Image source: Brewer Science

From Technologies to Market

Fan-Out Packaging

Technologies and market trends

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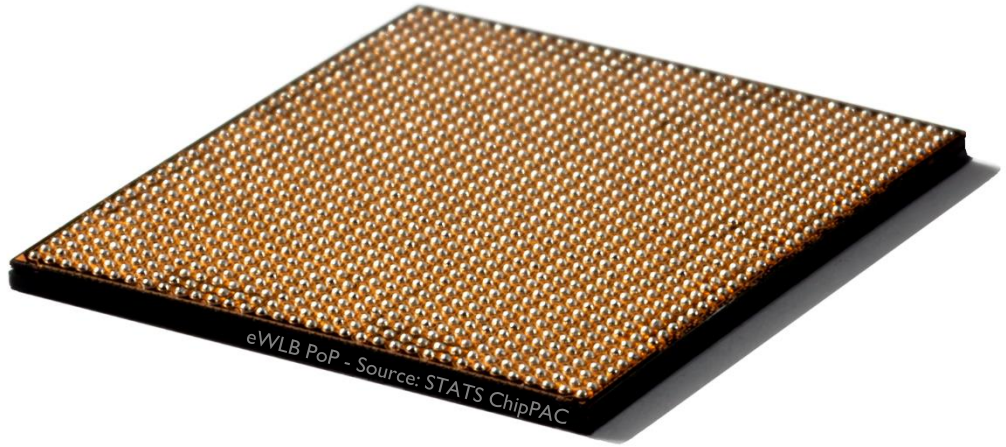
YOLE Développement

OUTLINE

Fan-Out Packaging

- Advanced Packaging Platforms & Market drivers
- Fan-Out Packaging Principle & Definition
- Applications and Players
- Technologies and roadmap
- Market analysis
- Conclusions



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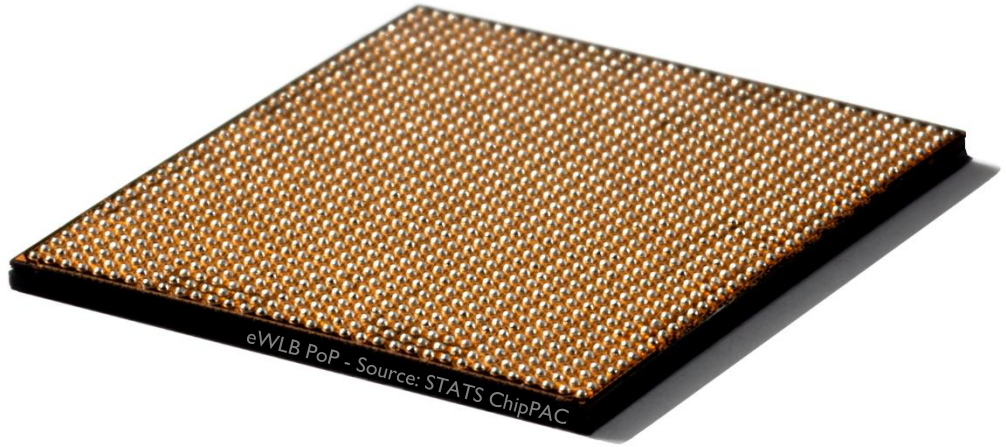
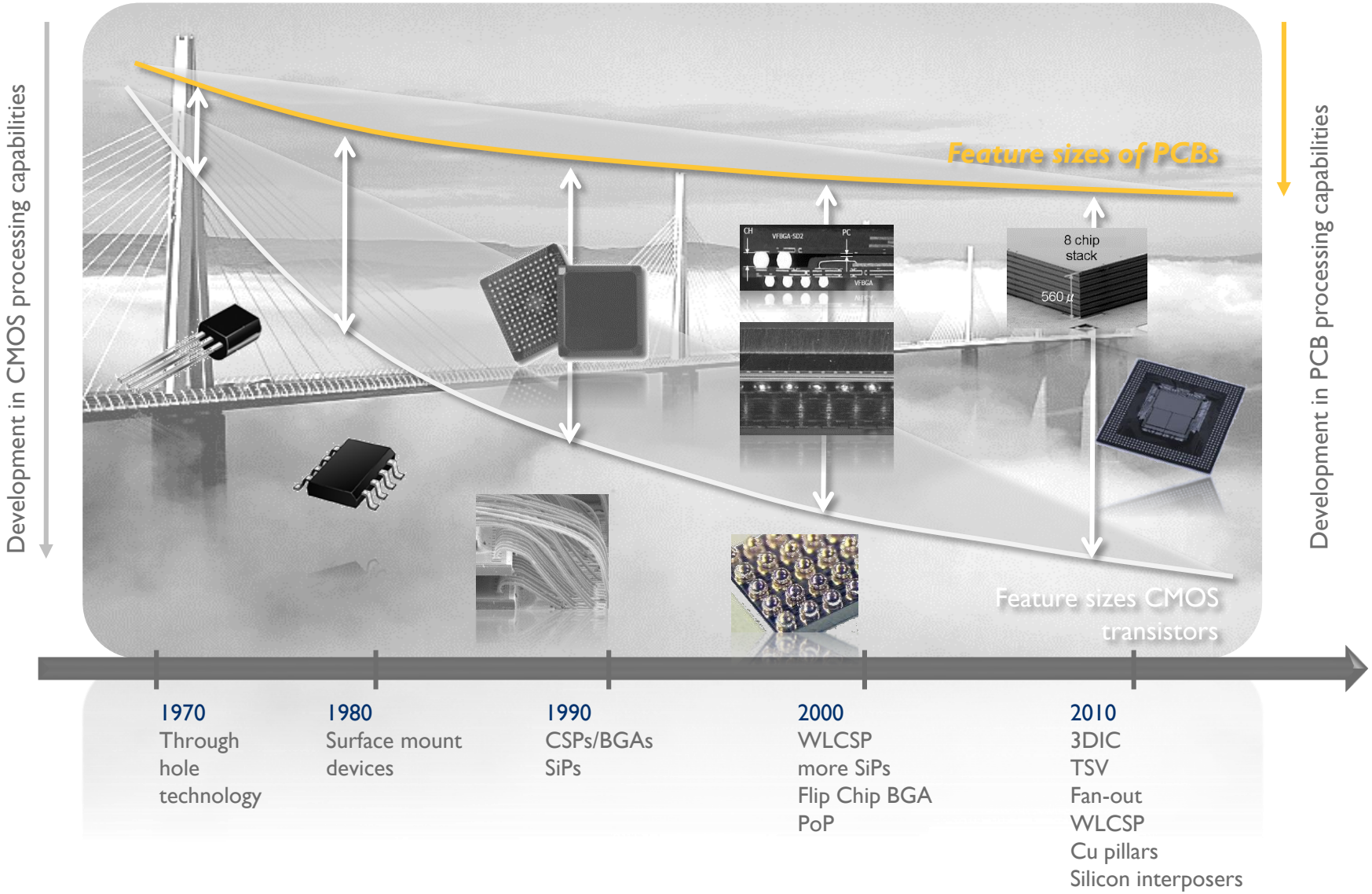


THE EVOLUTION OF SEMICONDUCTOR PACKAGING

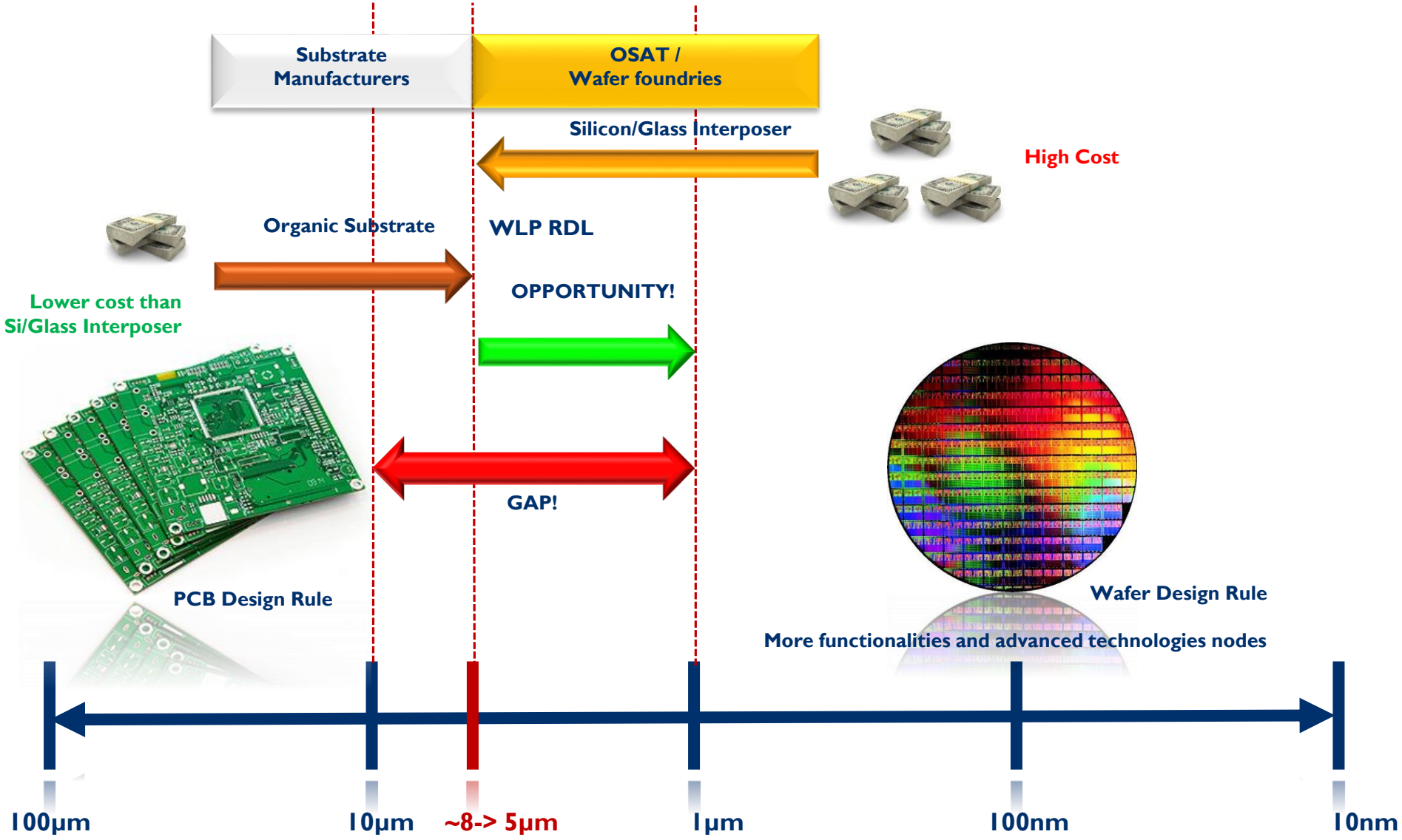
A bridging technology between ICs and PCBs

