< New market survey report >

FO-WLP & Encapsulant Report

~ Markets and Technologies ~

Japan Marketing Survey Co., Ltd

http://www.jms21.co.jp/

TEL:81-3-5641-2871 FAX:81-3-5641-0528

3-10-14 Higashi-Nihonbashi Chuoku Tokyo 103-0004 Japan

Focal points of survey

▼ FO-WLP

1. Driver of Market expansion
   - Application IC: AP, BB/RF, PMIC, Substitute PKG of 2.5D IC,
   - Assembly base format: wafer base or panel base

2. Technical issues for cost reduction and market expansion
   - Shift from wafer base assembly to panel base assembly, Enlargement of assembly work size
   - Technologies and issues to realize panel based assembly; warpage, mounting accuracy, tact, apply of resins for panel base…

▼ Encapsulation and material

1. Market trends of encapsulants for FO-WLP
   - Promise of liquid, granular and sheet types
   - By usage: for FO-WLP, or for Other packages
   - for FO-WLP by assembly base format, by application IC
2. Technical trends of encapsulation for FO-WLP:
   - Warpage, application for panel base format, dust, die shift, non-filling…

Subjects of survey

<Subjects of survey>

◆ FO-WLP (Fan-out Wafer Level Package):

- Chip-First type, RDL-First type
- Face-down type, Face-up type
- Wafer base assembly, Panel base assembly

* But RDL-first type FO-WLP not using photolithography for semiconductor is not included.

◆ Encapsulation system and material:

- System: Compression Mold, Vacuum printing, Lamination, Others
- Material: Liquid type, Granular type, Sheet type, Tablet type
- For FO-WLP, for others (MUF, PKF for long wires, hollow encapsulation, etc.)

<Companies surveyed>

▼ FO-WLP assembler

- ASE, SPIL, TSMC, Amkor, STATS ChipPAC, Nanium, Nepes, Deca, J Devices, Infineon, Freescale, Toshiba, Fujitsu laboratories, Others

▼ Encapsulant material supplier and equipment manufacturer

- Nagase Chemtex, Panasonic, Ajinomoto FT, Sumitomo Bakelite, Hitachi Chemical, Kyocera, Shin-Etsu Chemical, Nitto Denko, Others
- Apic Yamada, TOWA, Others

Table of contents -1-

Chapter 1 Executive Summary

1. Overall trend of FO-WLP market <P2>
1.1 Overview of FO-WLP market trend
1.2 Market size forecast of FO-WLP
1.3 Major IC to use FO-WLP
2. The adoption of FO-WLP for AP <P5>
2.1 Summary of trends of FO-WLP adoption for AP
2.2 Market size forecast of FO-WLP for AP
2.3 PKG technology comparison of Apple's A series, and the related firms
2.4 Related market and cost comparison of IC packages used for AP
2.5 Technology roadmap
3. Trends of FO-WLP market by wafer/panel base <P10>
3.1 Overview on market trends classified by assembly base form
3.2 Market size forecast of FO-WLP on area base
3.3 Market size forecast of FO-WLP on vale base
4. Market trends of encapsulant <P15>
4.1 Overview of market trend of the encapsulant for FO-WLP
4.2 Market trend forecast by form of semiconductor encapsulant
4.3 Market trend forecast of liquid, granular and sheet encapsulants by application
4.4 Market size forecast of encapsulants for FO-WLP by form
4.5 Market size forecast of encapsulants for FO-WLP by application
4.6 Market size forecast of encapsulants for FO-WLP by wafer/panel base assembly
5. Related companies to FO-WLP assembly <P22>
5.1 Major suppliers of material and equipment related to FO-WLP
5.2 Supply chain of encapsulants

Chapter 2 Trends of FO-WLP

1. Summary of FO-WLP <P25>
1.1 Features and issues of WL-CSP
1.2 Basic structure of FO-WLP
1.3 Advantages of FO-WLP
1.4 Wafer reconstitution
1.5 Process temperature and heat resistant temperature of components
1.6 Basic issues of FO-WLP
2. Technical trends of FO-WLP by type <P35>
2.1 Types of FO-WLP
2.2 Assembly technology of FO-WLP by type
2.3 Assembling process of FO-WLP by type
2.4 Specification comparison of FO-WLP by type
3. Enlargement of work size and encapsulation technology<P51>
3.1 Methods of cost reduction
3.2 Size enlargement and assembly-related technologies
3.3 Encapsulation technology for WLP
3.4 Summary of the evaluation of the equipments and materials

