< New report >

Advanced Packaging and Materials in the Chiplet Era

Subtitle: Trends in 2.xD packages and RDL dielectric materials, Encaplulants

Japan Marketing Survey Co., Ltd

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Subjects of survey

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< Subjects of survey >

▼ IC PKG: 2.5D Package (Si-IP type), 2.3D Package (RDL-IP type), Si-Bridge PKG (EMIB, others), Fan-out Package (FO-WLP, FO-PLP), 3D-TSV memory

▼ PKG material:

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

  * Market data is for liquid type only

- Encapsulant: Liquid, Granule, Sheet * Limited to wafer level or large panel base assembly

< Companies surveyed >

▼ IC PKG assembly and IC design/foundry

IC Packaging: TSMC, Intel, Samsung Foundry, Amkor, IBM, ASE / SPIL, Shinko, AOI Electronics

IC/Foundry: Intel, AMD, Nvidia, TSMC, Samsung Foundry, AWS, Cerebras, Graphcore, etc.

▼ RDL dielectric material and Encapsulant suppliers

Ajinomoto Fine-Techno, Asahi Kasei, Fujifilm Electronic Materials, HD MicroSystems, Nagase ChemteX, Namics, Resonac, Sunyu Rec, Sumitomo Bakelite, Toray Industries

Focal points of survey

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▼ Trends of Chiplet PKG

1. Chipletization of Major ICs and Trends in Advanced PKG Technology
2. Diversification of 2.xD PKGs and application of fan-out PKG technology
   - Si interposer (IP) alternatives: RDL-IP, Si-Bridge, Glass-IP
   - Larger IP/PKG, 3D IC, fine pitch bonding and hybrid bonding
3. Chiplet PKG technology trends of major IC/foundries/assembly companies

▼ Trends of major PKG materials

1. RDL Dielectric materials:
   - Shift from Si-IP (2.5D) to RDL-IP (2.3D PKG), Size expansion of IP/PKG size
   - Market trends by application, type of photosensitivity, type of polymer
2. Encapsulants for wafer/panel base assembly
   - Adoption of wafer level MUF, competition with liquid materials/granules, etc.
   - Market trends by material form, PKG type, and wafer/panel assembly

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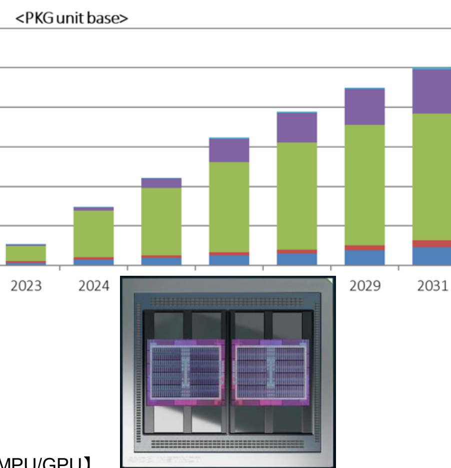
From Chapter 1, 2, 3 (Trends of IC Chipletization and PKG)

【Technology Trends of 2.5D system PKG by type 】

2.5D PKG (Si-IP)	- Until now, the demand for 2.5D used for these applications has packages and the demand for otl - The embedding of trench capac
EMIB (Si Bridge embedded substrate)	- The number of embedded Si Br - As chip embedding is assemble accuracy and flatness. - EMIB-embedded substrates are
2.3D PKG (RDL-IP)	- It has the largest cost advantag - Mass production of large-size p - PCB manufacturers are entering
Si Bridge-IP (Si Bridge embedded encapsulant)	- By embedding Si, which is respo the cost can be reduced compare advantage that capacitors and ot - Although the assembly process suitable for larger packages beca reducing the overall CTE mismat
Glass-IP	- It has an advantage in electric c advantage in manufacturing large - It has L/S of about 2/2 µm, whic interconnection formation.

【Market trend of 2.5D system PKG by IC 】

<PKG unit base>

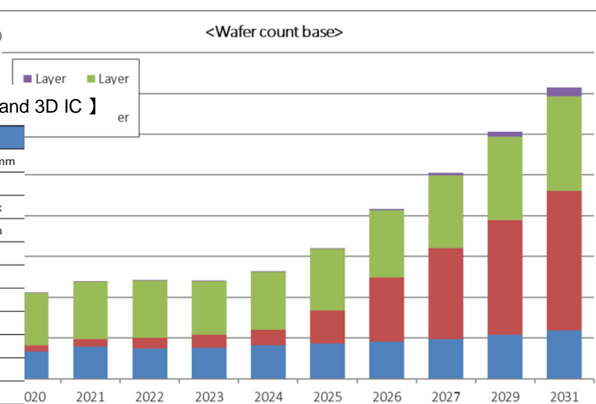


【 Table of PKG technology type adopted by IC 】

IC	Company	Product brand	2.5D	RDL-IP/
CPU	Intel	Xeon SP, Core	✓	
	AMD	Epyc, Ryzen		
	Fujitsu	A64FX		
GPU				
FPGA				
AI chip (ASIC)				
Network switch				