Packaging fills the gap in between ICs and PCBs different speeds of improvement

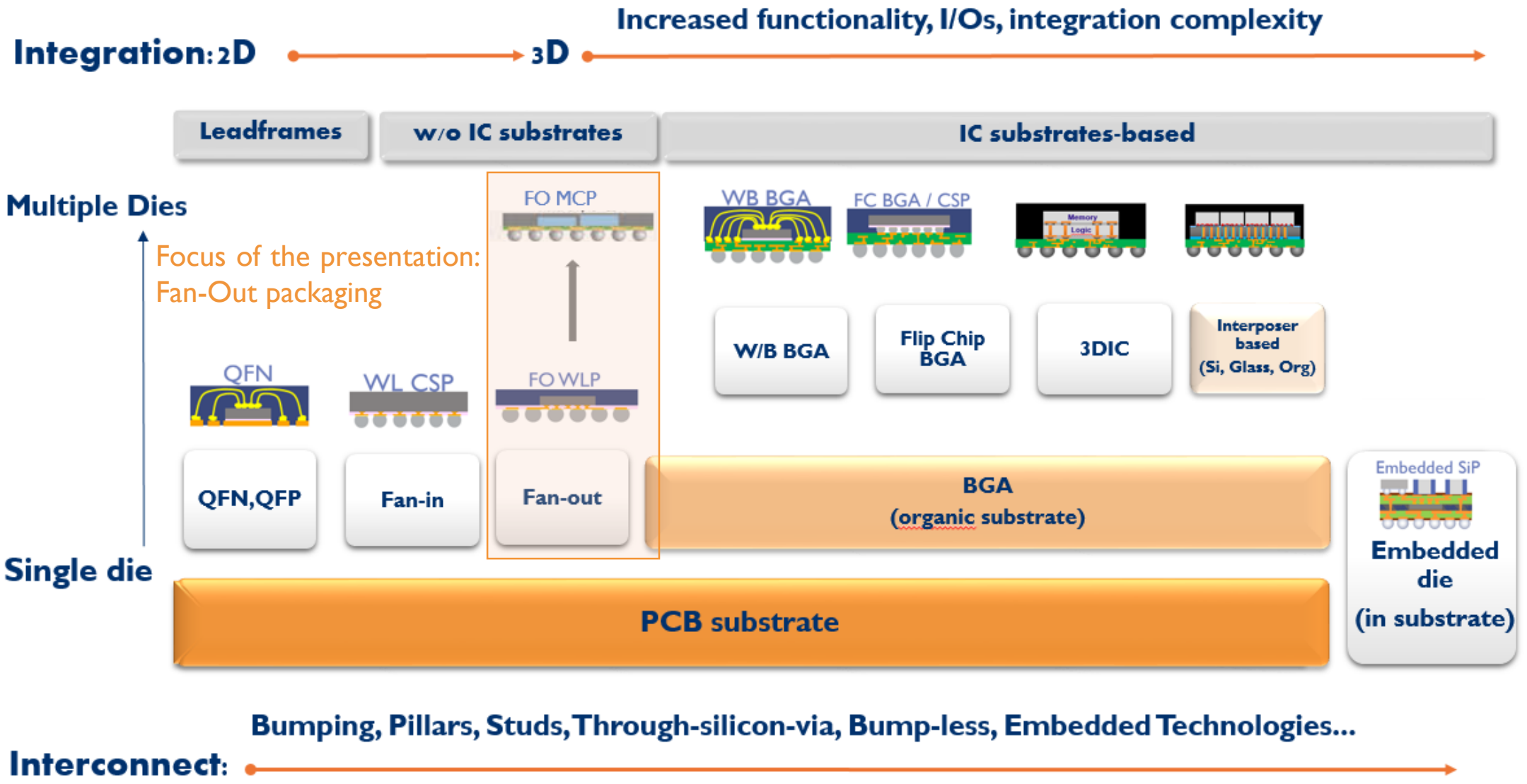


FILLING THE DIMENSION GAP

Substrate manufacturers vs. Wafer foundries



ADVANCED PACKAGING PLATFORMS



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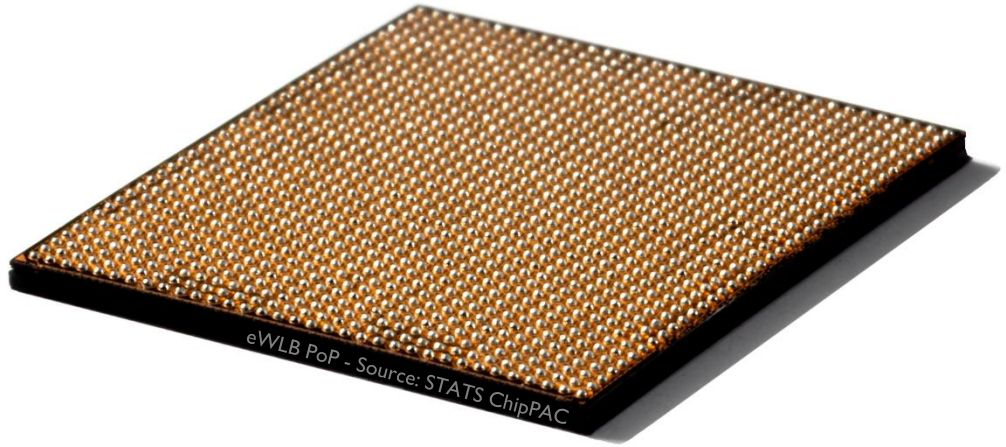
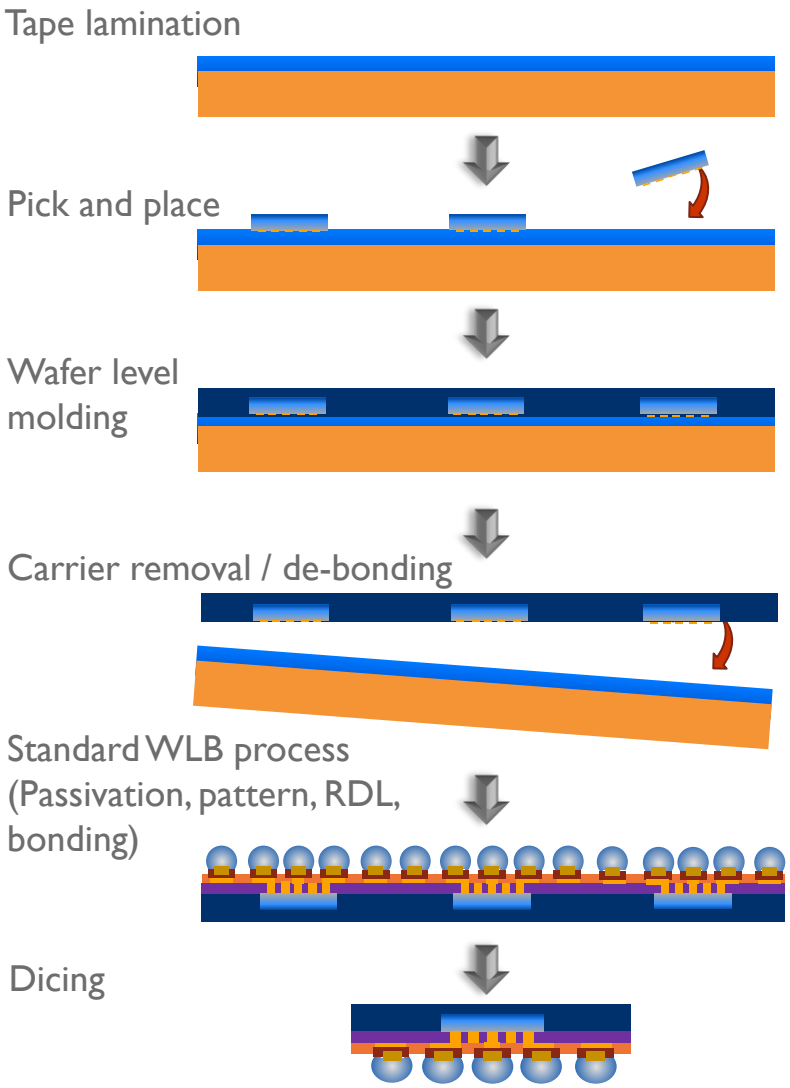


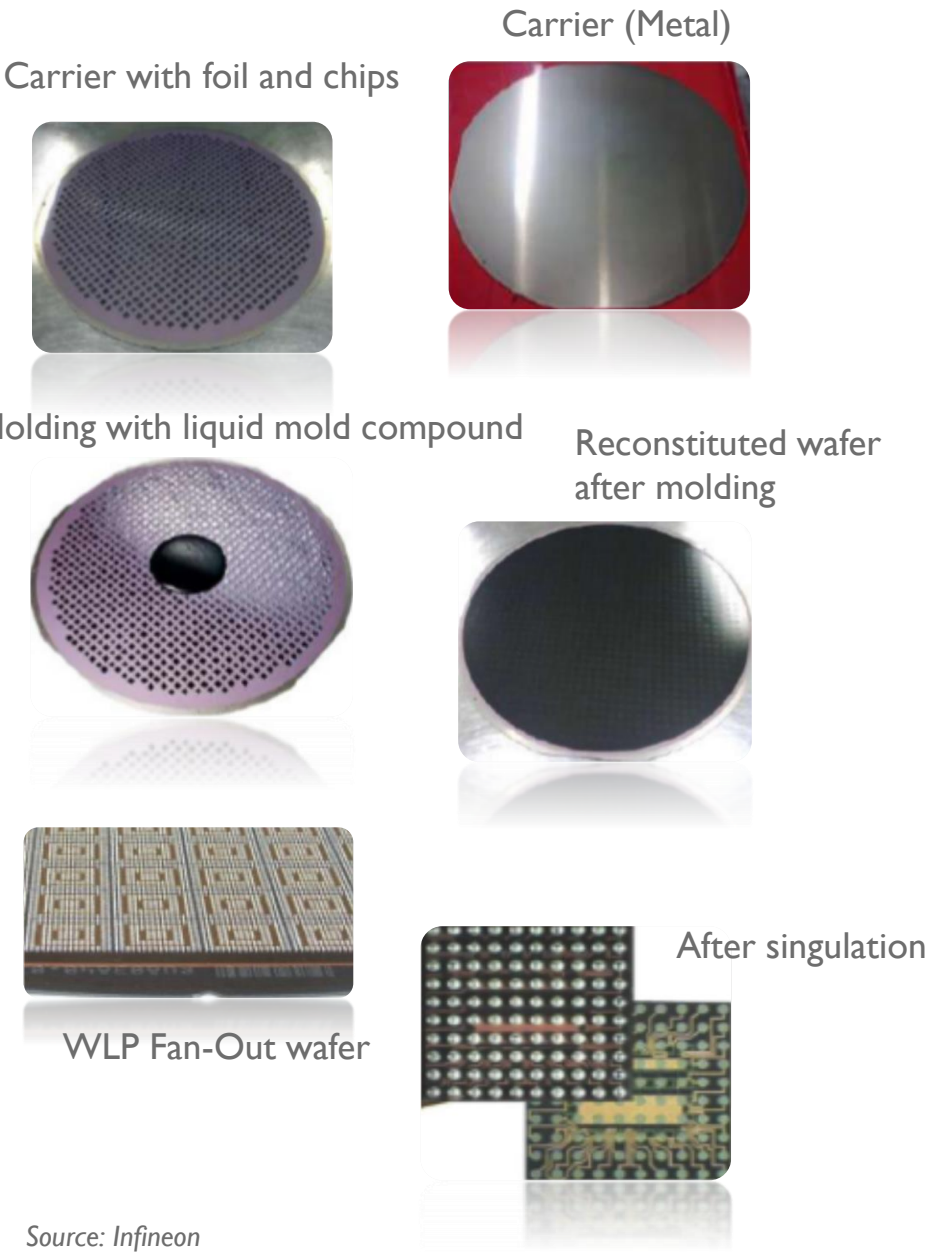
FAN-OUT PACKAGING PRINCIPLE

Fan-Out:

- Dies embedded in mold compound
- No advanced substrate
- Interconnections fanned out of chip surface

eWLB example (chip-first face-down)

