LEADING PROVIDER OF ADVANCED SEMICONDUCTOR PACKAGING AND TEST SERVICES FOR GLOBAL CUSTOMERS

Paradigm Inflection of Packaging Industry

Choon Lee, 20 Mar 2019

- Industry Movement
- Packaging Inflection
- More to come for future

Industry Movement

Semiconductor Acquisition since 2015

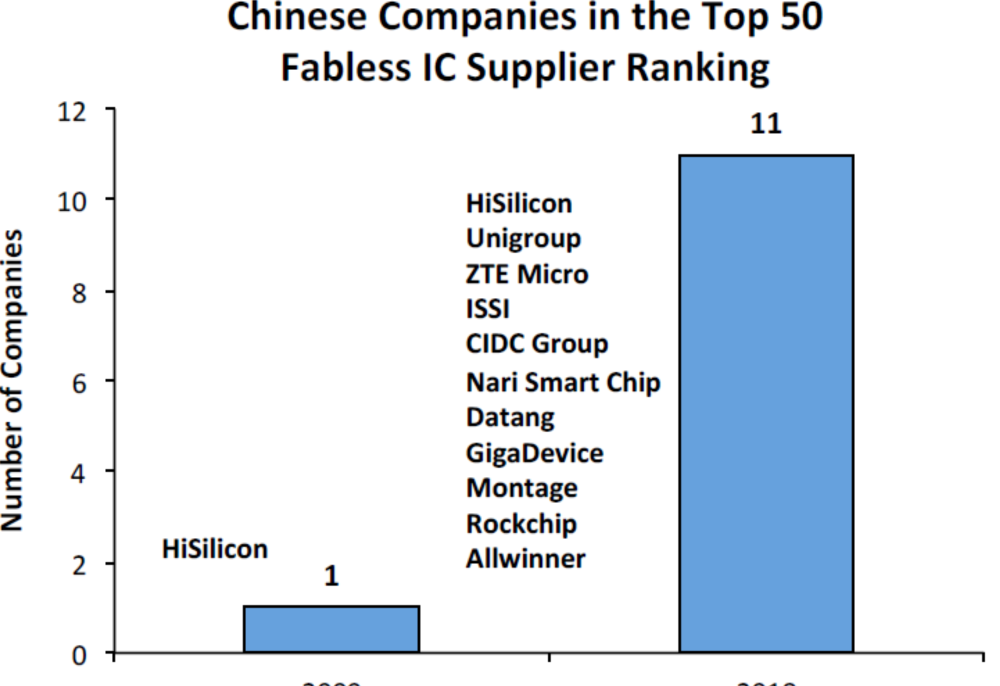
- **2015**
  - Avago (Broadcom)
  - Western Digital (SanDisk)
  - Intel (Altera)
  - NXP (Freescale)
  - Micrel (Atmel)
  - Microsemi (PMC-Sierra)
  - On Semi (Fairchild)
- **2016**
  - ADI (Linear Technology)
  - Renesas (Intersil)
- **2017**
  - Marvell (Cavium)
- **2018**
  - Microchip (Microsemi)
  - Renesas (IDT)

2018 : CA Technologies (Enterprise SW)

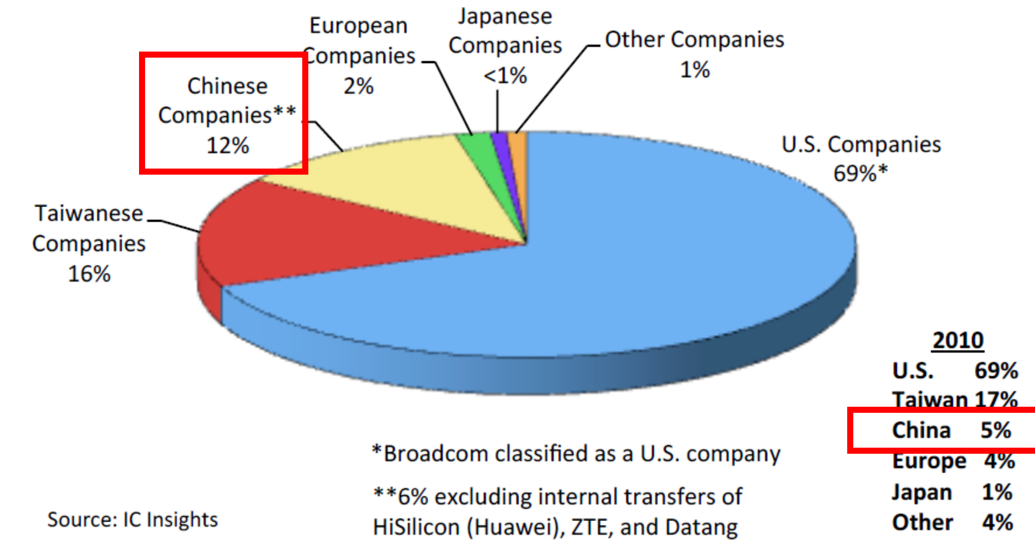
- **2019**
  - Nvidia (Mellanox)

