.5% $3.6tn 2017

5.0% $4.6tn 2022

Employment

Number of jobs directly and indirectly supported by mobile ecosystem

29m 2017

Smartphones

% of connections*

57% 2017

77% 2025

4G

% of connections*

29% 2017

53% 2025

5G

1.2bn 2025

14% of connections*

*Excluding cellular IoT

Internet of Things

7.5bn 2017

Total connections

25.1bn 2025

What Else Did IMF said about Smart Phone?

Source: World Economy Outlook IMF April 2018

"In the most developed markets with smart phones, today's digital consumers will likely become tomorrow's augmented customers in the 5G era; they will increasingly adopt emerging technologies such as AR/VR"

"AI will be the new frontier integrated with technology solutions and applications for smart homes, cities and buildings; and emerging services such as drone delivery, consumer & industrial robotics and autonomous cars. "

Source: World Economy Outlook IMF April 2018

A new Smart Phone Platform
The Folding Feature

Yesterday (February 20th) Samsung announced the Galaxy Fold, the long awaited Folding Smart Phone. the Samsung Galaxy Fold goes from a 4.6-inch display for phone mode and folds out to reveal a separate 7.3-inch display on the inside.

The 7.3-inch Infinity Flex display has a resolution of 2,152 × 1,536 pixels, while the previous smaller 4.6-inch display has a resolution of 1,960 × 840 pixels. The Samsung Galaxy Fold also has a 7nm processor and other functional features to support the $1989 list price.

What does Consumer want from a Smart Phone?

USA Today (February 20, 2019) Only Yesterday.

“Foldable phones, 5G and other hyped features aren't going to motivate most of you to buy a new smartphone.”

“You’re driven by something more basic – like a phone battery that’ll last a full day and beyond.

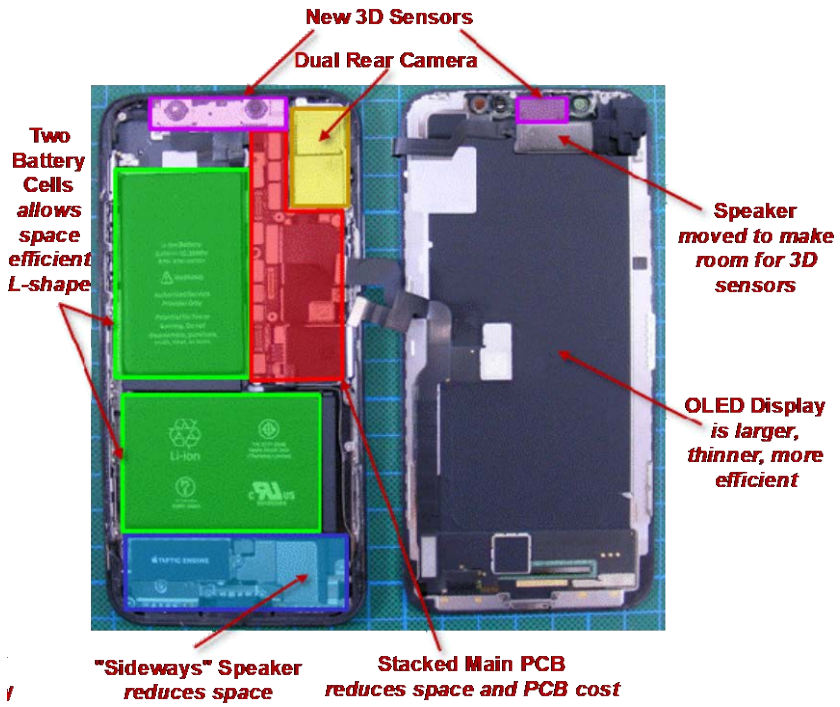
These are key takeaways from a survey of 1,303 smartphone buyers in the U.S., conducted this month on USA TODAY’S behalf”

How much space does the battery occupy?