Table of contents -2-

4. Technical comparison of FO-WLP by type <P59>
4.1 Technical summary of FO-WLP by type
4.2 Summary of the evaluation of FO-WLP by type
5. Introduction of FO-WLP and technology, classified by applications <P61>
5.1 Introduction of FO-WLP type by application IC
5.2 AP
5.3 WL-CSP alternative use
5.4 High frequency module use
5.5 Demand for multichip and space-saving
6. Market entry status of major assemblers <P79>
6.1 List of FO-WLP assemblers' status by type
6.2 List of FO-WLP assemblers' status by assembly work size
6.3 List of FO-WLP assemblers' application
7. Market trends and forecast <P82>
7.1 Current market size and various classifications
7.2 Production status of major assemblers
7.3 Overall market size forecast (2014-2024)
7.4 Market size forecast by assembly base form (2014-2024)

Chapter 3 Trend of encapsulation technologies and materials

1. Overview of semiconductor encapsulation technologies and materials <P108>
1.1 Encapsulation systems
1.2 Encapsulants
2. Technical trends of encapsulant for FO-WLP <P118>
2.1 Required characteristics of the encapsulant for FO-WLP
2.2 Liquid encapsulant for FO-WLP
2.3 Main technical problems of encapsulants for FO-WLP
2.4 Application and encapsulation to large format panels
3. Applications other than encapsulation / MIS <P125>
3.1 Structure and characteristics of MIS
3.2 Production process of MIS
3.3 Design specifications of MIS
4. Product characteristic of major encapsulant manufacturers
4.1 Liquid type 4.2 Granular type 4.3 Sheet type <P128>
5. Status of encapsulant manufacturers <P131>
5.1 Adoption situation of encapsulants by application
5.2 List of major manufacturers' status by form of material
5.3 List of major manufacturers' status by application
5.4 List of major manufacturers' status of liquid material by application
5.5 List of major manufacturers' status of granular / powder material by application
5.6 List of major manufacturers' status of sheet material by application
5.7 List of major manufacturers' status of encapsulants for FO-WLP by form
6. Market trends and forecast <P138-182>
6.1 Current market size by form of material
6.2 Major manufacturers' sales status
6.3 Market size forecast of overall encapsulants by form (~2024)
6.4 Market size forecast of encapsulant for FO-WLP（~2024）

Samples of contents (from Chapter 1)

1.1 Overview of FO-WLP market trend

Market size forecast	· Our estimation for t · CAGR for 5 years st amount base. CAGR unit base and 8.0% c
Major applications (IC)	· In 2015 the major m Baseband (BB) and P · In and after 2016 a measured by unit qu sales amount.
Market trend	· The adoption of FO · Panel based packag assembly. · IC for high-end syst · Wafer-based assen area. (By our forecas · It is anticipated tha
FO-WLP assembler's status	In production: STATS Under Development:

5.1 Major suppliers of materials and equipments related to FO-WLP

Wafer reconstitution process (encapsulation)

Temporary adhesive material: Nitto Denko, ---, ---, ---, ---, ---, ---, ---, ---, Others

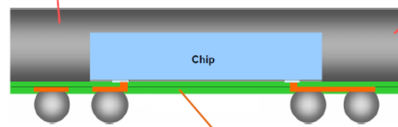
CM: Apic Yamada, ---, ---, Others

Mold Release Film: ---, Others

Liquid: Nagase Chemtex, ---, ---, Others

Granule: ---, ---, ---, ---, Others

Sheet: Nitto Denko, ---, ---, ---, ---, ---, ---, Others



RDL formation process

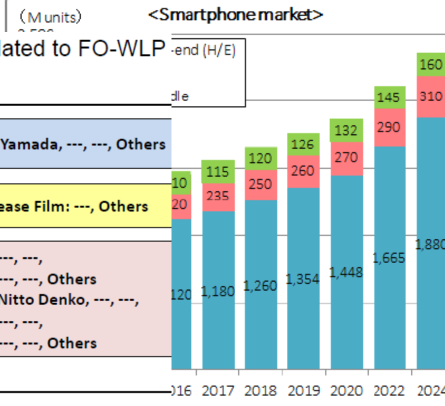
Dielectric material for RDL: ---, ---, ---, ---, Others