- Less number of customers ➔ Tougher cost game
- Industry transition to new wave like automotive and IoT ➔ More capex for advanced packaging
- Slow growth rate ➔ longer ROI concerns

China is the next wave of packaging opportunities



Source: IC Insights



Fabless/System IC companies ranked by growth rate

2018 Rank	Company	Headquarters	2017 ($M)	2018 ($M)	18/17 % Change
1	ISSI****	China	490	645	32%
2	Nvidia	U.S.	9,402	12,281	31%
3	Allwinner	China	160	207	29%
4	HiSilicon	China	4,715	5,880	25%
5	Monolithic Power	U.S.	471	583	24%
6	MegaChips	Japan	640	790	23%
7	AMD	U.S.	5,329	6,506	22%
8	Nordic	Europe	236	283	20%
9	GigaDevice	China	305	360	18%
10	Elite Semiconductor	Taiwan	344	405	18%

Source : iC insights
PWC China Semiconductor report

Correlation between WW GDP and IC Market Growth

Worldwide GDP Growth

Global GDP Growth
WW IC Market Growth

Worldwide GDP Change
5%
4%
3%
2%
1%
0%
-1%
-2%

IC Market Change
50%
40%
30%
20%
10%
0%
-10%
-20%
-30%
-40%

2.9%
2.5%
2.4%
2.7%
2.6%
2.4%
3.1%
3.0%
2.8%
2.5%
2.8%
2.9%
3.1%

1%
-4%
5%
7%
-2%
3%
25%
11%*
17%
10%*
7%*
2%
-1%
7%
9%
13%

= Global Recession Threshold

11
12
13
14
15
16
17
18
19F
20F
21F
22F
23F

Year

Source: IC Insights

*Excluding memory

Analog growth implies ...

Largest IC Product Categories, 2018 and 2019F

Rank	2018 Market	$M	2019F Market	$M	% Chg
1	DRAM	$101,400	DRAM	$96,125	-5.2%
2	NAND Flash	$62,604	NAND Flash	$57,095	-8.8%
3	Std PC, Server MPU	$53,961	Std PC, Server MPU	$56,120	4.0%
4	Wireless Comm—Spcl Purp Logic	$28,058	Computer and Periph—Spcl Purp Logic	$30,673	12.0%
5	Computer and Periph—Spcl Purp Logic	$27,387	Wireless Comm—Spcl Purp Logic	$29,741	6.0%
Rank	**2018 Shipments**	**Units, M**	**2019F Shipments**	**Units, M**	**% Chg**
1	Power Management Analog	69,333	Power Management Analog	73,411	5.9%
2	Wireless Comm—App Specific Analog	27,696	Wireless Comm—App Specific Analog	31,158	12.5%
3	Industrial—App Specific Analog	23,505	Industrial—App Specific Analog	27,637	17.6%
4	General Purpose Logic	20,649	General Purpose Logic	21,702	5.1%
5	Consumer—Spcl Purp Logic	16,253	Consumer—Spcl Purp Logic	20,736	27.6%

Source: IC Insights

Analog never dies!

IC Unit Volume Makeup Trends (1980-2023F)

Digital % of Total / Analog % of Total

Year	Digital % of Total	Analog % of Total
1980	68%	32%
1985	64%	36%
1990	61%	39%
1995	56%	44%
2000	54%	46%
2005	52%	48%
2010	51%	49%
2015	47%	53%
2016	47%	53%
2017	47%	53%
2018	45%	55%
2019F	44%	56%
2023F	42%	58%