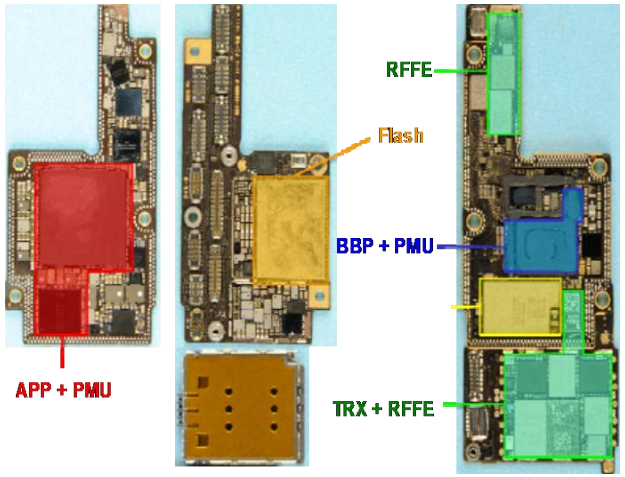
Example from Apple IPhone X

Source: Prismark Partners

Phone Assembly



Stacked Main PCB Board



PCB Footprint (1553 sq mm – 14% of the bottom frame area

Message

As the Smart Phone increase in Functions & Capabilities (such as Face Recognition and additional Camera), the pressure to shrink the the functional electronic package (14%) to give to the battery will continue.

A Great Challenge for Heterogeneous Integration & Miniaturization.

More Functions (AR/VR + 5G) in Less Space & Less Power.

Don’t forget Cost

A Quote from Gordon Moore

It may prove to be more economical to build large systems out of smaller functions, which are separately packaged and interconnected. The availability of large functions, combined with functional design and construction, should allow the manufacturer of large systems to design and construct a considerable variety of equipment both rapidly and economically.

- Reprinted from Gordon E. Moore, "Cramming More Components onto Integrated Circuits," *Electronics,* pp. 114–117, April 19, 1965.

It may prove to be more economical to build large systems out of smaller functions through Heterogeneous Integration into SiPs & Modules, which are separately packaged and interconnected. The availability of large functions, combined with functional design and construction, should allow the manufacturer of large systems to design and construct a considerable variety of equipment both rapidly and economically.