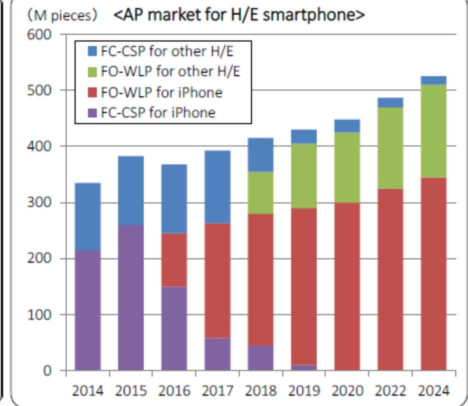
Exposure: ---, ---, ---, ---, Others

LDI: ---, ---, ---, Others

2.2 Market size forecast of FO-WLP for AP

【Market size forecast of smartphone by class (Left) and Market size forecast of AP for High-end smartphone by PKG type (Right)】





ket size forecast of AP packaged by FO-WLP technology, classified by application】

	2014	2015	2016	2017	2018	2019	2020	2022	2024
Ed e	0	0	95						
Cc Smartphone	0	0	0	0					
As pieces)	0	0							

2.4 Related market and cost comparison of IC packages used for AP

【Market and cost comparison of Apple A10 and A8】

A series		A10 (iPhone 7)	A8 (iPhone 6)
PKG name		InFO-WLP(FO-WLP)	FC-CSP
PKG market size	Quantity	--- M pieces*1	--- M pieces
	Amount		
	Unit cost (a)		
Market size of Encapsulant for A series	Quantity		
	Amount		
	Unit cost		
Dielectric material market	Quantity		
	Amount		
	Unit cost		
Unit cost of material (b)	Encapsulant [ratio (b/a)]		
	RDL material [ration (b/a)]		

2.5 Technology roadmap

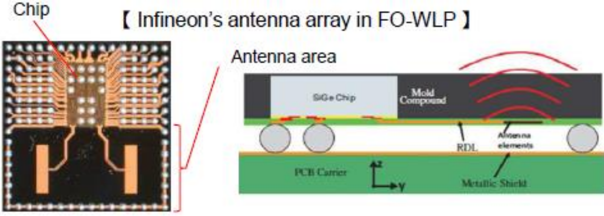
【Technology roadmap of AP for High-end smartphone】

			Year	2014	2016	2018	2020	2022	2024
AP Market for High-end smartphone *1				335					
PKG	Whole	Structure	PoP	⇒					
	Top (Memory)	Chip type	LPDDR series	3					
			Wide IO type						
	Bottom (AP)	PKG type	FC-CSP	100%					
			FO-WLP	0%					
FO-WLP for AP		Chip combination	Single chip	100%					
			+ α (Multi)	0%					
RDL of FO-WLP		Single side	3-layer	-					
		Double side	4-L & more	-					
Encapsulant		Thickness	[μm]	-					
		Material type	Liquid	-					
			Granule	-					
			Sheet	-					
FO-WLP assembly base			Wafer base	-					

Samples of contents (from Chapter 2)

【Types of FO-WLP and the comparisons】

		Encapsulated base		PCB-technology	RD
		Face-down mounting	Face-up mounting		Polymer
Process type		Chip-First		Chip-First	RD
Assembly base	Shape *1	Wafer/Panel		Panel	V
	Size *1	~300mm wafer		~515X410mm panel	300n
	At the time of Chip mounting				
	At the time of RDL formation				
Interconnection*2	Bump				
	FC connection				
Representative FO-WLP name					

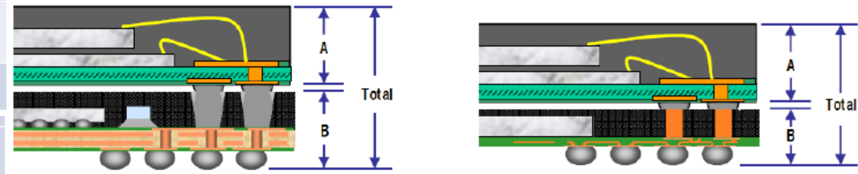


【 Infineon's antenna array in FO-WLP 】

【 Performance comparison of FC bonders and mounters 】

	FC bonder		Mounter	
	For CoW	For large size	Wafer supply type *1	Tray part/Reel part supply*1
Work size	~ 300 mm wafer	~ 560 x 610 mm	~ 610 x 610 mm	~ 710 x 774 mm
Alignment accurac				
Tact				
Chip orientation				
Si wafer				

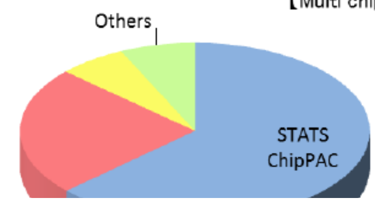
【Comparison of PKG height of AP by type (Left: FC-CSP based PoP, right: FO-WLP based PoP) 】