Share of Total: 0%, 20%, 40%, 60%, 80%, 100%

Year

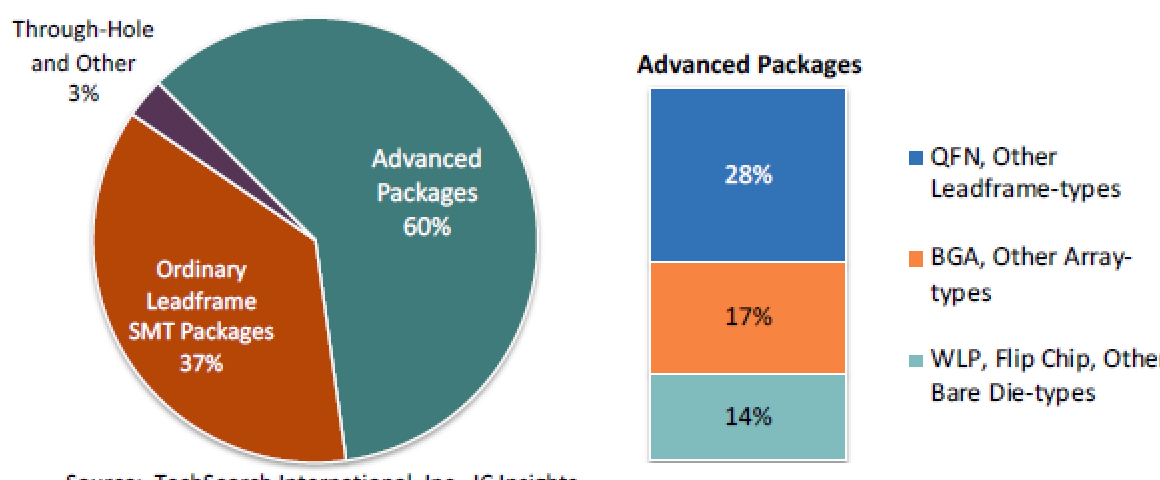
Source: WSTS, IC Insights

Packaging Inflection

Packaging growth in advanced packaging

IC Package Shipment Trends (Billions of Units)

Package Type	18	19F	20F	21F	22F	23F	18-23 CAGR	Examples
Advanced Packages	173.5	186.3	199.9	215.1	233.0	255.7	8%	CSP, S-CSP, WLP, flip chip, bumped die, PBGA, SiP, MCM
QFN, Other Leadframe-types	82.0	89.4	97.4	106.5	117.0	129.8	10%	QFN/MLF, SON, BCC, MIS, SiP
BGA, Other Array-types	50.3	51.9	53.2	55.3	57.2	59.8	4%	FBGA/LGA, PBGA/LGA, SiP, PoP, S-CSP, HBM, M-Series, InFO, MCM
WLP, Flip Chip, Other Bare Die-types	41.2	45.1	49.3	53.4	58.9	66.1	10%	Ultra CSP, microSMD, eWLB, FCOB, COB, COG, COF, TCP



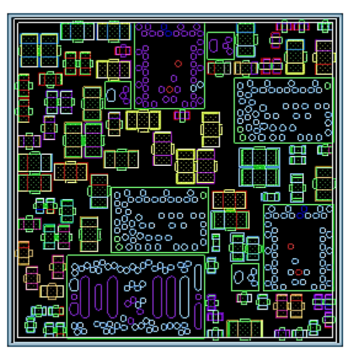
Source: TechSearch International, Inc., IC Insights

SiP Packaging Technology 1
: Mobile solutions

SiP Package Types		Features	Target Applications
AIP-SIP		• Embedded antenna • Discrete antenna • POP antenna	• mmWave and 5G • Networking/mobile
eWLB SiP		• Multi-die embedded • Multi-layer RDL (1-3L) • Passives Integration • Inductor with RDL for higher Q	• Connectivity • RF, PMIC module • RF MEMS • mmWave /radar
Leadframe/MIS SIP		• QFN or bare die + passives on MIS	• Power modules
Specialty SIP	MEMS	• ASIC/MCU + MEMS sensor • IR transparent molding • Optical isolation	• Fitness monitoring/WE • Automotive LIDAR
fcBGA-SiP		• SMT Module with/without H/S • Large body	• Hardware platform module • Automotive • Networking

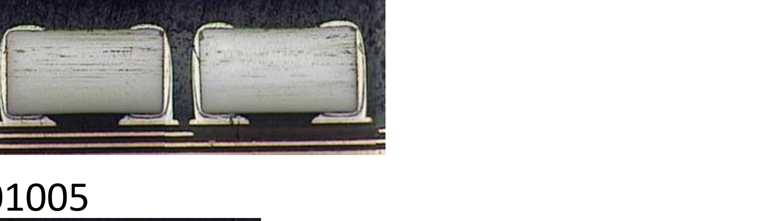
SiP Packaging Technology 2
: Core process solutions

High Density SMT



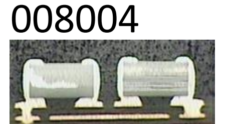
LGA 6x6mm
Sub 8L
GaAs FC (4x)
Si FC (4x)
008004 (32x)
01005 (23x)
0201 (26x)

0201

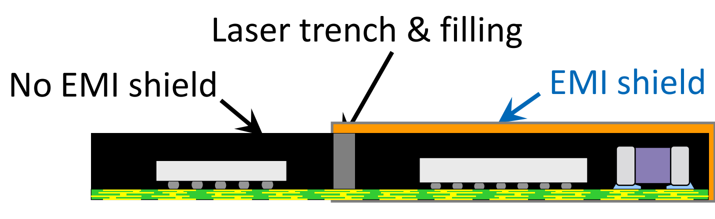


01005

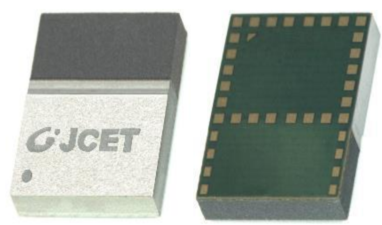
008004



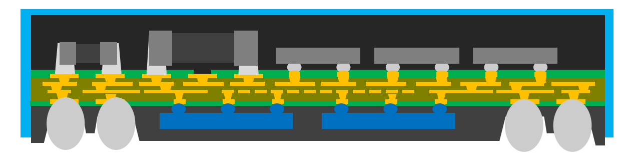
Compartmental + Selective Conformal EMI Shield