SiP/SiM Module in iPHONE 8 Main Board Assembly

HETEROGENEOUS INTEGRATION ROADMAP

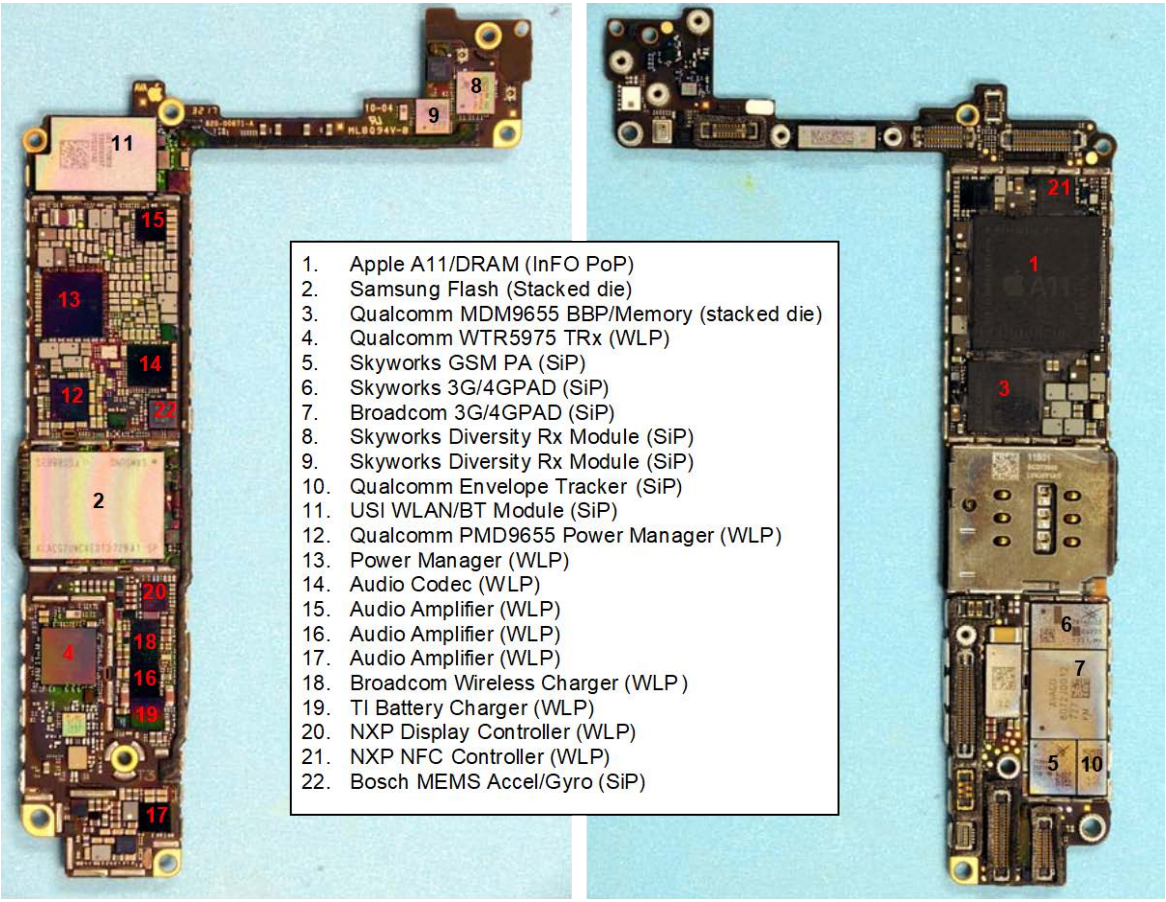


Photo source: Prismark/Binghamton University

Device Advanced Node – 10 nm

10 nm Processor/DRAM

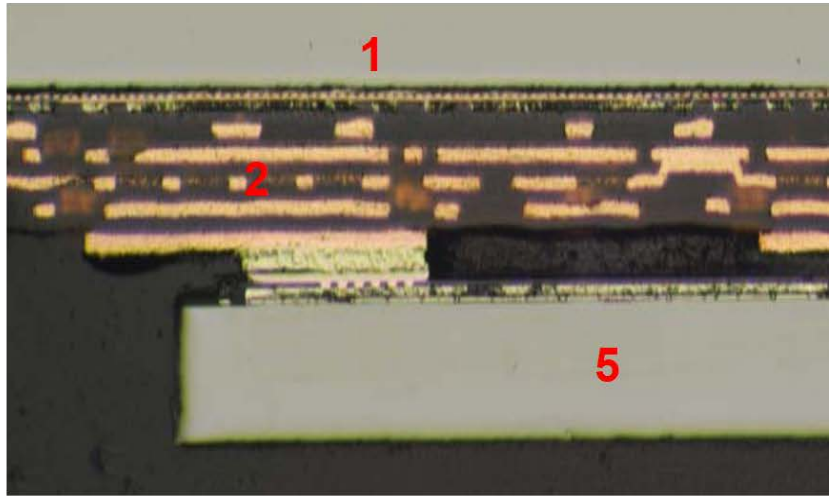
FAN OUT SiP	**1**
SiP	**8**
WLP (WLCSP)	**11**
Memory Stacked Die	**2**