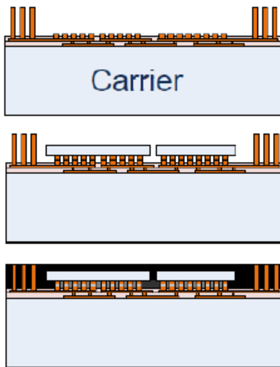
【 Comparison of compatibility to the panel forms, in view of the application and flow of resin, classified by forms of encapsulant

Form of encapsulant		Liquid		Granular	Sheet	
Encapsulation system		CM	Printing	CM	CM	Lamination
Resin	Application position	Single or multi-dot, Drawing	One side*1	Whole surface	Whole surface	Whole surface
	Flow distance*2	Long	Long	Very short	Very short	Very short
			be used	To be used	R&D	R&D
			vailable			

【Multi chip PKG】



【Comparison of mold through via process by type



Formation of RDL and Cu

FC bon

Encaps

【 Assembling flow of FO-WLP in case of Encapsulated base type with face-up mounting: M-ser

Process		Notes
Chip wafer process		
1. Bumping on chip wafer		· Bump for electropl · Wafer di
Reconstitution process		
2. Adhesive sheet lamination & Chip mounting		· Laminatio
3. Encapsulation & Carrier de-bonding		
4. Topside griding		
RDL formation process		
5. Die location measurement & Dielectric coating		
6. Pad part opening		

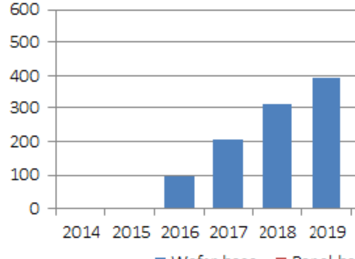
6.2 List of FO-WLP assemblers' status by assembly work size

Assembler	Name of FO-WLP	Wafer		Panel	
		Status	Work size	Status	Work size
ADL Engineering	pWLB				
Amkor Technology	WLFO				
	SWIFT/SLIM				
ASE	aWLP				
	(M-series)				
Deca Technologies	M-series				
Freescale Semiconductor	RCP				
Infineon Technologies	eWLB				
J-Devices	PLP				

【 Market size forecast of FO-WLP by assembly work base and

		2014	2015	2016	2017	201
Wafer base	RF/PM/Analog					
	BB					
	AP		0			
	mm Wave Radar					
	CPU/GPU/FPGA		0			
	IC for Health/Others					
	Total (K wafer)		259			

【 Market size forecast of FO-W



Samples of contents (from Chapter 3)

【 Types of encapsulation system 】

	Schematic views	Process outline	Type
Transfer Mold (TM)		Molding is conducted by filling the molding dies with resin, plunged through gates into the cramped dies.	Tabl… Liqu…
Compression Mold (CM)		Molding is conducted by compression, made by cramping the dies with resin applied to the internal of dies prior to the cramping.	Gra… Liqu… She…
Vacuum Printing	Squeegee Metal mask stencil Resin	Filling is made by squeezing down the resin with a squeegee, while the form is arranged by a mask.	Liqu…
Vacuum Lamination	(Stage)	Molding is cond… press, after the… laminated by us…	

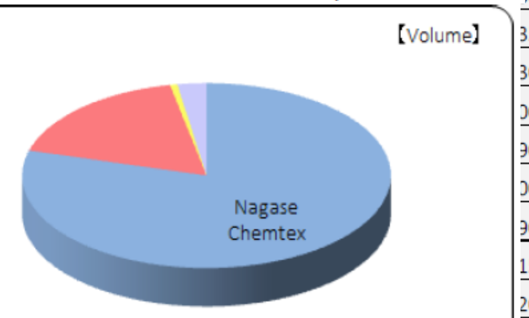
【 List of suppliers of semiconductor encapsulants by usage 】

	Wafer / Panel base encapsulation			For substrate manufacture		Underfilling as well as Overmolding	
	FI-WLP	FO-WLP	2.5D	EAD/EPD*1	MIS*2	MUF	Hollow
Ajinomoto Fine-Techno							
Hitachi Chemical							
Kyocera (Chemical)							
Nagase Chemtex							
Namics							
Nitto Denko							
Panasonic							
Sanyu Rec							

【 Sales status of major encapsulant manufacturers by form of material (2015) 】

	Amount (M JPY)				
	Tablet	Granule	Liquid	Sheet	Total
Sumitomo Bakelite	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Hitachi Chemical					
Panasonic					
Kyocera					
Shin-Etsu Chemical					