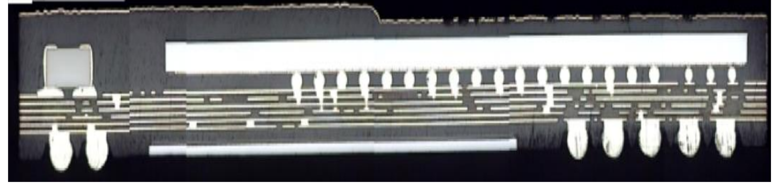


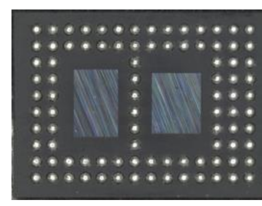
Package Construction for SiP Product



Double Sided Mold with Strip Grinding



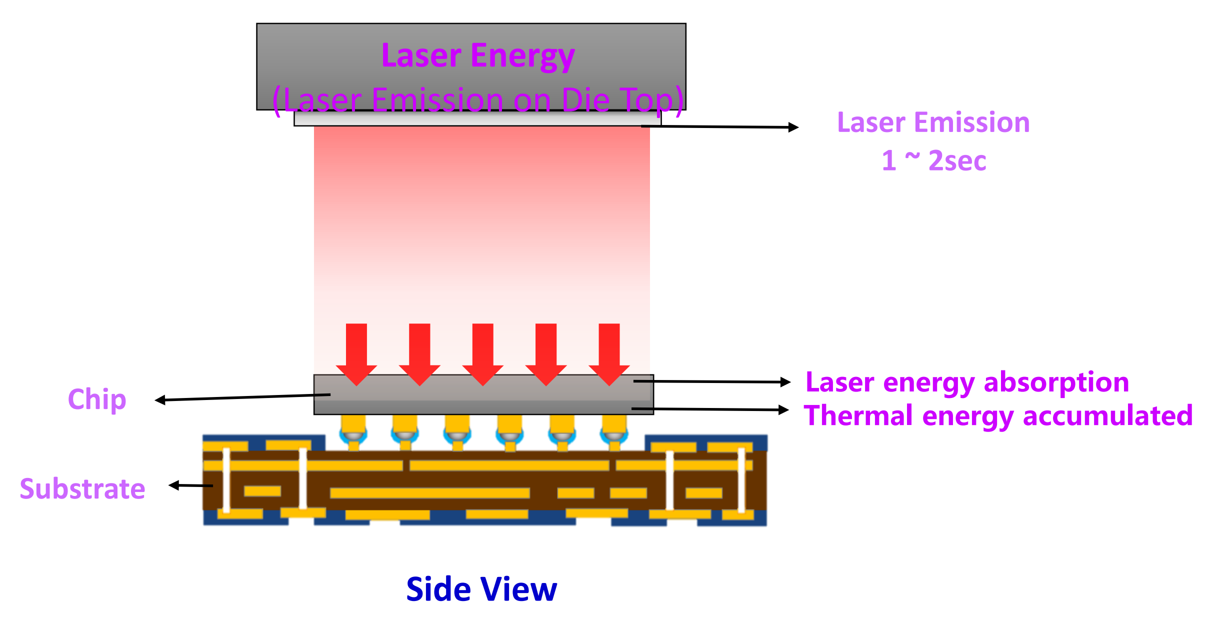




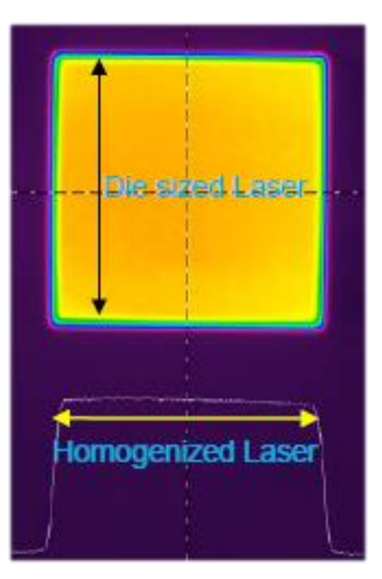
DS-SiP after Bottom Mold Grind

SiP Packaging Technology 3
: Interconnection technology
– Laser Assisted Bonding vs Mass Reflow