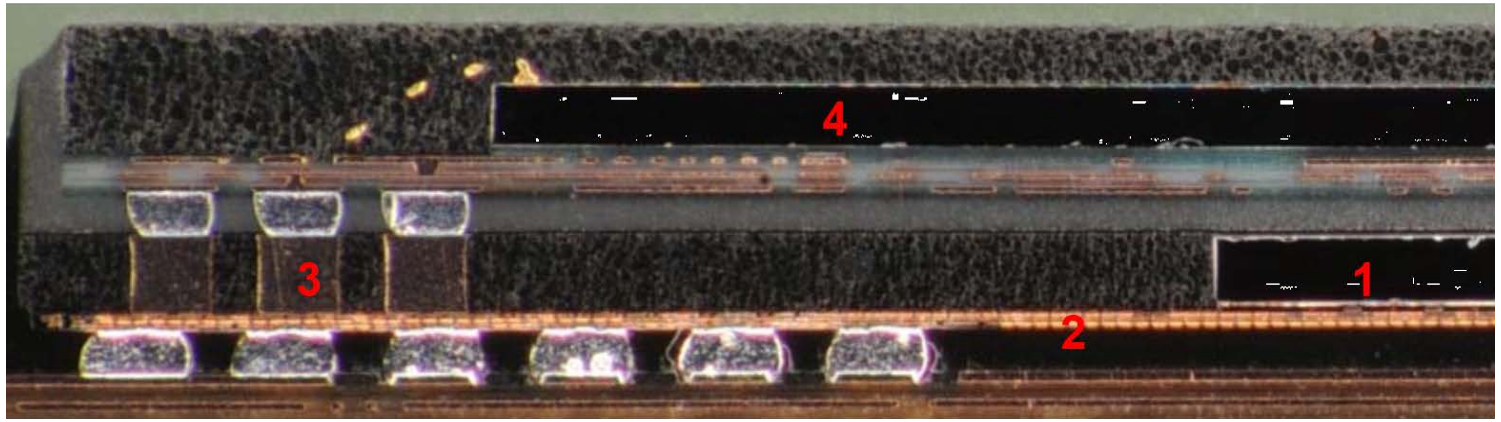
Apple iPhone 8 Application Processor/Memory in Fanout (Info) Package

Source: Prismark Partners October 2017

HETEROGENEOUS INTEGRATION ROADMAP

- 13.9 x 14.8mm InFO PoP Package
  - 8% smaller than A10
  - 790µm package height
- Memory package with SxS die
  - Die Thickness:140µm
  - 140µm EMC thickness over die
  - 3L substrate; 90µm thick
  - Underfill between packages
- Processor : ~10 x 8.7mm
  - 30% smaller than A10
  - 150µm thick; 15µm "top coat"
  - 50µm thick, four-metal-layer RDL

