Fan-Out Wafer Level Packaging

Patent Landscape Analysis – November 2016

With Apple and TSMC changing the game, 2016 is a turning point for the Fan-Out market. The number of enforceable patents is increasing worldwide, with several companies already standing out by virtue of their strong IP position.

REPORT OUTLINE

- Fan-Out Wafer Level Packaging Patent Landscape Analysis
- November 2016
- PDF (200+ pages)
- Excel file (3,100+ patents)
- €5,990 (Multi-user license)

KEY FEATURES OF THE REPORT

- **IP trends**, including time evolutions and countries of patent filings
- Patents' current legal status
- Ranking of main patent applicants
- IP collaboration, joint development, and licensing agreements
- Key players' IP position, and relative strength of their patent portfolios
- Patent segmentation by technology solution (chip-first, chip-last, facedown, face-up), process steps (die placement, molding, planarization, RDL), architecture (multi-chip, PoP, SiP, face-to-face package), and technical challenge (warpage, die shift)
- Matrix showing patent applicants and their patented technologies
- Technical solutions found in patents for warpage and die-shift issues.
- FOWLP IP profiles for 18 key companies, including countries of filing, patents' legal status, patented technologies, prior art strength index, IP blocking potential, partnerships, and IP strategy
- Excel database with all patents (3,100+) analyzed in this report, including technology segmentation

RELATED REPORTS

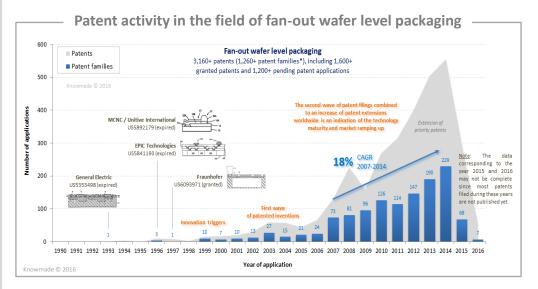
- Fan-out: Technology & Market Trends 2016, Yole Développement, August 2016
- <u>TSMC Integrated Fan-Out (inFO)</u> <u>Package in Apple's A10 Application</u> <u>Processor</u>, System Plus Consulting, October 2016
- <u>Samsung's Galaxy S7 Processor</u> <u>Packages: Qualcomm/Shinko's</u> <u>MCeP vs. Samsung's PoP</u>, System Plus Consulting, June 2016

FAN-OUT IP LANDSCAPE IS THE MOST DYNAMIC IN ADVANCED PACKAGING

With Apple and its A10 processor employing TSMC's InFO-PoP technology, the fan-out market has exploded. Apple's involvement will undoubtedly generate increased interest in the fanout platform, and market revenue is forecast to reach around US\$2.5B in 2021, with 80% growth between 2015 - 2017 (See Yole Développement's August 2016 report, <u>Fan-out:</u> <u>Technology & Market Trends 2016</u>). Moreover, following the high-volume adoption of InFO and the further development of fan-out wafer level packaging technologies, a wave of new players may enter the market. The supply chain is also expected to evolve, with a considerable amount of investment in Fan-Out packaging capabilities.

In such a fast-growing Fan-Out market, it is essential to deeply understand the global patent landscape in order to anticipate changes, harvest business opportunities, mitigate risks, and make strategic decisions in order to strengthen one's market position and maximize return on one's IP portfolio.

Knowmade has thoroughly investigated the Fan-Out packaging patent landscape (chip-first, chip-last, face-down, face-up, single-die, multi-chip module, package-on-package, system-in-package, etc.), and this report contains detailed patent analyses including countries of filing, patents' legal status, and patented technologies, as well as patent owners, their IP position, and IP strategies.



More than 3,100 patents relating to over 1,200 inventions on Fan-Out packaging have been published worldwide through September 2016, coming from 100+ patent applicants. A first wave of patent applications occurred from 1999-2006, induced by Infineon. Patent applications have increased since then, with Freescale (NXP), STATS ChipPAC (JCET), SPIL, Amkor, and TSMC entering the Fan-Out IP arena. Today the number of enforceable patents is increasing worldwide, with several companies already standing out by virtue of their strong IP position.

All of major players involved has filed patents on Fan-Out packaging, except for Nanium, which does not file any patents at all but instead has adopted a different IP strategy that we discuss in this report. Another special case is the presence of patent licensing companies like Polaris Innovations (WiLAN), which in 2015 acquired key patents from Infineon/Qimonda. The visibility of such companies in the patent landscape is a tangible sign of the market explodes. In the next few years Polaris Innovations could assert its patents to make money, and in this report we present its most critical patents. We have also noted Samsung's conspicuous



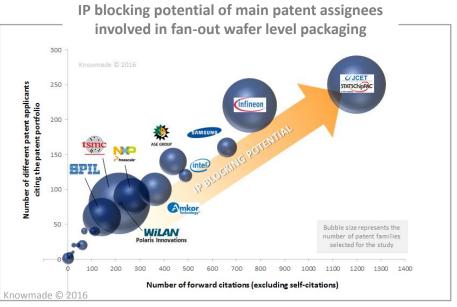


IP presence in the FOWLP patent landscape, despite the company's unclear market position. R&D labs are also present (i.e. Fraunhofer, A*STAR, CEA), but to a lesser extent. Most new entrants in the FOWLP patent landscape are Chinese players (HuaTian Technology, NCAP, SMIC), and more recently we have observed Apple's appearance. Apple, which this year chose TSMC's InFO-PoP technology for its A10 APE, has recently filed some patents on Fan-Out wafer level packaging (chip-last, chip-first, PoP, and SiP), reflecting a genuine interest in the FOWLP platform.

