

Trends of Advanced IC packages in Data Center Era and the materials

*Subtitle: Trends of FO-WLP/PLP, 2.5D PKG and the encapsulants,
RDL dielectric materials*

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< Subjects of survey >

▼ IC PKG: FO-WLP, FO-PLP, 2.5D Package, EMIB, 3D Package

▼ PKG material:

- Encapsulant: Liquid, Granule, Sheet

* Limited to encapsulants for a wafer level or a large panel base assembly

- Dielectric material: Photosensitive (Positive/Negative) and Non-photosensitive types

< Companies surveyed >

▼ Assembler of Advanced PKG and IC company

TSMC, ASE, SPIL, Amkor, Intel, Samsung, JCET/STATS ChipPAC, PTI, Nepes, JCET/JCAP, Infineon, Micron, SK Hynix, Shinko, China Wafer Level CSP, HuaTian

▼ Encapsulant material supplier and equipment manufacturer

Asahi Kasei, Toray Industries, HD MicroSystems, Fujifilm Electronic Materials, Sumitomo Bakelite, Showa Denko Materials, Shin-Etsu Chemical, Ajinomoto Fine-Techno, Nagase ChemteX, Panasonic, Namics, Sunyu Rec

* Trends of Heterogeneous Integration PKG

1. Trends of CPU/GPU/FPGA PKG for Data center

- Shift to 2.5D PKG, 3D PKG and Fan-out PKG

2. Technology trends of Advanced PKG

- 2.5D PKG: Size expansion of PKG and Si interposer, Competitiveness between 2.5D PKG and EMIB
- FO-WLP/PLP: Size expansion, Replacing in Si interposer by RDL technology

* Trends of main materials for IC PKG

1. Dielectric materials for RDL:

- Shift from FO-WLP to FO-PLP, Size expansion of PKG
- Market by application, type of photosensitivity, type of polymer

2. Encapsulants for wafer/panel base assembly

- Shift from Liquid to Granule and Sheet type
- Demand for wafer/panel level MUF
- Market by material form, applied PKG type, assembly process type (Chip-First & Chip-Last)

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- By RDL count

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Chapter 2 Trends of ICs for Data Center

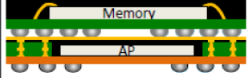
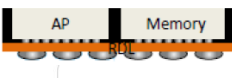

[Product trends of Xilinx's FPGA and SoC for Cloud]

Year	2014	2016~	2018~	2019	2020
Brand	Virtex UltraScale	Virtex UltraScale +		Versal	
Series/Product #		VU3P ~29P	VU31P ~47P	Prime, AI core	Premium AI
Architecture	UltraScale				
Si process	20nm				
FPGA/SoC	FPGA x 1~4				
Peripheral device	-				
PKG type	2.5D PKG, Oth.				
PKG size	2.5D	40x40 ~ 55x55mm			
	Others	40x40 ~47.5x47.5mm			
Memory support	DDR4				

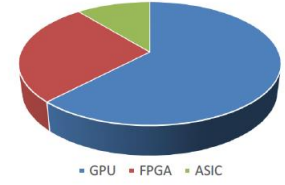
【NNP-T1000】

【Ascend 910】

[Kinds of Samsung's FOPLP]

	FOPLP-PoP	FOSIP	2.5D RDL-Interposer
Cross-section			
L/S size of RDL	10/10 ~ 5/5μm		
Assembly process	Chip First		
Die bump	less		

[Wafer unit base]



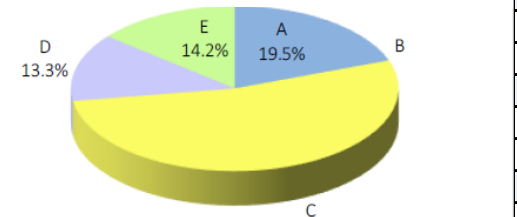
[List of assembly technologies by FOWLP/PLP]