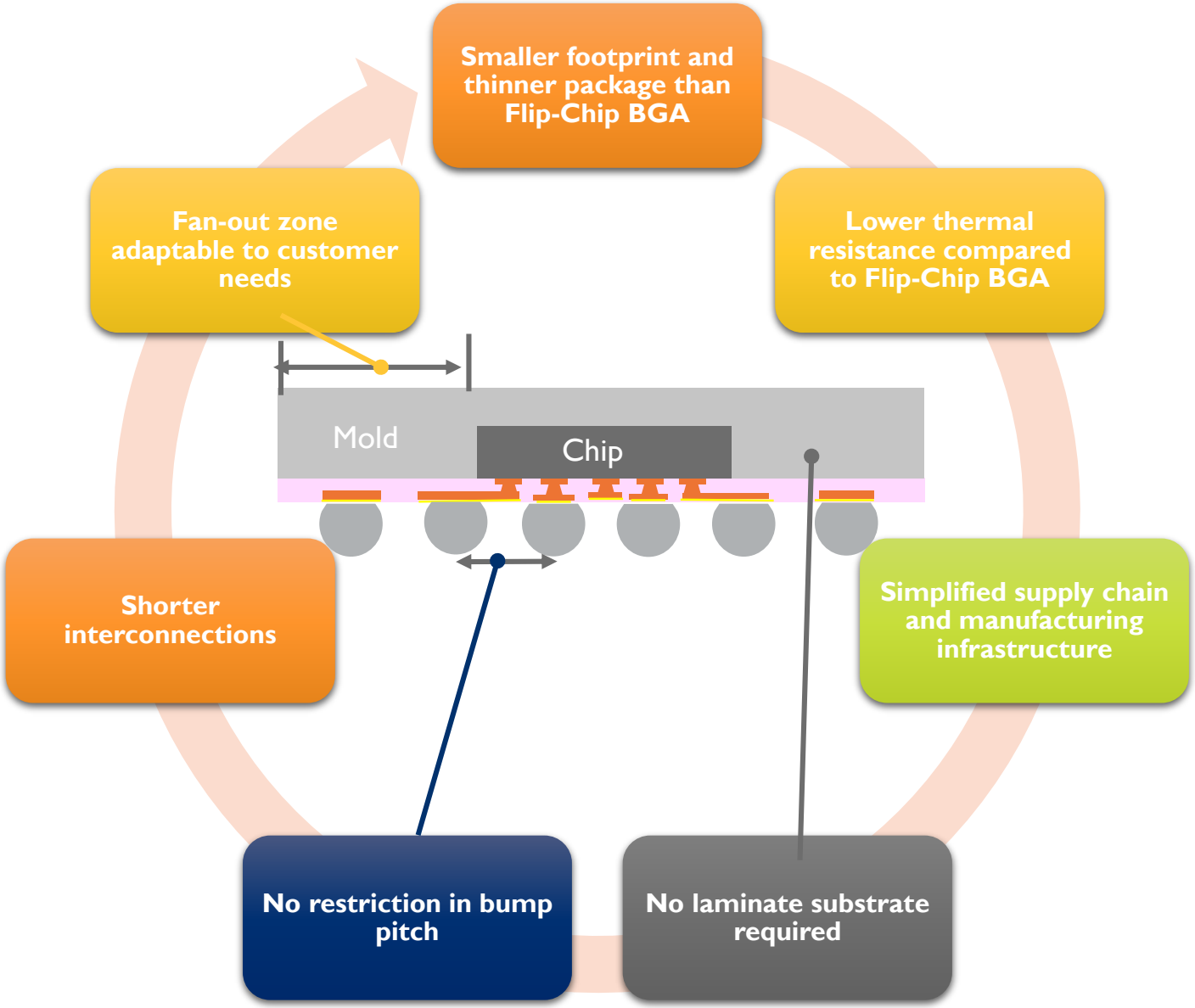




Source: Infineon

FAN-OUT PACKAGING KEY DIFFERENTIATORS

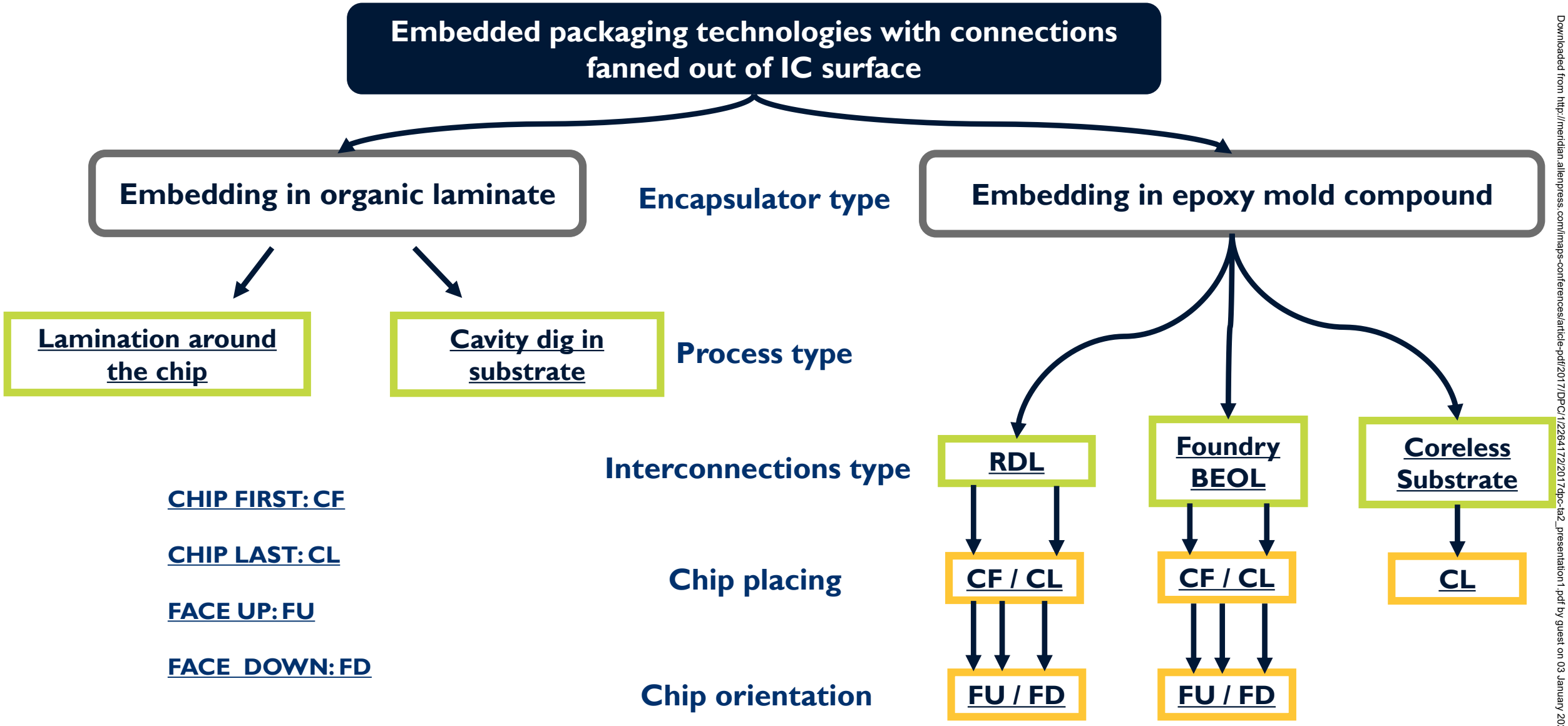
Fan-Out packaging provides several advantages



And others such as:

- Better board level reliuability compared to WLCSP
- RoHS an REACH compliant package
- Excellent electrical performance
- High degree of package design freedom
- Reliable, miniaturized high performance package