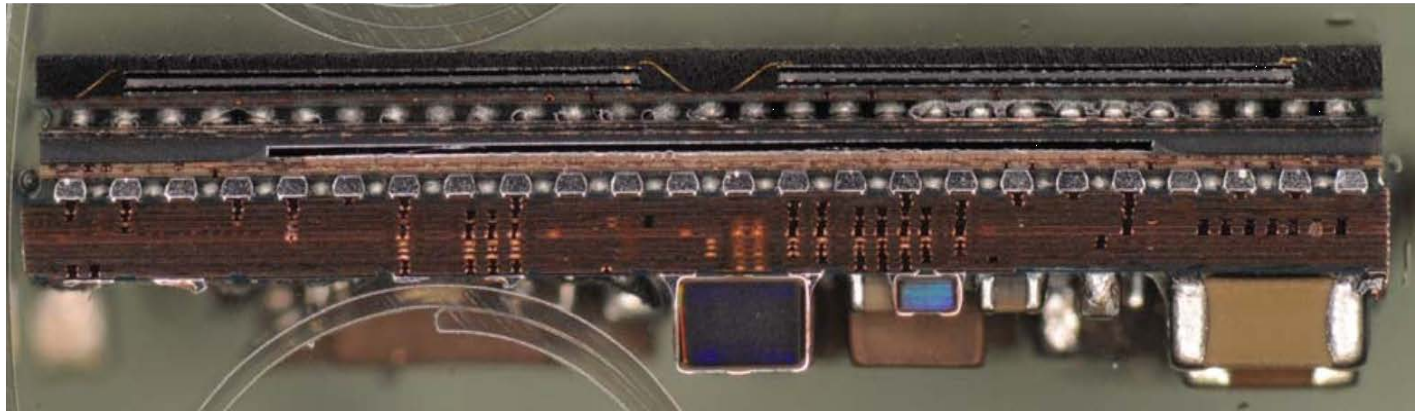


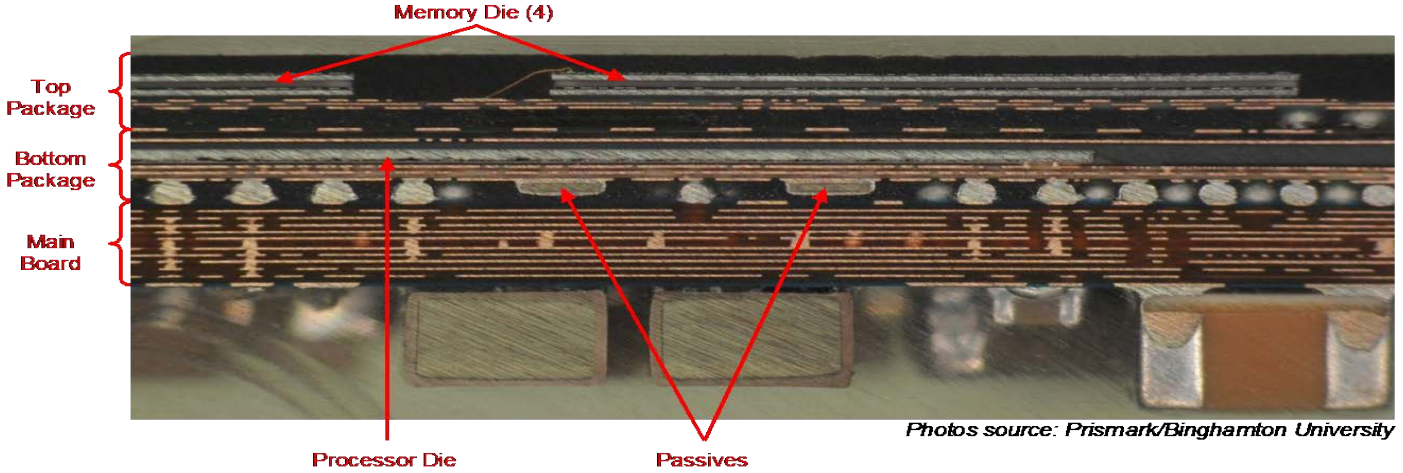


1 A11 Die
2 RDL
3 Vertical Connection
4 Memory
5 Capacitor

Samsung Galaxy 8: Qualcomm 835 PoP Package

Source: Prismark Partners April 2017





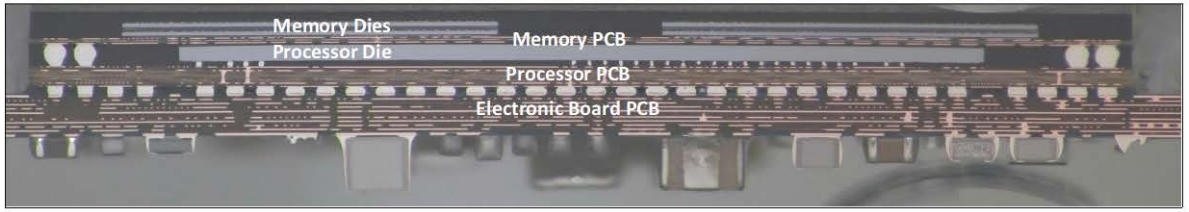
Photos source: Prismark/Binghamton University

PoP Package Comparison

Source: System Plus Consulting Report 2018

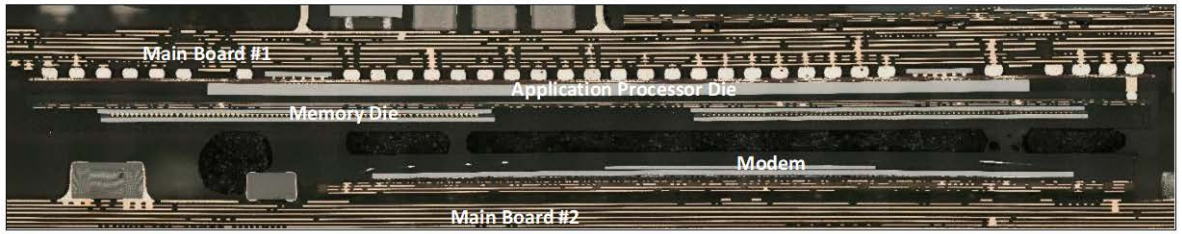
Package Comparison – PoP technology

Standard PoP



MCeP

inFO



Board Cross-Section – Optical View

©2018 by System Plus Consulting

	Standard PoP		MCeP		inFO
Package Support	PCB	-50%	2 x Embedded Trace PCB	-60%	RDL
Package Height	0.55 mm	-21%	0.43 mm	-47%	0.23 mm
Minimum Bump pitch	0.2 mm	-20%	0.16 mm	-19%	0.13 mm