【 Market size forecast of Fan-out packages by RDL count - 】

<Wafer count base>



【Technology roadmap of 2.5D system PKG and 3D IC 】

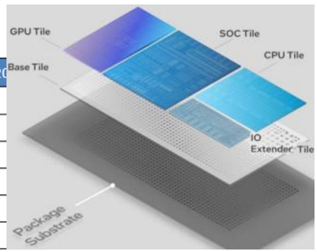
			2021
PKG w/ IP		PKG size	~ 100 x 100 mm
		Chiplet to IP/Bump pitch	40 µm
	2.5D PKG	Si-IP size	Reticle: 2 x
		L/S size on Si-IP	0.4/0.4 µm
	2.3D PKG (RDL-IP)	RDL-IP size	
		L/S size	
		RDL layer count	
	Si-Bridge FO	Die embedded RDL size	
Si-Bridge/EMIB		PKG size	
		Substrate layer count *1	
		EMIB count	
		Bump pitch	
3D IC PKG/ Chip to Chip tech.		M/L on L*2	Bump pitch
		HBM	Bump pitch

【Product launch roadmap of AMD's MPU/GPU】

		2019年	2020年	2021年	2022年	2023年	2024年
MPU	Server/ HPC	7nm Rome					
	Work-station	12nm Colfax	7nm Castle Peak				
	Desk-top PC	7nm Matisse	← Vermeer				
	Mobile PC	12nm Picasso	7nm Renoir				
GPU	GPGPU		7nm Arcturus				
	Gaming PC	7nm Navi 10, 14 Vega 20 XT	← Navi 21, 22				

【Specs of AMD GPGPU products 】

		2020	20
Model		Instinct MI100	
Codename		Arcturus	
Architecture		CDNA	
Si process		7nm	
# of GPU dies		Single	
GPU die size		750mm²	
Memory	Type	HBM2	
	Size	32GB	
PKG tech for chiplets		2.5D	



【Types of Si interposer alternative materials and technologies】

	(2.5D PKG)	2.3D PKG	Si Bridge PKG	
Type	Glass interposer	RDL interposer	Fan-out technology base	Substrate built-in
Structural image drawing				
Rigid layer of IP				(no IP)
Fine wiring layer				Build-up substrate technology
Via formation *1/ Resin				Laser / non-photo
Work shape				Panel
Comparison with Si-IP, advantages				Assembly using existing PKG technology, Cost reduction

EMIB	Foveros	...	...
Si bridge			
55~45µm			

【Intel's PKG lineup for Chiplet】

【Market size forecast of Fan-out packages by Assembly base shape 】

		2020	2021	2022	2023	2024	2025	2026	2027	2029	2031	CAG
Small	Wafer base											
	Panel base											
	Sub-total											
Middle (PoP)	Wafer base											
	Panel base											
	Sub-total		1,450.0									
Large (2.5D)	Wafer base											
	Panel base											
	Sub-total											

Sample images -2-

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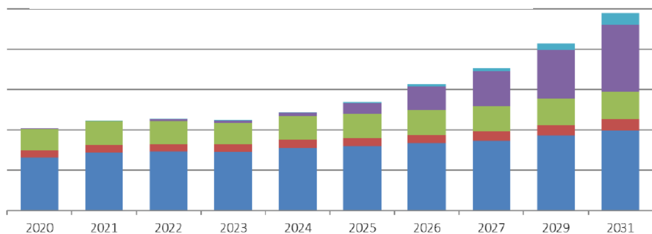
From Chapter 1, 4, 5 (Trends of PKG material markets and companies)

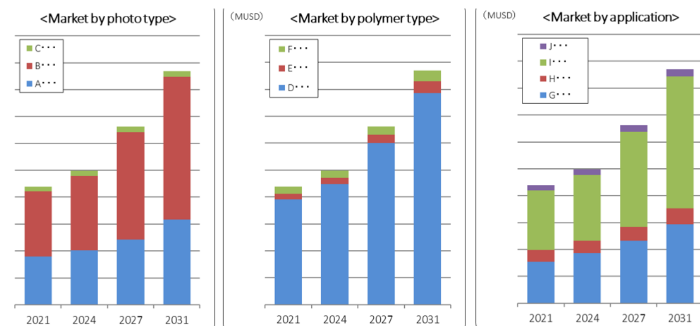
【Market size forecast of RDL Dielectric materials】