EMBEDDED PACKAGING TECHNOLOGIES

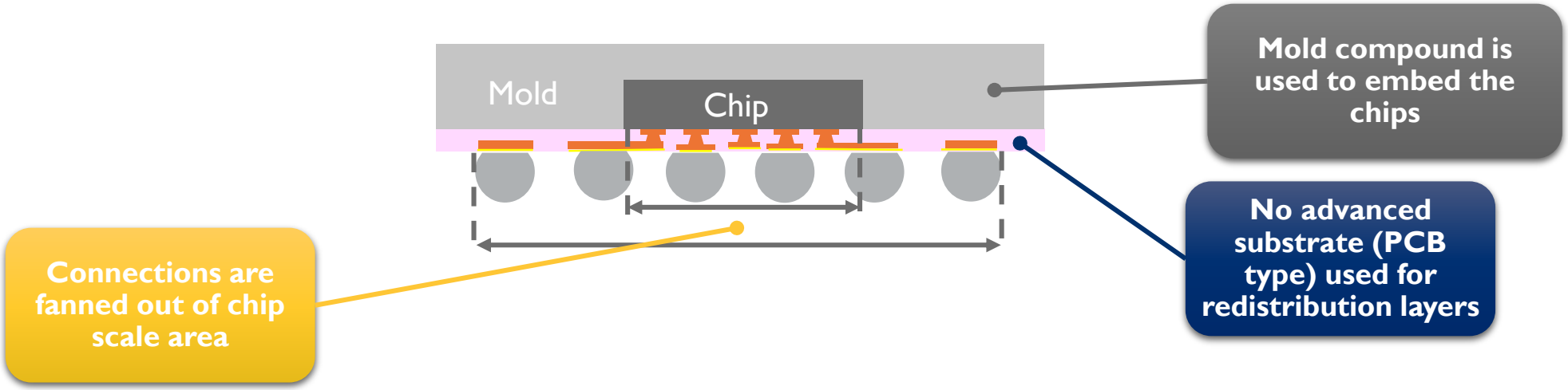


FAN-OUT DEFINITION

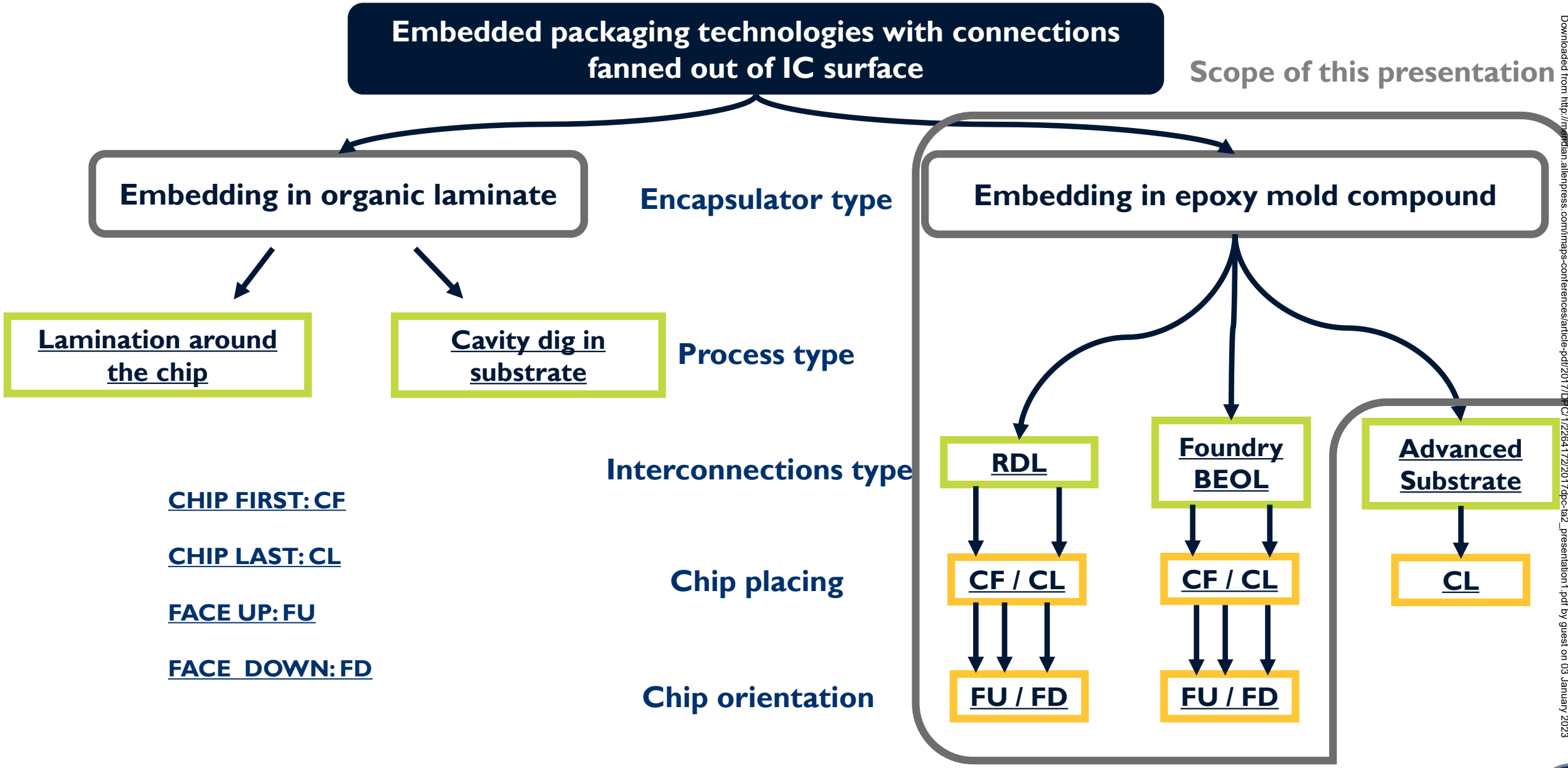
A proposal of definition…

Fan-Out can be a lot of different things…

- A confusing situation: Literally speaking, "Fan-Out" packaging can be any package with connections fanned-out of chip surface
- To make a fair comparison with technologies, historically considered as "Fan-Out", most of them being "wafer-level-package", we consider other parameters to propose a definition
  - "Fan-Out" solutions are using mold compound
  - "Fan-out" solutions' RDL are not using advanced substrate (PCB laminate type of layer)



EMBEDDED PACKAGING TECHNOLOGIES



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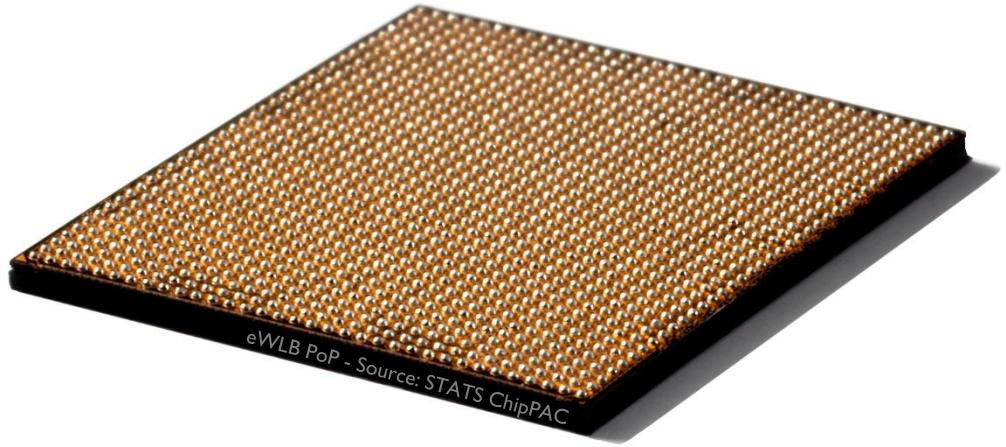
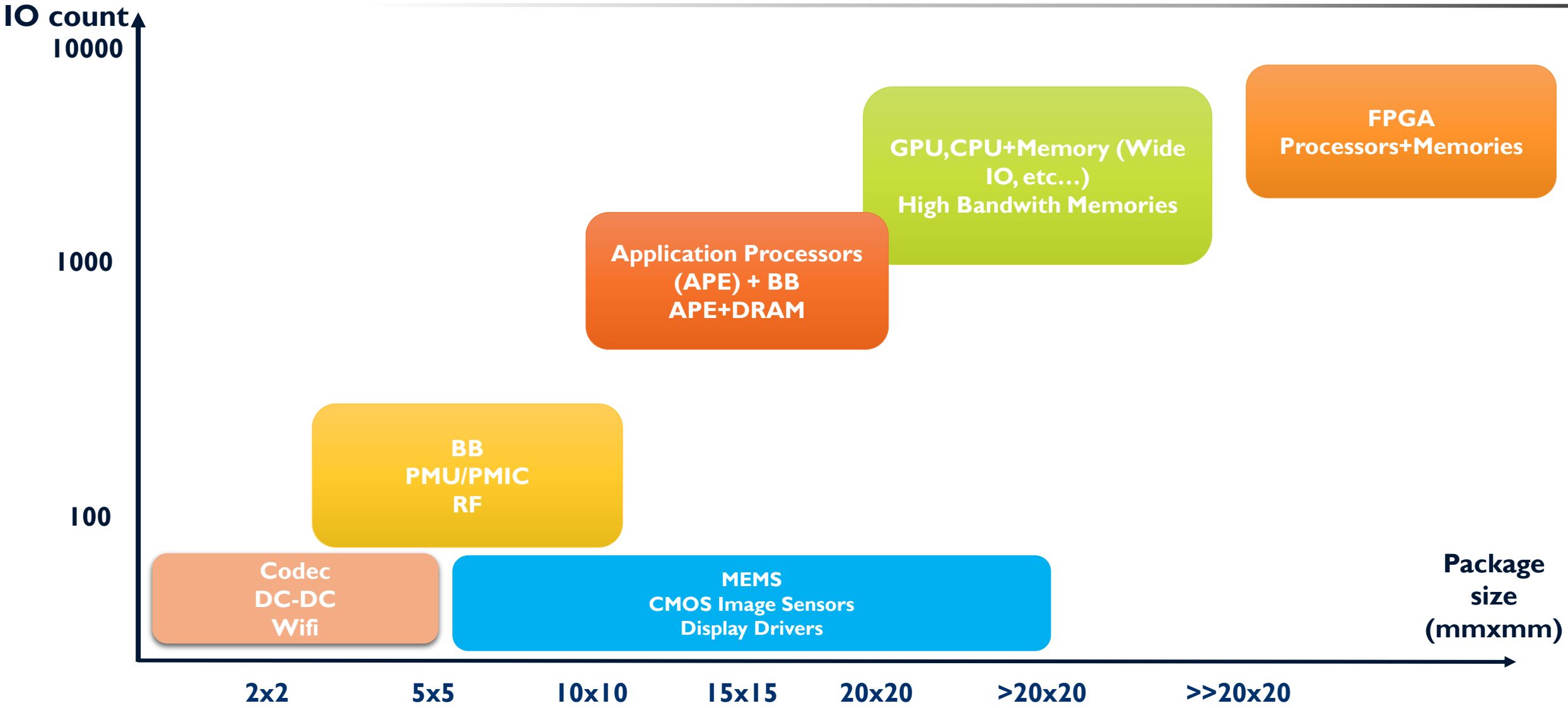


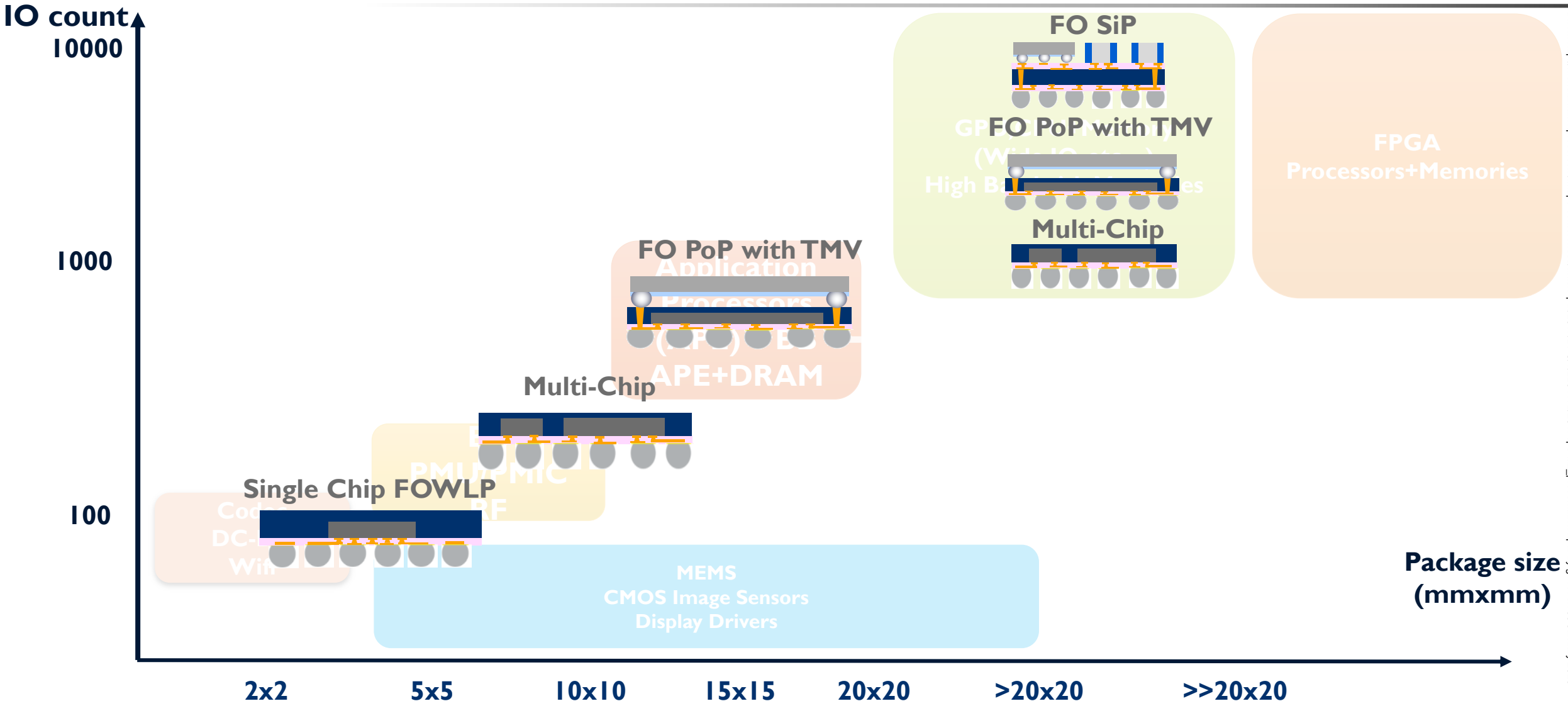
FAN-OUT APPLICATIONS

Different applications with different needs and characteristics (Density, package size)



FAN-OUT APPLICATIONS

Potential applications for Fan-Out: Where does Fan-Out fit and how?