Assembler	PKG name	Assembly process	Bonding
Amkor Technology	eWLB	Chip-First	
ASE			
...			
...			
JCET/STATS ChipPAC			
Nepes			
Powertech Technology			

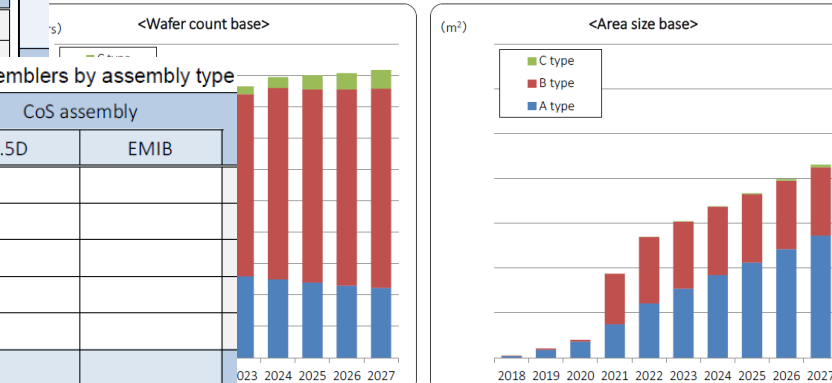
[Market size forecast of 2.5D like PKG by IC & w/ and w/o HBM]

IC	w/ HBM	w/o HBM	2018	2019	2020	2021	2022	2023	2024
			GPU						
FPGA									
ASIC									
CPU									

[Market share by assembler: 2.5D like PKG by CoW assembly in 2019]

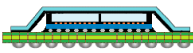
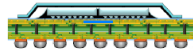



[Market size forecast by PKG type: FO-WLP (left), FO-PLP (right) - area base]



Chapter 3 Trends of Heterogeneous Integration packages

[Comparison of 2.5D type PKG and FO-MCM]

A	2.5D PKG	EMIB	FO-MCM
Cross section image			
Wiring material between ICs	Si-IP	Die embedded substrate	RDL
L/S size	L/S size	0.4/0.4μm	
	Area size	800 ~ 1600mm ²	
	Thickness	100μm	
	Manufacturer	IDM / Foundry	TSMC
Bump of IC	Bump formation	Yes	B
	Minimum pitch *2	45μm	C
Encapsu-	PKG	Yes or Non	D
			E

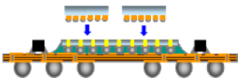
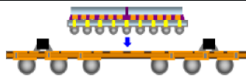
[Trends of FO-WLP/PLP market and major assemblers by WLP]

	FO-WLP (K wafers)			
	Small	Middle	Large	Total
TSMC	0	1,xxx		

Trends of 2.5D like PKG market and major assemblers by assembly type

	CoW assembly		CoS assembly	
	2.5D	EMIB	2.5D	EMIB
TSMC				
B				
C				
D				
E				
Total (K pieces)				

[Outline of assembly process of CoS and CoW and the comparison]

Chip on Substrate (CoS)	Chip on Wafer (CoW)
	
After a Si-IP is mounted on a packaging substrate, chips are mounted on it.	Chips are mounted on a Si-IP wafer, which then singulated and mounted on package substrates.
C2C base (bonding to Si-IP of unit piece)	C2W base

Sample images -2-

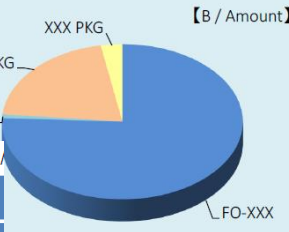
Chapter 4 Trends of main packaging materials

[List of applicable encapsulation by type of Heterogeneous Integration PKG]

PKG	Type	PKG encapsulation	UF encapsulation
FO-WLP/PLP	By assembly process	Chip-First	✓
		Chip-Middle	
		Chip-Last	
2.5D PKG	By assembly process	CoW	
		CoS	
	By FC bump	Between Chip	
		Between IP - F substrate	
EMIB	-		
3D PKG	-		

[Sheet type encapsulant situation]