【 Manufacturers' share of FO-WLP encapsulant market in



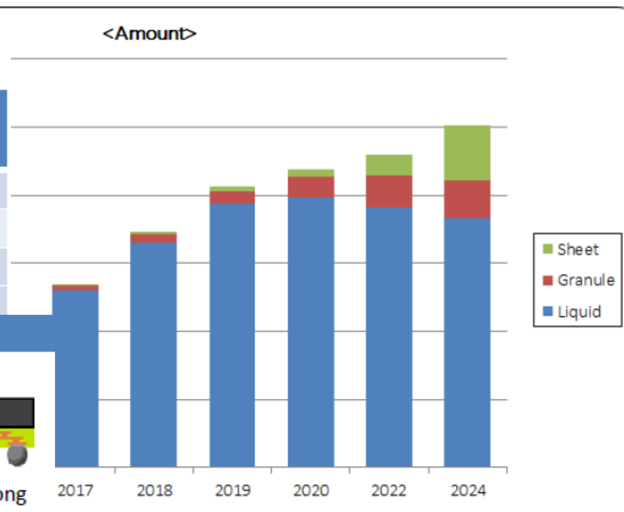
Introduction of panel base

Changes of Area size & Base shape

【 Characteristics of granule encapsulants 】

Encapsulant company			—	—	
Product			—	—	
Type		-	Granule	Granule	Granule
Filler size	Cut size	μm	55	54	20 ~ 74
Filler content					
Spiral flow					
Tg					
CTE					
Modulus					
Flexural modu…					
Application					

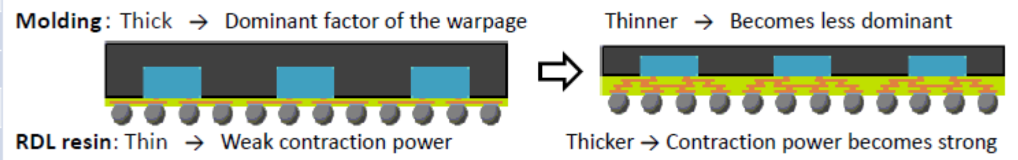
【 Market size forecast of FO-WLP encapsulant by form of material (in amount) 】



【 Comparison of characteristics of encapsulants by form 】

		Solid		Liquid *2	Sheet *3
		Tablet	Granule/Powder		
Tg		115 ~ 175 deg.C		45 ~ 175 deg.C	110 ~ 190 deg.C
Gel time *2		20 ~ 45 s	60 ~ 90 s	60, 210, 400 s	60 ~ 90 s
Viscosity	175deg.C	5 ~ 15 Pa·s	7 ~ 15 Pa·s	-	5 ~ 8 Pa·s
	25 deg.C	-	-	15 ~ 800 Pa·s	-
Spiral flow					
Cure condition *4					
CTE					
Thickness					

Thinner encapsulation layer / shift to multilayer RDL



About the report and how to order

- Published: January 25, 2017
- Format: A4 size, 182 pages
- Price: 530,000 JPY
- Product: a bound book & a CD (PDF files)

▼ How to order

You have two choices to order our report.

In case of payment by credit card, please send the application form of the next page by FAX after filling in a necessary matter, for security of your card information.

In case of payment by wire transfer, you can order from our website.

For those who prefer wire transfer, please remit the payment to the following bank account.

Bank: MIZUHO BANK (Swift code: MHCBJPJT)
Branch: Kobunacho Branch (Phone: 81-3-3661-3111)
Branch code: 105
Branch Address: 8-1, Nihonbashi-kobunacho Chuo City, Tokyo 103-0024 JAPAN
Account No. 1653912
Account Name: Japan Marketing Survey Co., Ltd.

Application Form

Date: ____________________

To; Japan Marketing Survey Co. Ltd. (Fax:+81-3-5641-0528)

Market report: FO-WLP & Encapsulant Report ~ Markets and Technologies ~

Corporate Name : ______________________________

Applicant's name: ____________________ Title: ____________________

Section: ______________________________

Address: ______________________________

____

TEL: ____________________ Email (or FAX): ____________________

Select the payment method: ☐ By Credit Card, ☐ By Wire Transfer * check mark

<Card Information>

Card Type:____________________ Card number: ____________________

Exp. Date:____________________ Name on the Card:____________________

NDA: Accepting the conditions below, please put the corporate name and the applicant's signature in the blanks below.

____________________ *promises not to release the contents of the report(s) above to a third party without obtaining written consent from Japan Marketing Survey Co., Ltd.* Signature: ____________________

Comments :