FAN-OUT APPLICATIONS

Where can we and will we find Fan-Out? Some examples below

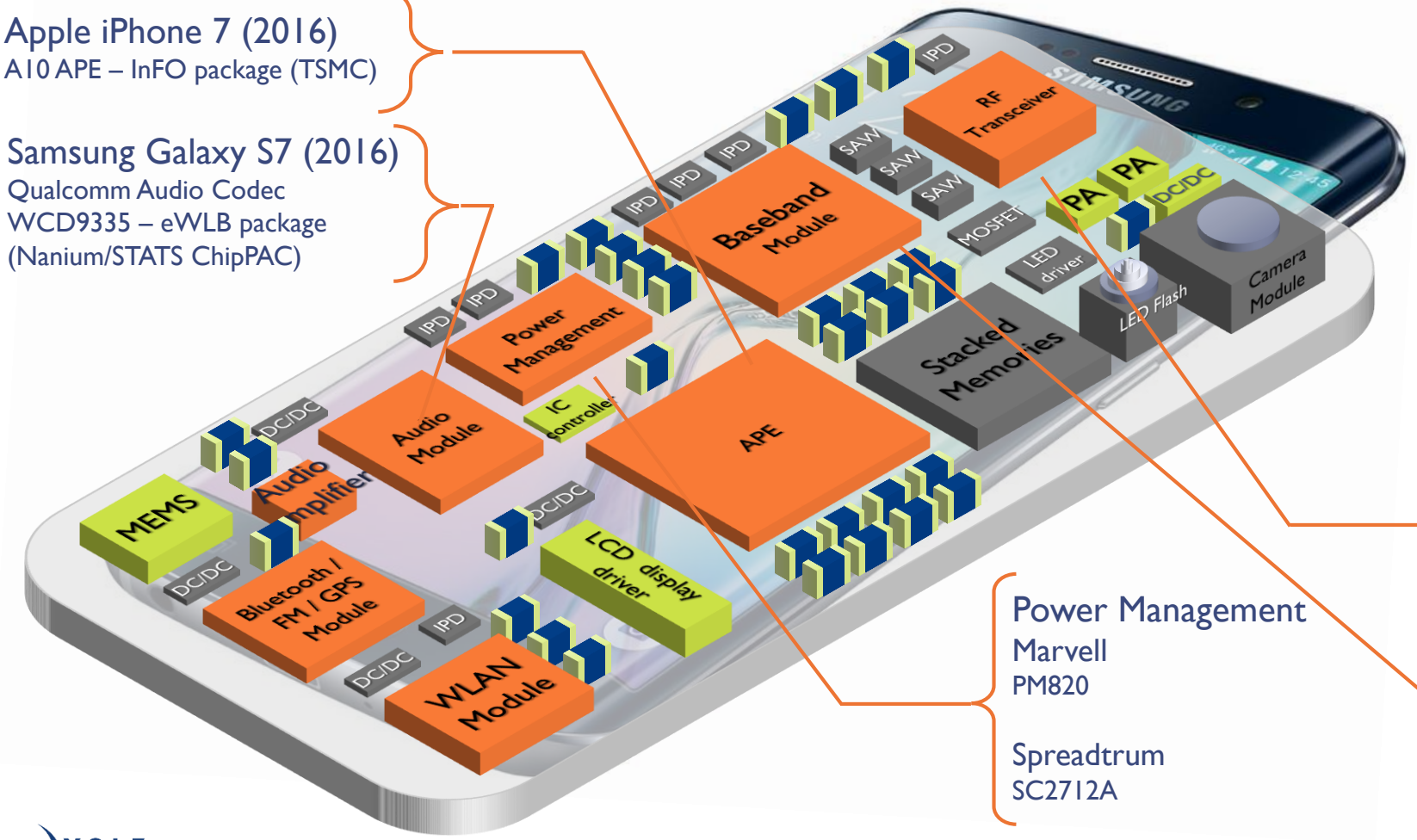
Orange: Devices that can be found in FOWLP packages today

Green: Devices that could be found in the future in FOWLP

Grey: Devices that will likely remain on WLCSP or flip-chip package or move to 3DIC or Embedded die

Apple iPhone 7 (2016)
A10 APE – InFO package (TSMC)

Samsung Galaxy S7 (2016)
Qualcomm Audio Codec WCD9335 – eWLB package (Nanium/STATS ChipPAC)



Power Management
Marvell
PM820

Spreadtrum
SC2712A

RF
Spreadtrum
SC8502

Intel-Mobile/Infineon
PMB5712, PMB5726

Baseband
Spreadtrum
SC8502

Intel-Mobile/Infineon
PMB7900, PMB9810, PMB9801

Bosch MRR1Plus Radar (2015)
Infineon RASIC™ (77GHz RADAR System IC Chipset) – eWLB Package

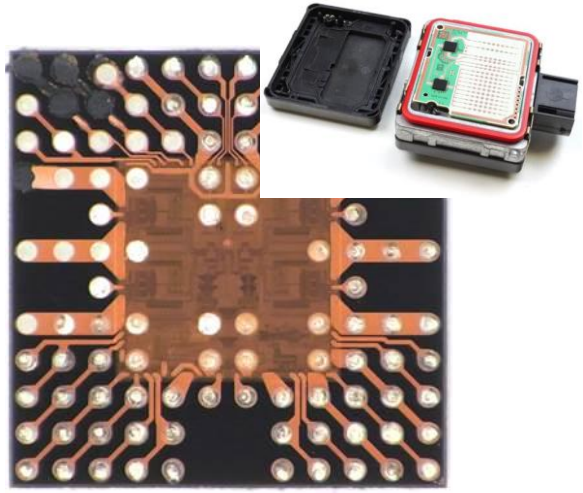
Continental ARS400 Radar (2015)
NXP MR2001 (77GHz multichannel RADAR) – RCP Package

BK Ultrasound Sonic Window (2015)
Multichip Module – eWLB Package (Nanium)

FAN-OUT APPLICATIONS

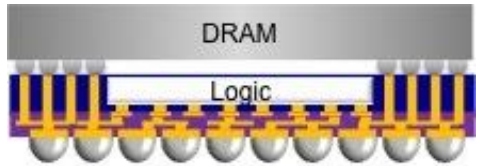
Example of Qualcomm's Audio Codec WCD9335 – eWLB package Die size: 3.6x3.6mm² Package size: 4.18x3.91mm² 113 balls bumped Source: System + Consulting

Audio codec



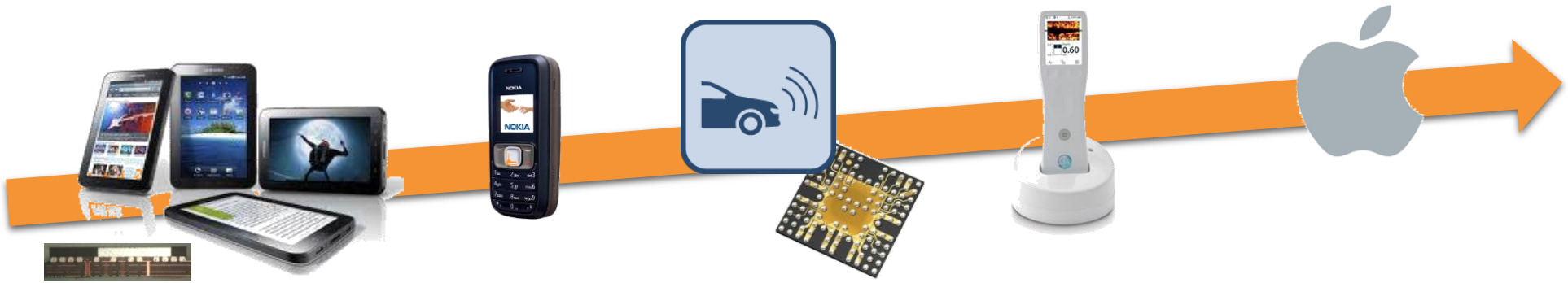
Example of Infineon's Transceiver and Receiver in Bosch MRR1 Plus Radar – eWLB packages Source: System + Consulting

RF in automotive



TSMC's InFO for Apple A10

APE

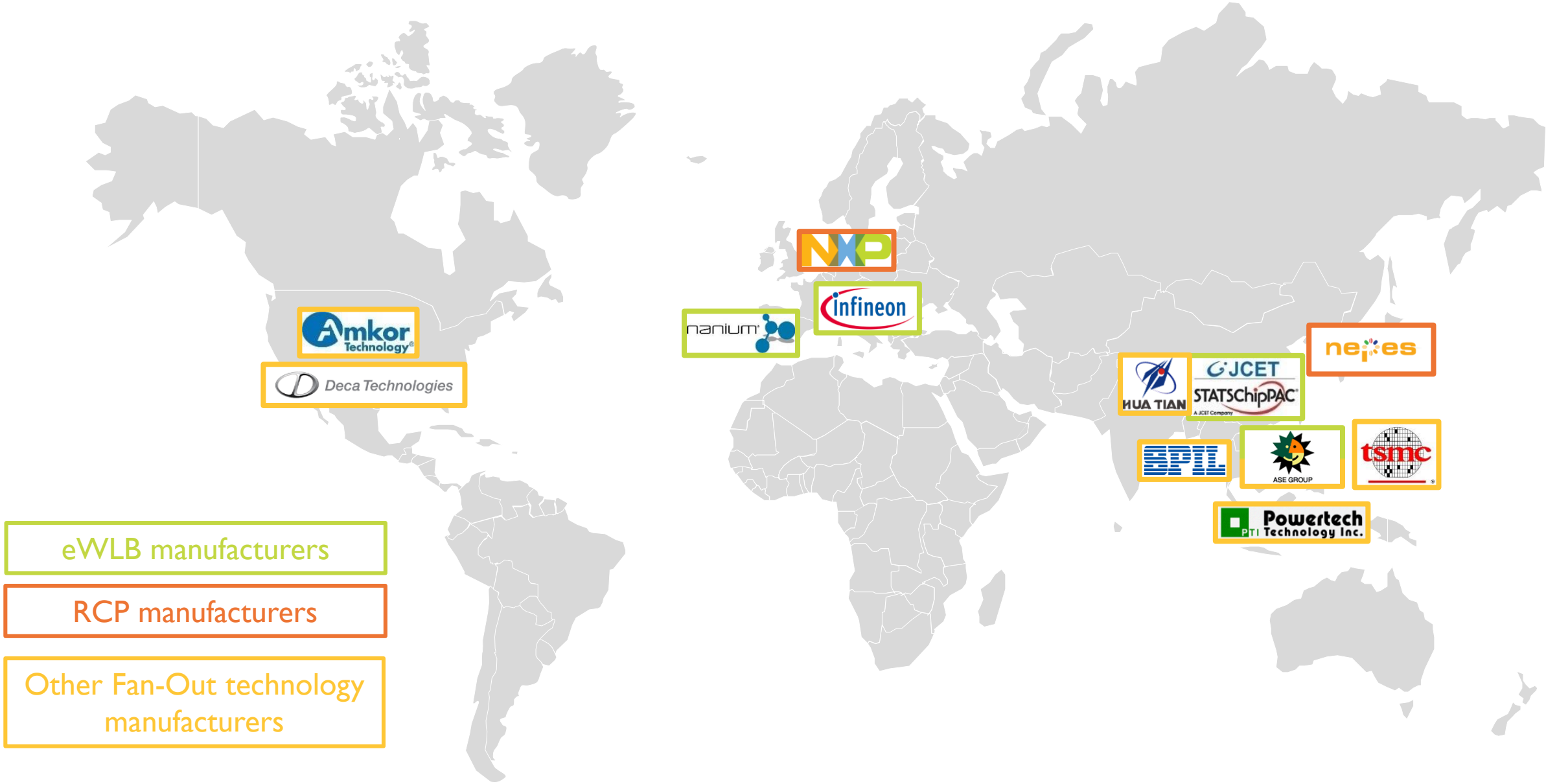


2011 2012 2013 2014 2015 2016

FAN-OUT ACTIVITIES: GLOBAL MAP OF MAIN PLAYERS*

*Non-exhaustive list of players: Numerous companies have an interest in Fan-Out…

FAN-OUT ACTIVITIES: GLOBAL MAP OF MANUFACTURERS



eWLB manufacturers

RCP manufacturers

Other Fan-Out technology manufacturers

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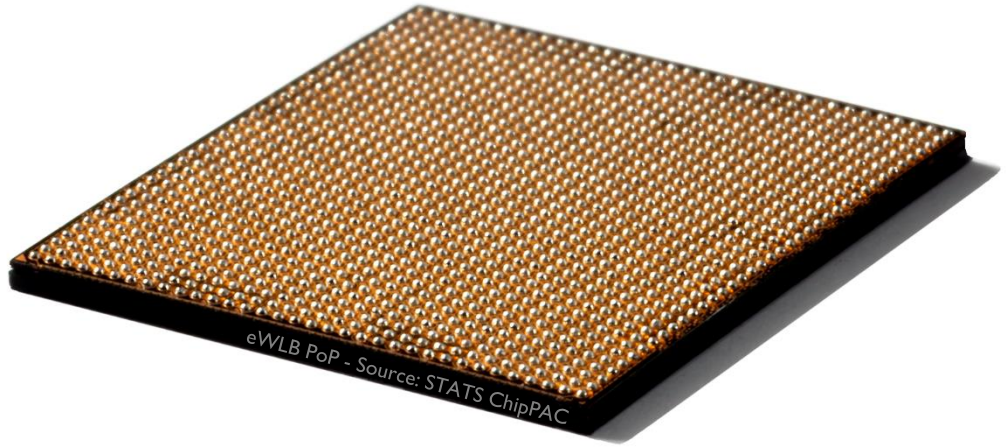
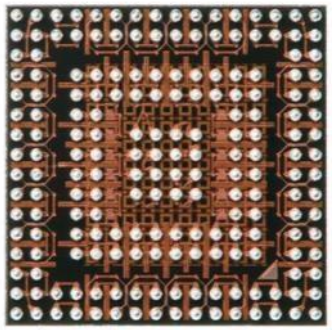