JCET



Side View

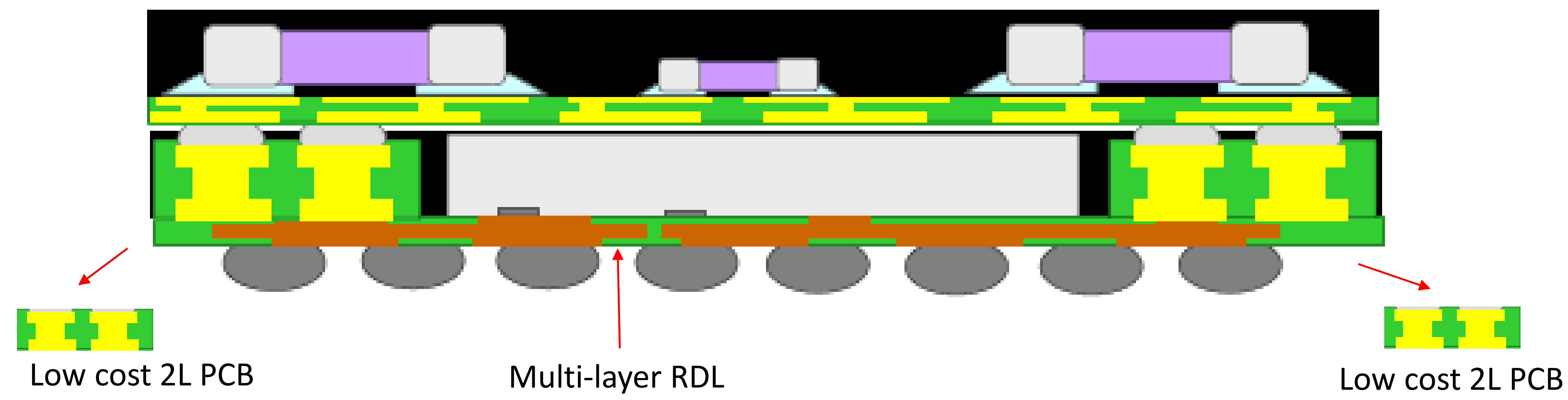


Top View

Source : Protec

2000	2010	2018
Flip chip mass reflow	Flip chip Thermo-compression	Flip chip LAB

SiP Packaging Technology 4
: Interconnection technology – eBAR



Option for replacing Mega-pillar plating

All in one SiP

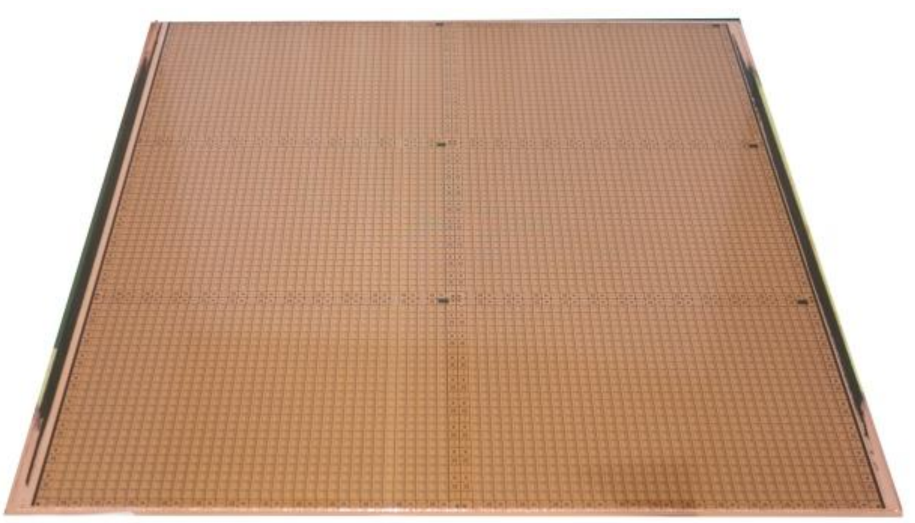
Qualcomm Snapdragon SiP1 **(ASUS Zenfone Max Shot and Max Plus M2)**

Image Source: Tudocellular via Manchikoni.com

Application processor,
Modem,
RF front end,
Audio codec,
RAM
NAND Storage

Small motherboard → bigger battery(4000 mAh)/extra camera/memory card slot/etc

Low Cost : Panel Level Fan Out



Source : TechResearch International Inc., adapted from PTI

Company	Chip First or Last	Process	Panel Size (mm x mm)	Line/Space (μm)	Production Status
ASE and Deca	Chip-first	Face-up	600 x 600	15/15,10/10, 8/8, 5/5, future 2/2	R&D, with production planned for 2020
Nepes (nPLP)	Chip-first	Face-down	600 x 600, expandable to 650 x 650	15/15	Production demonstrated
PTI (ePLP®)	Chip-first	Face-up	510 x 535	15/15, future 5/5 and 2/2	Production
SEMCO (FOPLP)	Chip-first	Face-down	415 x 510, expandable to 600 x 600	7/8, future 5/5 and 1.7/1.7	Production
Unimicron	Chip-last	Face-down	370 x 470; 510 x 515 under development	8/8, with target of 5/5, future 2/2	Production by end of 2019

Source : TechResearch International Inc.