KNOW THE KEY PLAYERS' IP POSITION

This report analyzes in detail the IP status and IP strategies of key players and provides an understanding of their patented technologies. This report also provides a ranking and analysis of the top patent holders' relative strength, derived from their portfolio size, patent citation networks, countries of patent filing, and patents' current legal status. Furthermore, we reveal the IP strength of the key IP players involved in FOWLP technologies, and we depict their competitive IP position.

JCET/STATS ChipPAC and TSMC lead the FOWLP patent landscape. From a quantitative point of view, TSMC is the most prolific patent applicant of the last few years, but according to our analyses, JCET/STATS ChipPAC has by far the strongest IP position. The company has



formidable "IP blocking potential" that empowers it to deter other players to patent inventions that are similar to its own IP portfolio. TSMC is the most serious IP challenger, and it may reshape the patent landscape in the near future upon the approval of its numerous pending patent applications. Both companies feature a large enforceable patent portfolio and a long remaining lifetime of their patents.

PATENTED TECHNOLOGY AND IP STRATEGY

The 1,200+ inventions selected for this study are categorized by technology solution (chip-first/face-down, chip-first/face-up, chiplast), process steps (die placement, molding, planarization, RDL), architecture (multi-chip module, PoP, SiP, face-to-face package, etc.) and technical challenges (warpage, die shift). In this report we also reveal the IP strategy and technical choices of the main patent assignees. A special focus is placed on technical solutions found in patents for solving warpage and die shift issues. This report also provides an IP profile for 18 key players: Infineon, NXP/Freescale, STATS ChipPAC, TSMC, ASE, Deca Technologies, Nepes, Nanium, SPIL, Amkor, Powertech Technology, Intel, STMicroelectronics, Samsung, NCAP, WiLAN, 3D PLUS, and Apple. Each company's IP profile includes the time evolution of their patent applications, a world map of granted patents and pending patent applications, and key features and strength of their patent portfolio.

	PROCESS STEPS				TECHNICAL CHALLENGES		ARCHITECTURE						
	Die placement	Molding	Planarization	RDL	Foundry BEOL	Die shift	Warpage	MCM (multi-chip module)	PoP (package-on-package)	SiP (system-in-package)	F2F (face-to-face package)	Stacked dies	TMV (through molding
Chip-first Face-down	(infineon (intel) BPIL	SUSCIONER Confineon		CJCET STRICTOR	Qualconne		GJCET SNYCHORC BPIL			FUĴITSU	ne;es	ANSUNC SUISSING	BPIL Suschart für
Chip-first Face-up	ChipMOS	SUCET SUSCET Deca Technologies	tsmc	Dece Technologies	tsinc	BPIL	EPIL NCAP	CJCET ESTIC ENCERT	COCT RANCORC BPIL	FUÏITSU	SUCET SINGORE	GJCET SUICKOC	CJCET SHITCHING
Chip-last				GJCET STATION	Smkor.	СЛСЕТ ЛИХОНОВС јсар акаселекалос	BRIDGE		SUCCET SUASSOFICE EFFIL Ornege SUPPLIE	GJCET SATISFIELD	SPIL	Epil	Contractions

- Patented technologies of main patent assignees involved in fan-out wafer level packaging

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USEFUL PATENT DATABASE (3,100+ patents)

This report also includes an Excel database containing the 3,100+ patents analyzed in our study. This useful patent database allows for multi-criteria searches and includes patent publication number, hyperlinks to the original documents, priority date, title, abstract, patent assignees, technological segments, and legal status for each patent family member.

COMPANIES MENTIONED IN THE REPORT

3D Plus, A*STAR, ACE Technology, ADL Engineering, Altera, Amkor, Apple, ASE, Avago Technologies, Bridge Semiconductor, Bridgelux, Broadcom, Camtek, CEA, Cheng Ming, ChipMOS, Cirrus Logic, Conexant Systems, Cypress Semiconductor, Dainippon Screen Manufacturing, Deca Technologies, EPIC Technologies, EV Group, Flipchip International, Fraunhofer, Fujitsu, GE Embedded Electronics, General Electric, Gerad Technologies, GlobalFoundries, Hana Micron, Hitachi Chemical, HuaTian Technology, Infineon, Intel, ITRI (Industrial Technology Research Institute), JCAP, JCET/STATS ChipPAC, J-Devices, Jiangsu University of Science & Technology, LSI Logic, Macrotech Technology, Maxim Integrated Products, MediaTek, Medtronic, Micron Technology, Murata Electronics, NCAP, Nepes, Niko Semiconductor, Nippon Electric Glass, Nitto Denko, North Star Innovations (WiLAN), NXP/Freescale, Nytell Software, Oerlikon, PacTech Packaging Technologies, Philips, Polaris Innovations (WiLAN), Powertech Technology, Princo Middle East FZE, Qimonda, Qualcomm, Renesas Electronics, Samsung Electronics, Samsung Electro Mechanics, Semiconductor Components Industries, Seoul National University (SNU), Sharp, Shinko Electric Industries, SK Hynix, SMIC, Sony, Sound Technology, SPIL, STMicroelectronics, Technische Universitat Berlin, Tera Probe, Tessera, Texas Instruments, Toray Advanced Mat Korea, Toshiba, TSMC, Ultratech, Unimicron Technology, United Microelectronics, United Test & Assembly Center, X-Celeprint, Xenogenic Development (Intellectual Ventures), Xilinx, Xintec, Zhongxin Changdian Semiconductor ...

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- Granted patents near expiration date

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We Know Technology, We Know Patents





allowed.

ORDER FORM

Fan-Out Wafer Level Packaging

Patent Landscape Analysis – November 2016

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Job Title:	Check To pay your invoice using a check, please mail your check to the
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BIC or SWIFT code: CCBPFRPPNCE

IBAN: : FR76 1560 7000 6360 6214 5695 126

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