FAN-OUT PACKAGING MANUFACTURERS' TECHNOLOGIES AND STRATEGIES

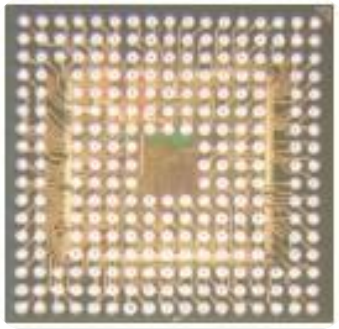
Fan-Out packaging suppliers can be classified per Fan-Out technology license

eWLB is the most widespread technology but many players are showing up with different processes

- **eWLB manufacturers (Infineon Technology):**
  - First FOWLP that reached volume production (since 2009!)
  - Already in mass production and with big wireless/mobile customers
  - Licensed to several manufacturers (Nanium, JCET/STATS ChipPAC, etc…) → Multi-sourcing capability



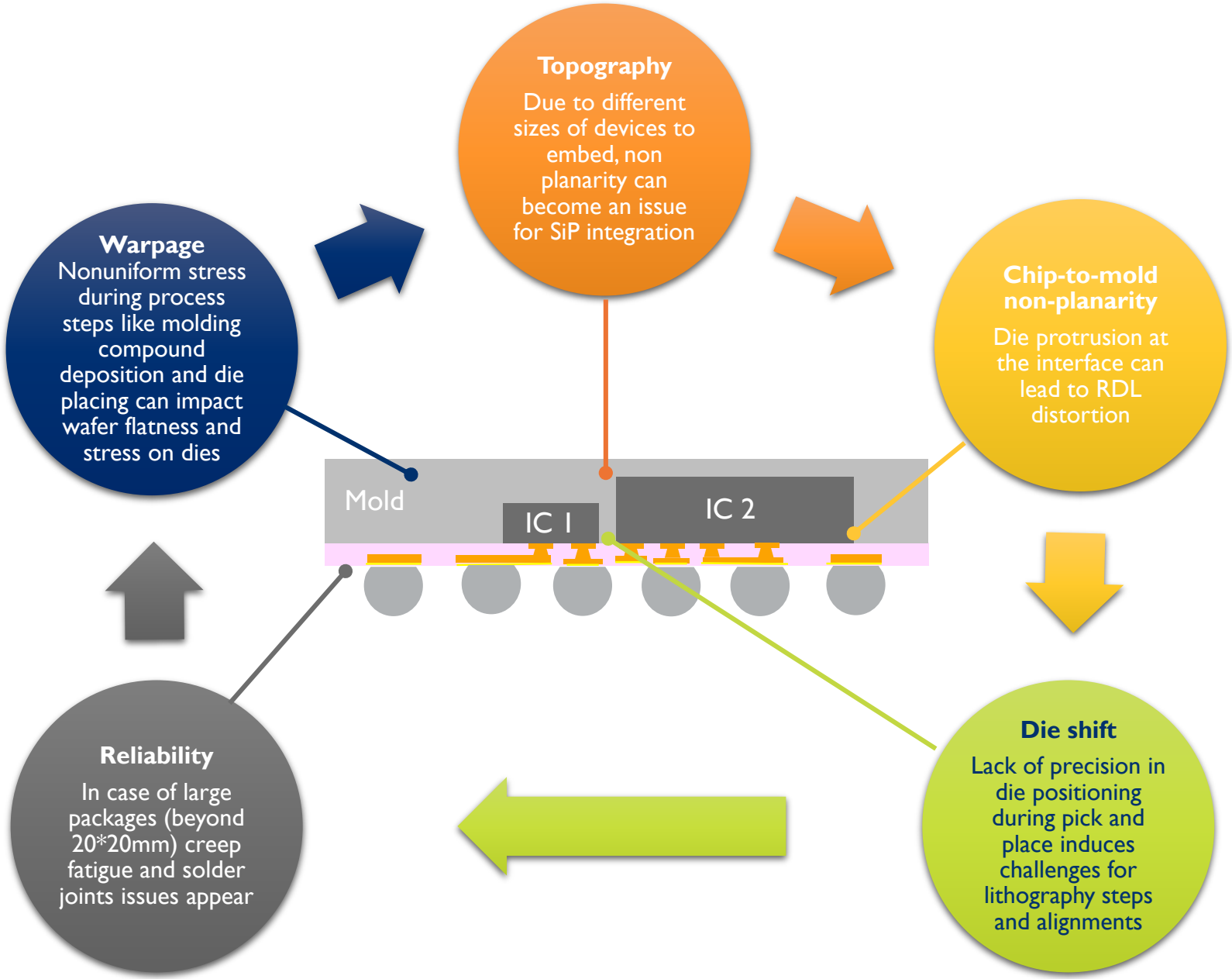
- **RCP manufacturers (Freescale (NXP) technology):**
  - Targets high integration applications, automotive, wearable and IoT markets following NXP portfolio
  - Limited success: No real high volume compared to eWLB production and few licensees (Freescale, NEPES)



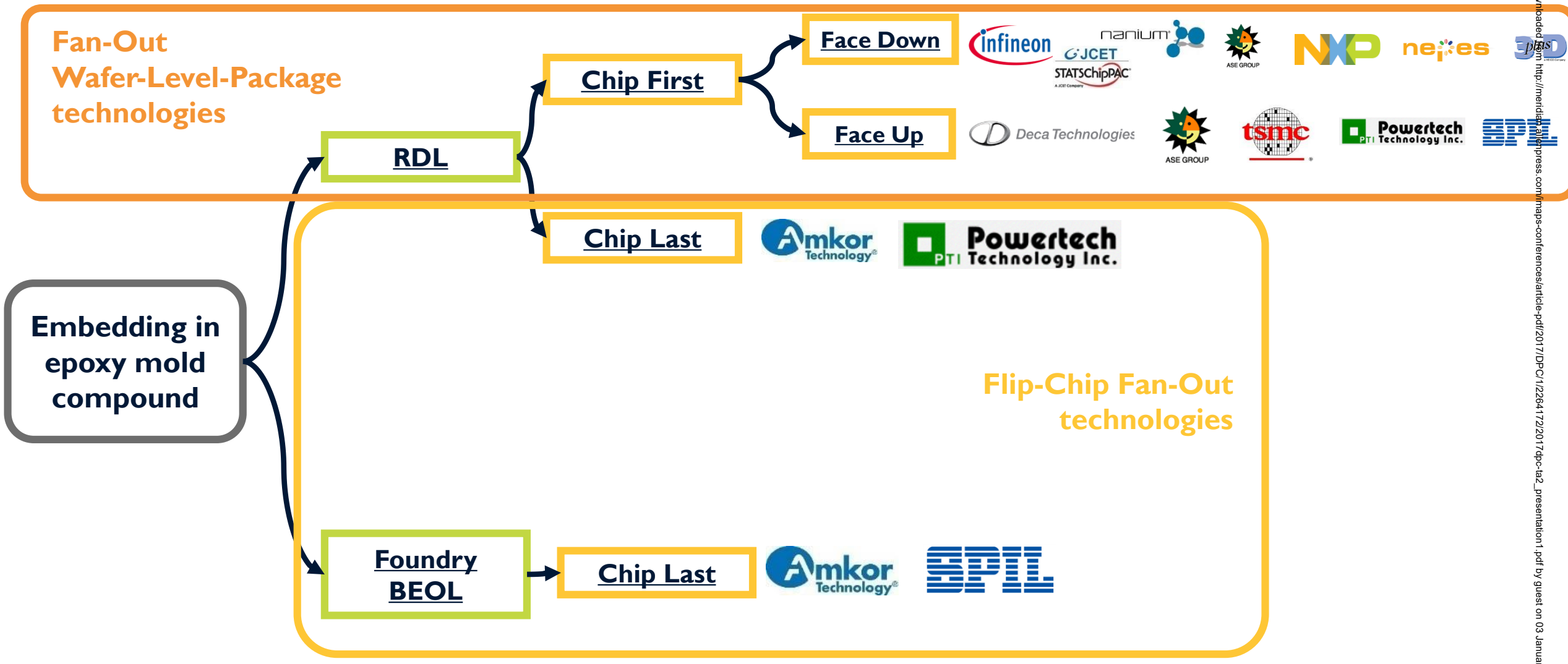
- **Other Fan-Out technology manufacturers:**
  - Other OSATs such as Amkor/Deca Technologies/SPIL/PTI develop their own technology. ASE has recently licensed Deca Technologies' solution bringing more interest in that choice
  - Strong interest from IDMs/foundries in having a Fan-Out capability to complete their offer for their customers. TMSC used that strategy to earn A10 market thanks to InFO technology completing their front-end offer
  - Different end-market per Fan-Out technology

FAN-OUT PACKAGING: TECHNICAL CHALLENGES

Fan-Out packaging features come with technical challenges, addressed in different ways by the manufacturers



FAN-OUT TECHNOLOGIES SEGMENTATION: PLAYER POSITIONING*



*Non-exhaustive list of players

VOLUME PRODUCTION ROADMAP FOR FAN-OUT PACKAGING

Integration roadmap

Architectures with more integration such as PoP and SiP will widespread thanks to better technologies (higher IO count, RDL number, TMV, Chip-Last, etc…)

	2015	2016	2017	2018
Maximum package size	10*10mm²	12*12mm²		25*25mm²(SiP)
Max level of RDL	2RDL			4RDL
Line/Space	8/8µm	5/5µm		2/2µm
Package minimum thickness (without BGA)	250µm	200µm		150µm

Package architectures

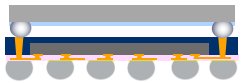
1st generation Fan-Out

Single Chip FOWLP

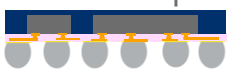
Single chip with passives

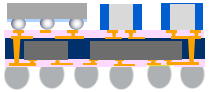
2nd generation Fan-Out

FO PoP with TMV

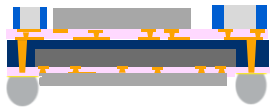


Multi-Chip

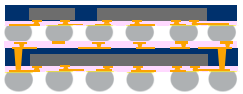




FO SiP + F2F

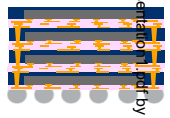


FO PoP with 2 FO Packages



FO WLP + Face to Face (F2F)