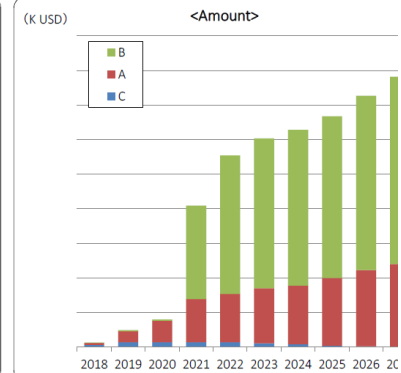
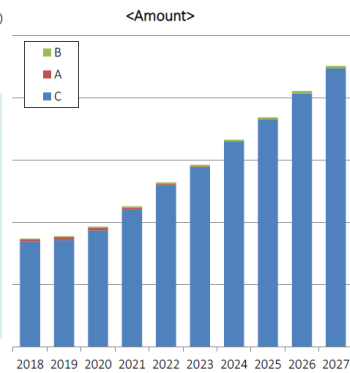
Material manufacturer	PKG encapsulant		
	Large base *1	Hollow	following a shape
...			
Dexerials			
...			
Hitachi Chemical			
Kyocera			



[Sales status of major encapsulant manufacturers for wafer/panel base assembly by material form in :

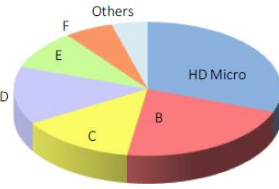
Manufacturer	Volume				Amount (K USD)		
	Liquid	Granule	Weight total (kg)	Sheet (m ²)	Liquid	Granule	Sheet
Nagase Chemtex							

[Market size forecast of encapsulants for wafer base assembly (left) and panel base assembly (right) by material form (amount base)]



[Characteristic table of negative tone liquid dielectric materials for FO-WLP]

Product	Asahi Kasei	Fuji Film	Toray	Nippon Kayaku
Solvent	Organic			
Polymer	PI			
Film thickness	2~30 μm			
Cure condition	200~400 deg.C/h			
Tg	200 deg.C			
Thermal decomposition temp.	- deg.C			
Weight loss temperature 5%	335 deg.C			
CTE	60~70 ppm/deg.C			
Young's modulus	3.5 GPa			
Tensile strength	> 120 MPa			



[List and status of liquid photosensitive dielectric material]

Material manufacturer	Negative		
	Product series	Polymer	Status
Asahi Kasei	BL-300 series	PI	MP
	BM-300 series	PI	MP

Chapter 5 Case studies of material manufacturers

[Adoption status of product series of dielectric materials by application]

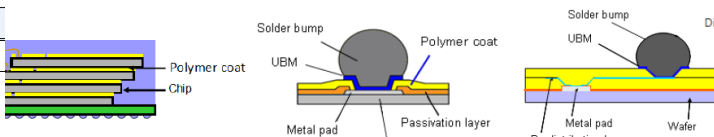
Photo type	Polymer	Product series	Feature	Buffer Coat			FC bump	RDL	
				Memory	Logic	Power		FI-WLP	FO-WLP
Posi	PBO	...-8300	Standard, g&i-line	✓	✓	✓		✓	

[Market size forecast of liquid dielectric materials for buffer coat by application]

Application	2018	2019	2020	2021	2022	2023	2024	2025
Memory								
Logic								
Power								
Total (t)								

[Types and usage of dielectric materials]

Type of dielectric material	Usage
Photosensitive (Positive/Negative), Non-photosensitive	Surface protection and stress buffer coat, Bump reflow, Dielectrics (incl. redistribution layer), Formation of hollow structure



[Sales trends of dielectric materials by type and application (2019)]

Type	Application	Buffer Coat			FC bump	RDL		
		Memory	Logic	Power		Sub-total	FI-WLP	FO-WLP
Volume	Positive				0			0
	Negative				0			0
	Non-photo				0			0
	Total (kg)				0			0
Amount	Positive				0			0
	Negative				0			0
	Non-photo				0			0
	Total (K USD)				0			0

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