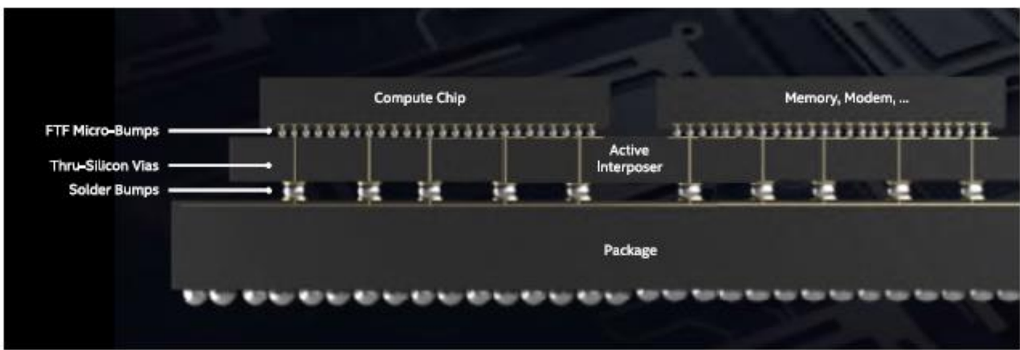
2.5D/3D TSV Packaging Technology
: FPGA, GPU and ASIC solutions for AI accelerators/HPC

Xilinx Virtex UltraScale+

- **Virtex UltraScale+ silicon interposer with TSVs using TSMC's CoWoS**
  - Interposer as large as 30mm x 36mm
  - Metal line stitching used for larger than reticle interposer products
  - 3 Cu metal layers plus 1 Al layer
  - <1µm lines and spaces
  - Thickness of 100µm
- **Approximately 660,000 interconnects in module**

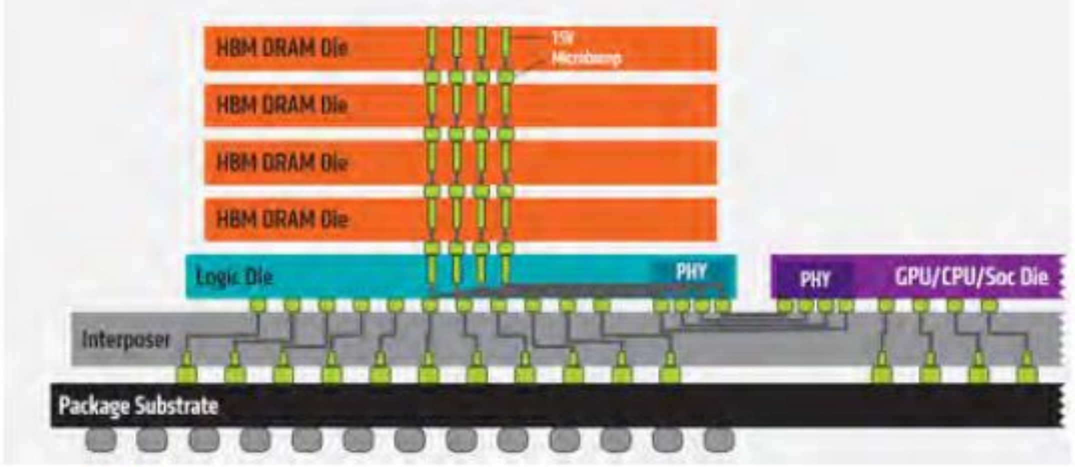
Source: Xilinx

Intel Foveros Face-Face Chip Stacking for Heterogenous Integration



Source: Intel

High Bandwidth Memory (HBM) Architecture



Source: AMD

Do not lost a sight on this : emerging with 5G

Smart Watch Market

- 2017 33.3Mu/2018 46.2Mu (39%↑)
- 2022 CAGR of 19.5% : 121.1Mu

	Apple Watch Series 4 with LTE	Apple Watch Series 4 without LTE	Samsung Galaxy Watch
FO-WLP	1	1	-
FO-PLP	-	-	1
WLP	26	21	7
FBGA	3	3	2
LGA	10	5	5
QFN	-	-	3
DFN	-	-	6
Flip Chip	1	1	1
TOTAL	41	31	25

Source : TechSearch Internation Inc., Adapted from eWise

AR/VR headset market forecast (units)