3D PoP Stacked dies



2015 2016 2017 2018

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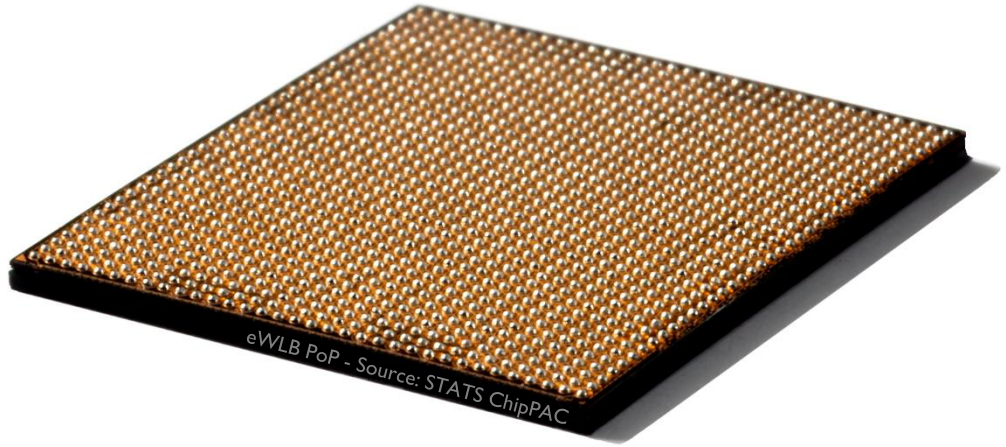


FAN-OUT MARKET STATUS

Entering a new era…

Fan-Out market has reached a turning point

- A confirmed ramp-up and high expectations for a promising "core" market.
- A high potential for "High-Density" Fan-Out

- Is there a Fan-Out Bubble?
- Fan-Out is the new trendy platform the industry is focusing on…
- … but main part of Fan-Out Market for 2016 will be associated to only one product

IS THERE A FAN-OUT BUBBLE?

Fan-Out market risks

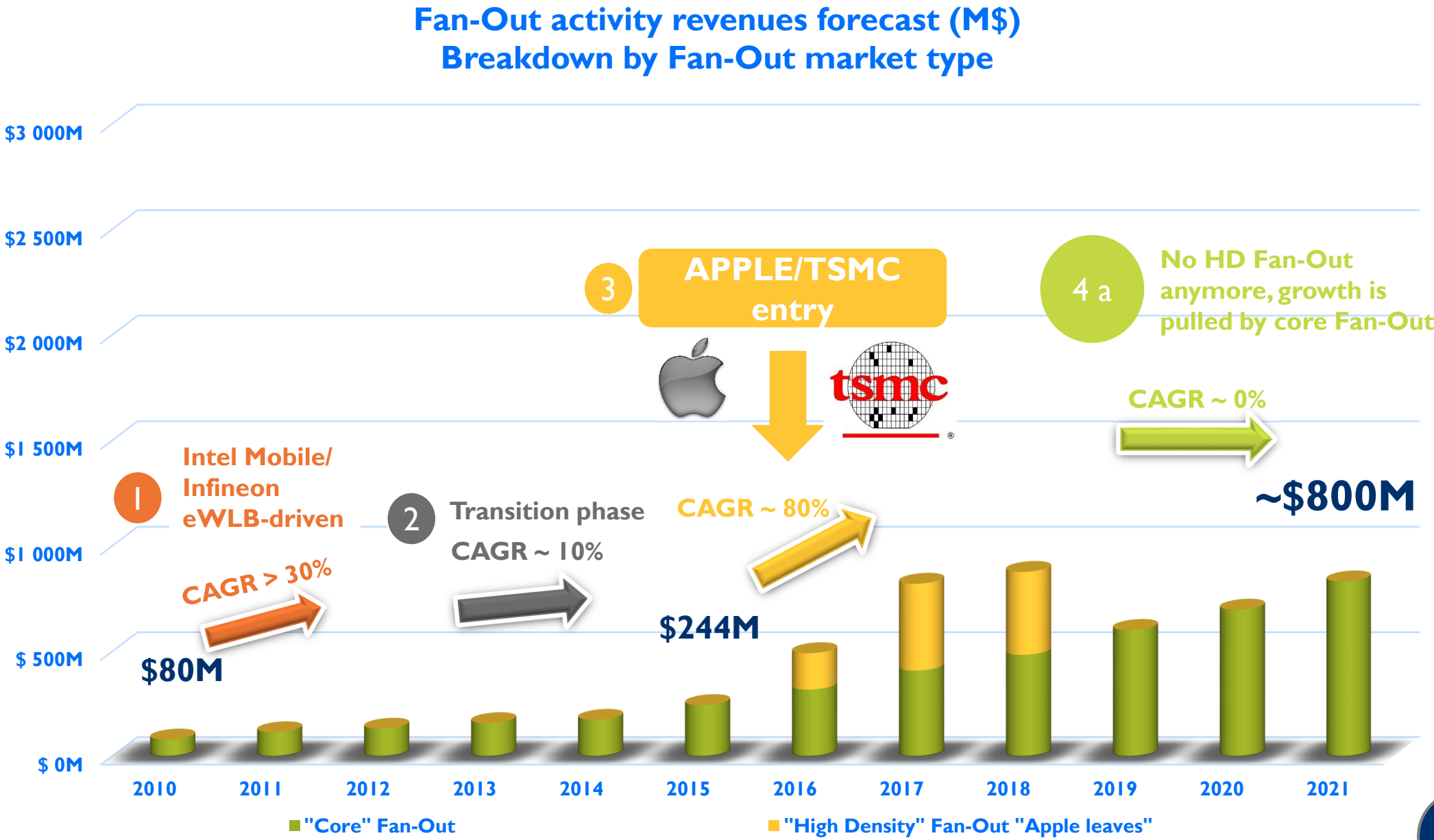
High expectations induce risks

- Fan-Out market may not be not as sustainable as it seems: Few players dependency

- Heavy competition pushed by substrates manufacturers may limit its success

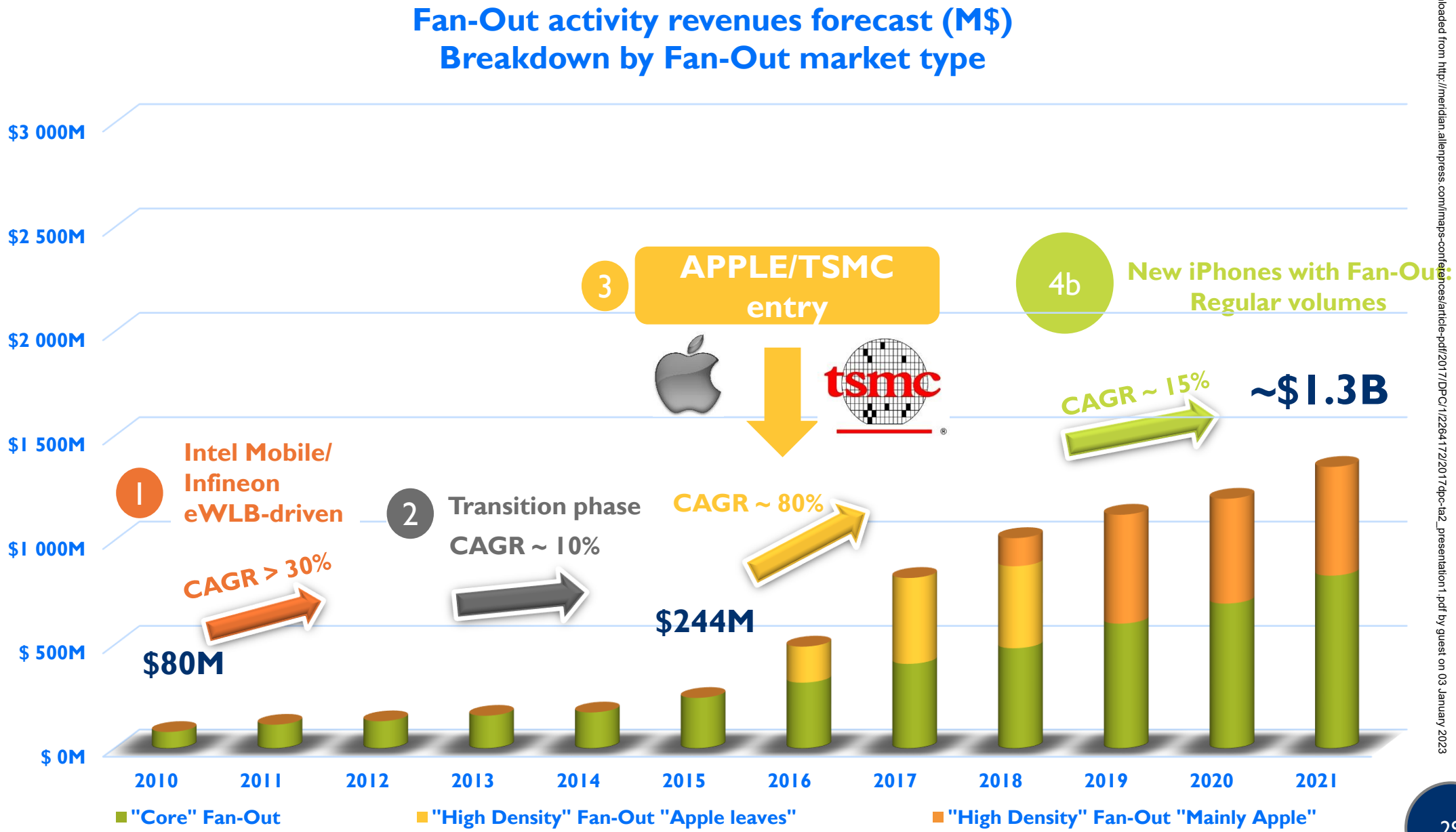
FAN-OUT ACTIVITY MARKET FORECAST WITH APPLE ENTRY

Pessimistic scenario: Apple will be the only player using Fan-Out for APE



FAN-OUT ACTIVITY MARKET FORECAST WITH APPLE ENTRY

Conservative scenario: Apple A10 is a one-hit occurrence and Fan-Out won't spread in APE packaging