Leading Edge Materials & Technologies Implementation as seen in recent smart phones (Apple iPhone 8)

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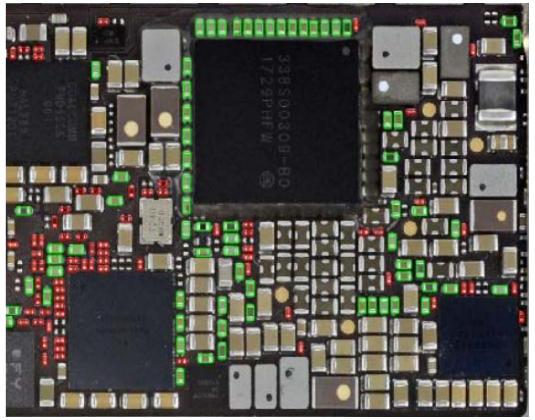
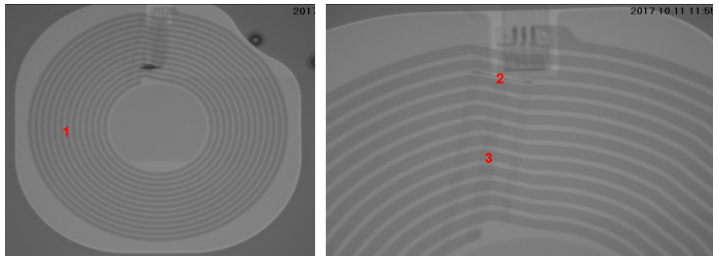
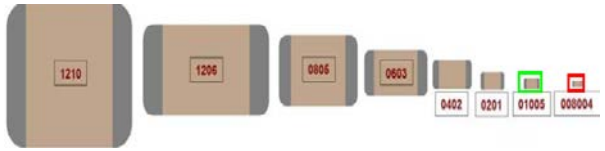
Source: Prismark Partners October 2017