	2018	2022	CAGR
Augmented Reality	0.8 million	26.7 million	107%
Virtual Reality	8.1 million	39.2 million	49%
TOTAL	8.9 million	65.9 million	67%

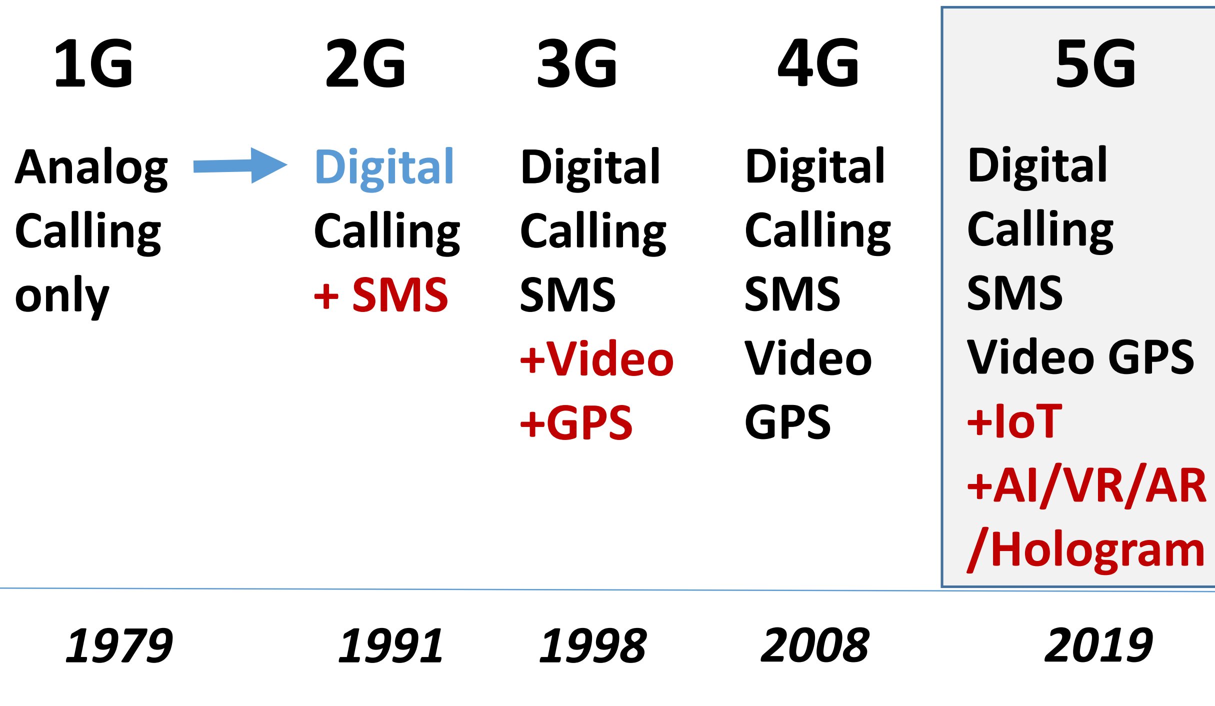
Source :IDC

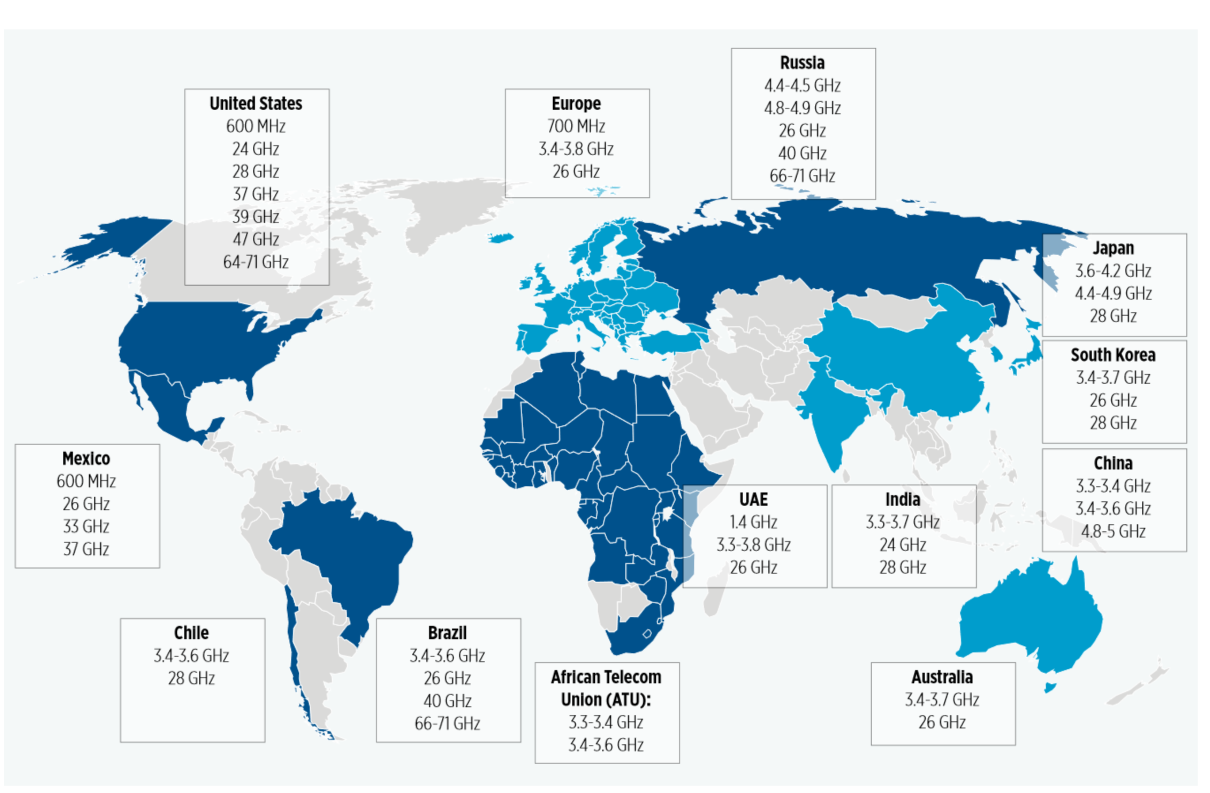
	Vive (2016)	Vive Pro (2018)
WLP	31	62
FBGA	4	5
FLGA	2	3
QFN	11	11
DFN	60	35
QFP	4	-
SOP	4	-
COB/COF	3	4
TOTAL	119	120