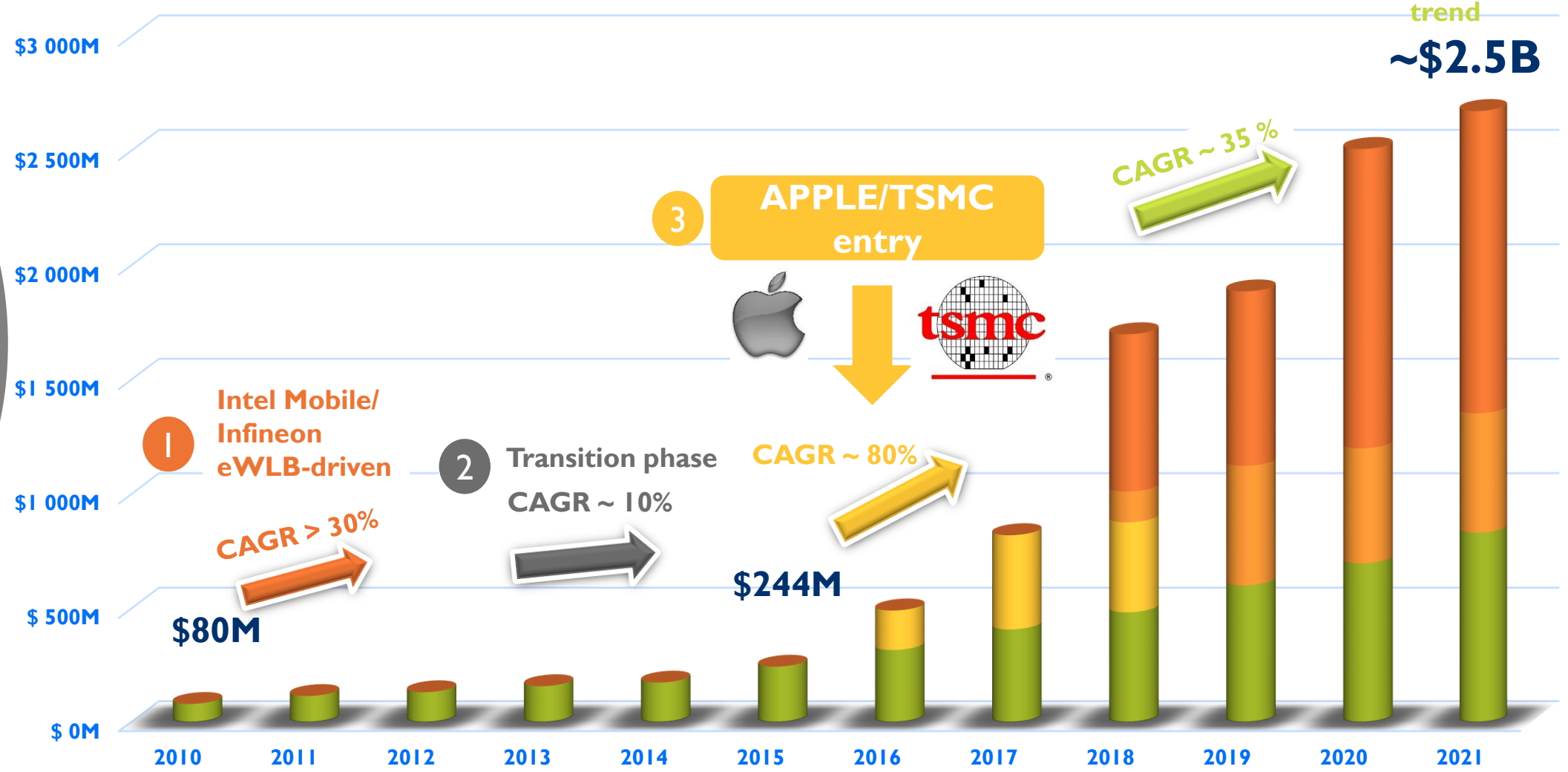


FAN-OUT ACTIVITY MARKET FORECAST WITH APPLE ENTRY

Optimistic scenario: Apple example will show the way to competitors

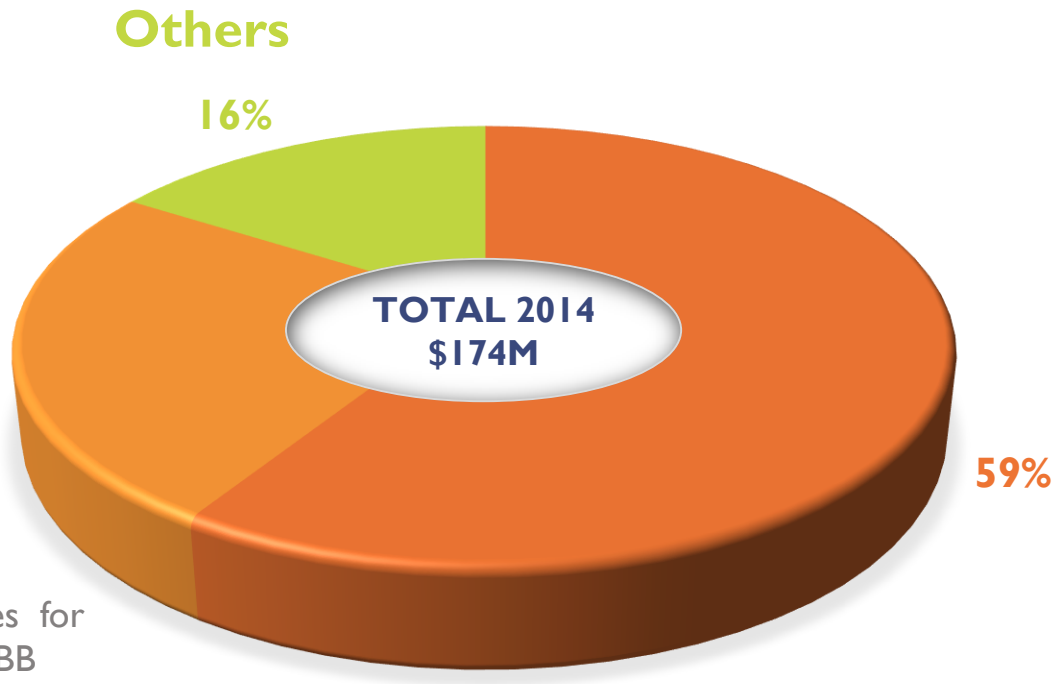
Fan-Out activity revenues forecast (M$)
Breakdown by Fan-Out market type

4c Confirmation phase: Apple keeps its APE in FO and other players follow the trend



FAN-OUT PACKAGING 2014 REVENUES MARKET SHARES (IN M$)

2014 FOWLP market status shows a domination of two players using eWLB



nanium

Main products:

- eWLB single die packages for Mobile and Wireless → BB and Wireless SoC, RF, PMIC
- MCP/SiP products for Mobile (PMU), Industrial, Medical and Security applications

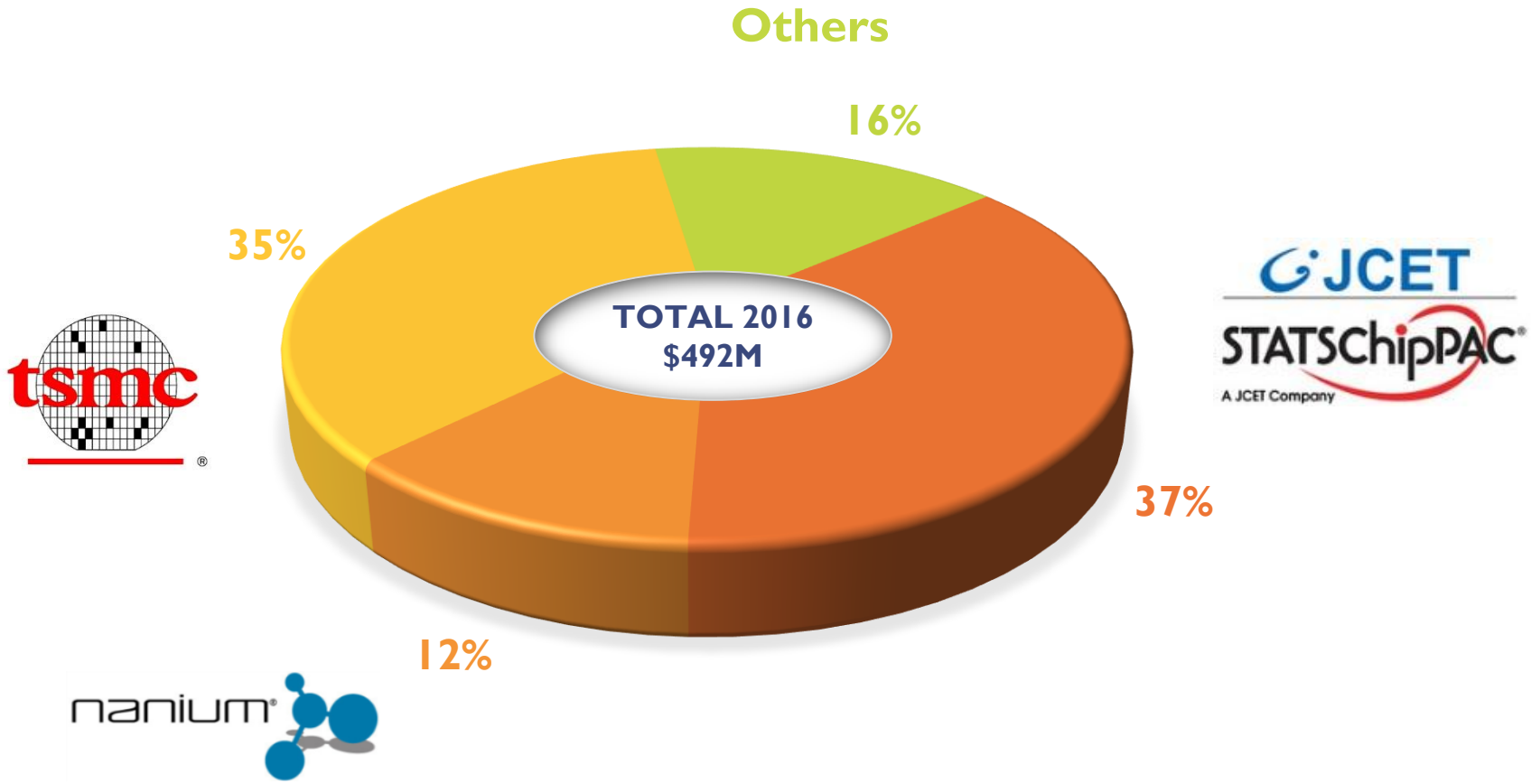
STATSChipPAC

eWLB products mainly for

- Mobile and Wireless → BB and Wireless SoC
- PMU/PMIC
- RF

FAN-OUT PACKAGING 2016 REVENUES MARKET SHARES (IN M$)

2016 Fan-Out market status shows TSMC entry and inFO take over



2016: Apple A10 entry with TSMC info will change the Fan-Out market landscape!

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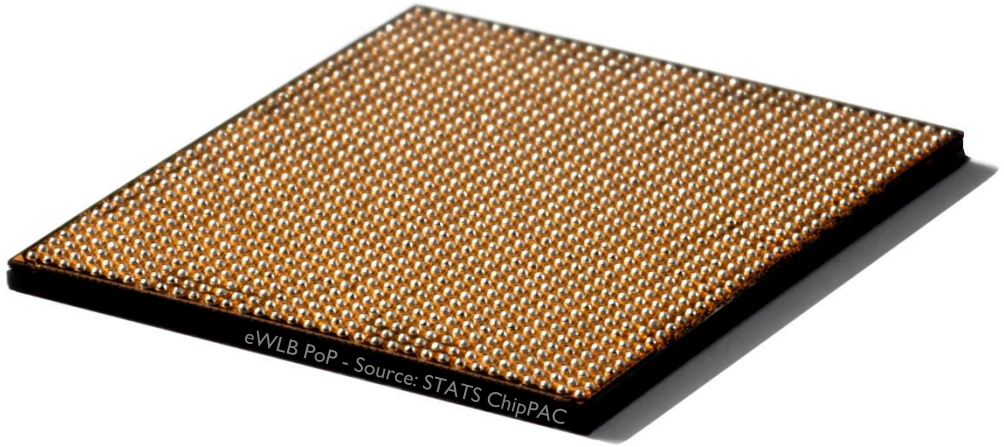

FAN-OUT: CONCLUSIONS

- Fan-Out packaging has numerous added values
  - Small form factor, high electrical performance, high integration capability, "middle-end" supply chain, etc…
- Fan-Out Packaging is already adopted by the industry and will keep growing
  - Many manufacturers understood that potential and tough competition will start
  - Mobile/wireless will remain the first puller but other markets will gain more and more shares.
- Following that the success numerours players entered the game and provided new technologies
  - Inducing some confusion on what is "Fan-Out"…
- Apple entry using TSMC InFo has changed the game and may have created a bubble…
- … but the market will enlarge anyway:
  - High potential in telecom but also in medical, industrial, automotive, etc….
  - High integration capability may open new perspectives

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Thank you! Any question?

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