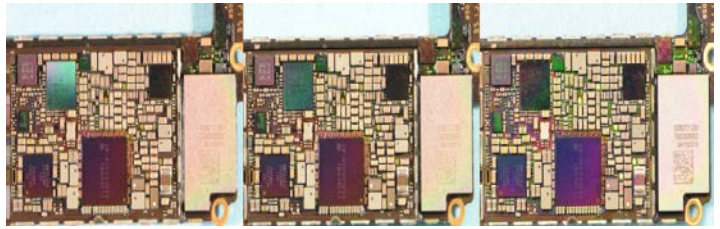




Wireless Charging Coils

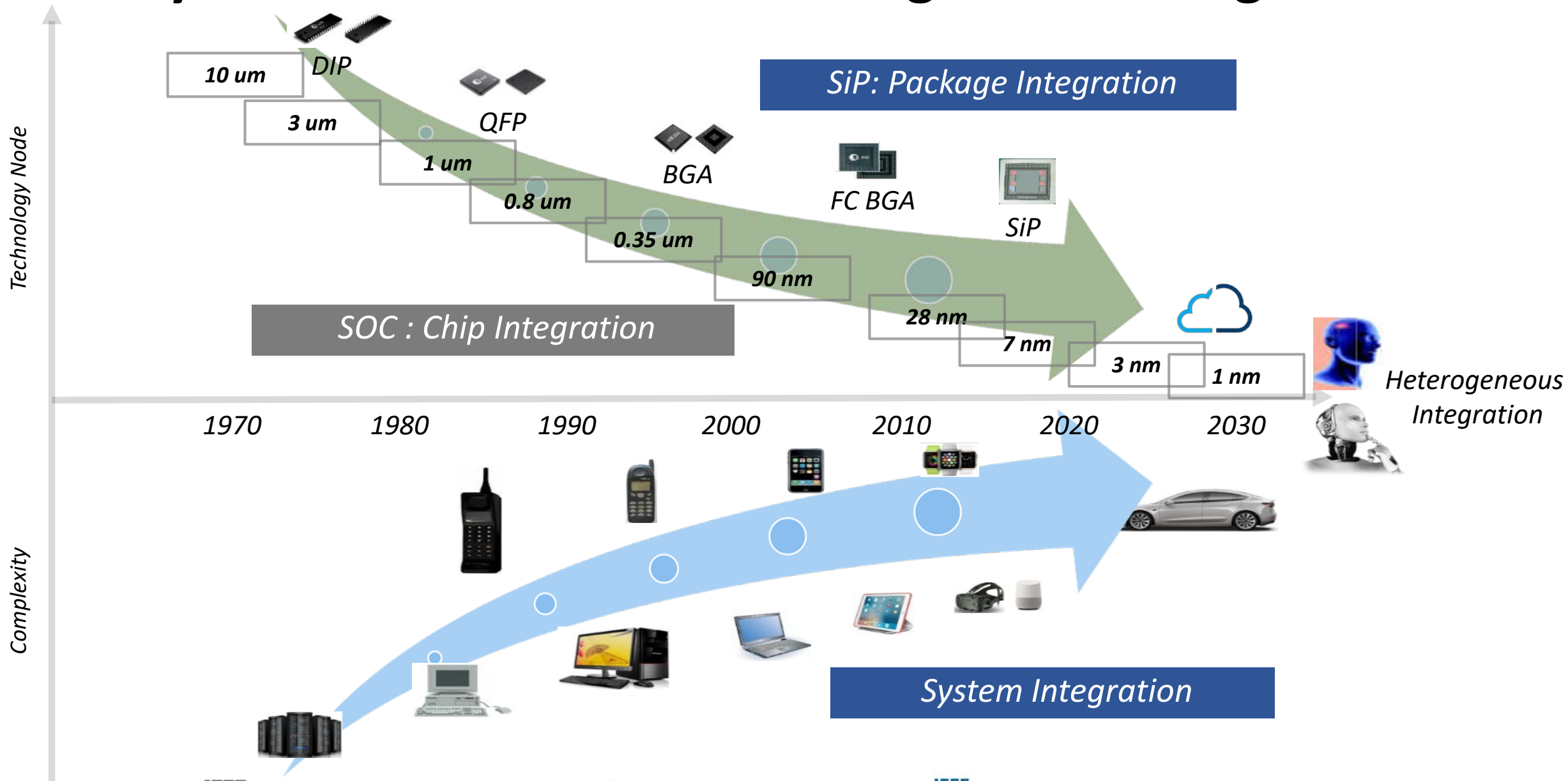


About 1000 Passives:
smallest 01005



Nano Coating Material

System Innovation and Heterogeneous Integration



IEEE | IEEE photonics Society | semi | IEEE Electronics Packaging Society | ASME | Electron Devices Society

Challenges

Mobile/Smart Phone: A Driving Force for Innovation

- **Continued introduction in Functions and Performance while retaining same form factor in size and thickness.**
- **Continued introduction in Functions and Performance while expanding affordability to broad global population**
- **Cyber security across all phones 4G - 5G & Beyond**
- **Customization & High Volume across all regions**
- **Global sustainbility**

Summary

Mobile/Smart Phone: A Driving Force for Innovation

- As the dominant human-machine interface, Smart Phone, tablets & smart watches connected to high speed networks and the cloud will lead the industry in diverse applications to medical & health, industry I0T, finance, education and others where we cannot yet imagine.
- Smart Phone made up of SiP/SiM Modules, leading the way for the continued innovation, sophistication, and implementation of Heterogeneous Integration Technologies across broader electronic applications.
- Smart Phone will be the platform driving and launching innovative technologies – 5G, AR, VR & AI - that will propel innovation and the proliferation of electronics in our world for many years to come.
- The Heterogeneous Integration Roadmap will play a significant role in bringing the ecosystem together to foster the spirit of innovation and collaboration.

Last Words

It may prove to be more economical to build large systems out of smaller functions, which are separately packaged and interconnected. The availability of large functions, combined with functional design and construction, should allow the manufacturer of large systems to design and construct a considerable variety of equipment both rapidly and economically.

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Thank You

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