Source : TechSearch Internation Inc., Adapted from iFixit and datasheets

More to come for future

5G is a revolutionary milestone in all industry including mobile, automotive and IoT : RF SiP and Optical applications





McKinsey estimate that growth in the semiconductor market from 2017 to 2025 will be dominated by AI semiconductors **at 5X higher CAGR than all other semiconductor types combined**.

Worldwide Deep Learning Chipset Revenue

$70B
$60B
$50B
$40B
$30B
$20B
$10B
$-B

2016 2017 2018 2019 2020 2021 2022 2023 2024 2025

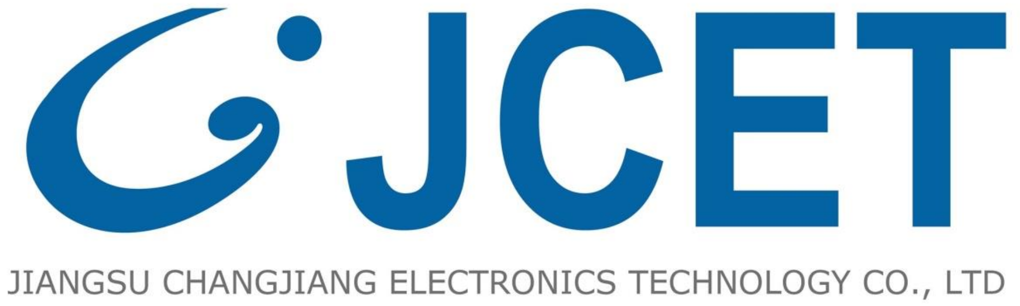
SoC Accelerator & Other
ASIC/ASSP
FPGA
GPU
CPU

Source: Tractica

Source: Tractica, with Arteris IP overlay

Summary

- More SiP will come along with 5G development
- Require more knowledge and expertise in RF testing
- More automation for SiP manufacturing line with AI edge applications
- More analog conversion to advanced packaging such as WLP
- More dedication to cost efficient solutions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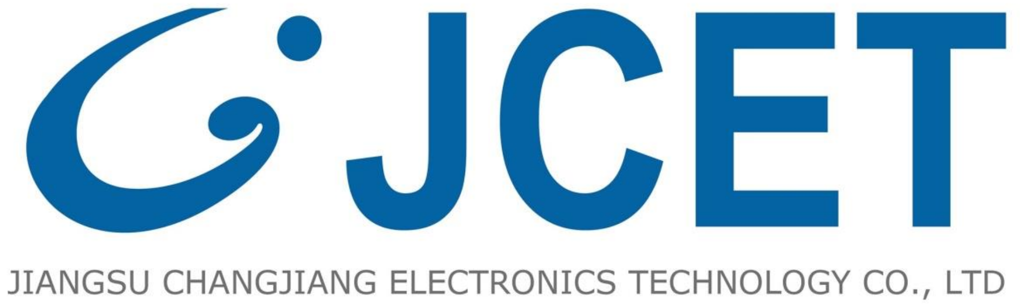
JIANGSU CHANGJIANG ELECTRONICS TECHNOLOGY CO., LTD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