【Market trend forecast of Liquid encapsulants by type】

			2021	Ratio	2024
Value market		Total (K USD)	11,280	100.0%	
	by PKG use	FO/Small			
		FO/Middle			
		FO/Large			
		2.5D PKG			
		TSV Memory			
	by assembly base	Wafer base			
		Panel base			
	by encapsulant type	MUF			
		Non-MUF			
Volume market		Total (t)			
Overall average		(USD/kg)			

【Market trend forecast of Liquid dielectric materials by various category classification (amount basis) 】



【Characteristic table of Low Dk / Df type Dielectric material (liquid and film type) 】

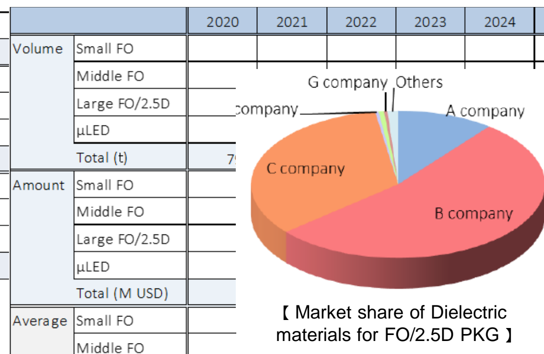
			Toray	・・・	JSR
Product			UR-D		
Form of material		-			
Tone		-	Nega/Orga		
Dielectric constant (Dk)		-	2.8		
Dielectric loss constant (Df)		-	0.0063		
Polymer		-	PI		
Film thickness		μm	-		
Cure condition		deg.C/h	200/1		
Tg		deg.C	125		
Weight loss temperature	5%	deg.C	340		
CTE		ppm/deg.C	80		
Young's modulus		GPa	2.2		
Tensile strength		MPa	74		
Elongation		%	40		
Residual stress		MPa	-		

【 Market size and breakdowns by usage and photosensitive type (volume & amount basis) 】

		Buffer Coat				FC bump	RDL			Others	Tot
		Memory	Logic	Power	Sub-total		FI-WLP	FO/2.5D	Sub-total		
Volume	Positive										
	Negative										
	Non-photo										
	Total (kg)										
Amount	Positive										
	Negative										
	Non-photo										
	Total (K USD)	85,600									
Average price	Positive										
	Negative										
	Non-photo										
	Total (USD/kg)										

【 Market size forecast of liquid dielectric materials by application type 】

		2020	2021	2022	2023	2024
Volume	Small FO					
	Middle FO					
	Large FO/2.5D					
	μLED					
	Total (t)	7				
Amount	Small FO					
	Middle FO					
	Large FO/2.5D					
	μLED					
	Total (M USD)					
Average	Small FO					
	Middle FO					

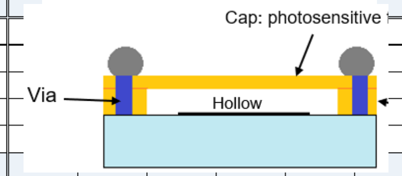


【 Market share of Dielectric materials for FO/2.5D PKG 】

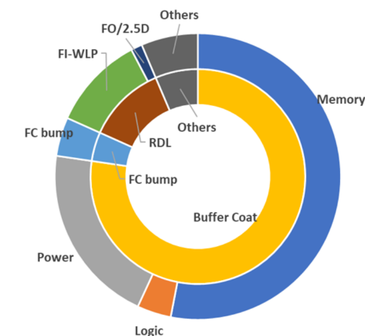
【Market size forecast of liquid encapsulant for wafer/panel base assembly by applied PKG type 】

		2020	2021	2022	2023	2024	2025
Volume	FO/Small						
	FO/Middle						
	FO/Large						
	2.5D PKG						
	TSV Memory						
	Total (kg)						
Amount	FO/Small						
	FO/Middle						
	FO/Large						
	2.5D PKG						
	TSV Memory						
	Total (K USD)						

【Hollow structure PKG used with photosensitive resin 】



【A company's sales ratio of Liquid dielectric materials by application 】



【 Comparison evaluation of PKG encapsulants by form 】

Form of material	Tablet
Encapsulation system	TM
Temperature for molding and cure	High
Flowability of resin	Lower
Effective usage ratio	Low
Price	Low

【 Sales status of major encapsulant manufacturers by material form 】

	Volume				Amount
	Liquid	Granule	Weight total (kg)	Sheet (m^2)	
Nagase Chemtex					
B					
C					
D					
E					

【 A company's Adoption status of product series of dielectric materials by application 】

Photo type	Poly-mer	Product series	Feature	BC			FC bump	RDL	
				Memory	Logic	Power		FI-WLP	FO-WLP
		----	Standard	✓	✓	✓		✓	
		----	High adhesion						
		----	High speed, High contrast						
	PBO	----	High chemical resistance.						

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