FAN-OUT PACKAGING: TECHNOLOGIES AND MARKET TRENDS 2019

Market & Technology report - January 2019

Samsung and PTI, with panel-level packaging, have entered the Fan-Out battlefield.

WHAT'S NEW

- Overview of the latest technologies: available and in-development
- Comparison of different Fan-Out packaging platforms and associated costs
- Commercialization status update with market adoption for new applications, updated forecasts, and potential-analysis update, by technology
- Updated strategy analysis for main players and new entrants, including TSMC, SEMCO/Samsung, PTI, Amkor, JCET Group, ASE, and Deca, …
- Analysis of key players' FOPLP technology and strategy
- Fan-Out-on-panel status update: volume and market forecasts 2017 - 2023, player-by-player status and analysis
- Updated market volume, market size, and market forecasts 2017 - 2023

KEY FEATURES

- Market forecasts in volume (units and wafers) and revenue, split by application and end-market
- Drivers and challenges for Fan-Out packaging
- Product/technology description and analysis, by player
- Fan-Out-on-panel status, evolution, and technology roadmap
- Detailed supply chain explanation
- Commercialization status with strategy analysis, by player
- Analysis of Fan-Out potential and penetration rationales, by application

SIGNIFICANT NEW DEVELOPMENTS IN A DYNAMIC FAN-OUT LANDSCAPE

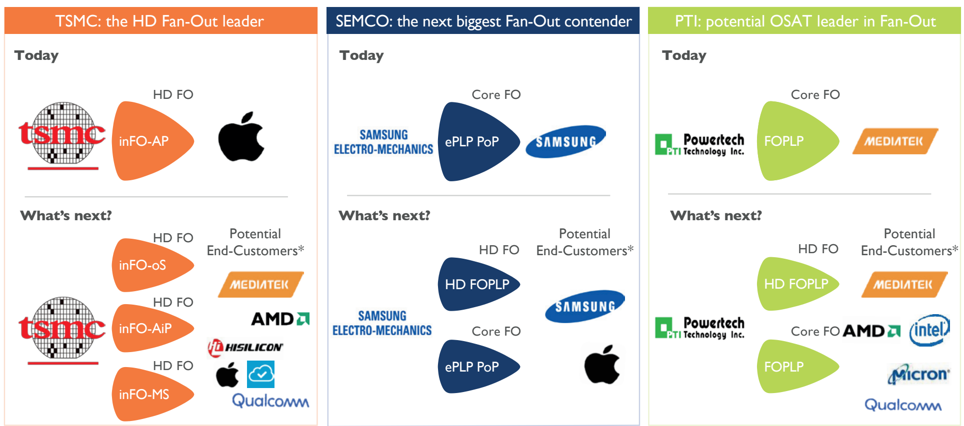
TSMC has further extended its lead in the "High-Density Fan-Out" (HD FO) market, with gen-2 integrated Fan-Out (inFO) High-Volume Manufacturing (HVM) production and successful qualification of gen-3 inFO for Apple's iPhone application processor engine (APE). TSMC understands that industry technologies and applications are undergoing unprecedented change in a new, digital mega-trend-driven era. Consequently, exciting technological developments exist to address these new demands.

TSMC has commenced risk-production of inFO-oS (on substrate) for HPC qualifications. Moreover, the company is developing inFO-AiP (antenna-in-package) for mmWave applications (5G, etc.), and inFO-MS (memory-on-substrate) for data-server applications (i.e. cloud). TSMC is also creating a new market segment called ultra-high-density Fan-Out (UDH FO), with a very aggressive sub-micron L/S roadmap and >1500 I/O.

In the "core" Fan-Out (Core FO) market, SEMCO and Powertech Technology Inc. (PTI) have stolen the limelight by rolling out Fan-Out panel-level-packaging (FOPLP) volume production for the first time in Fan-Out packaging history. SEMCO utilized embedded package-level-packaging (ePLP) technology in the Samsung Galaxy smartwatch for the consumer market, for a multi-die FO package consisting of APE + Power Management Integrated Circuit (PMIC) with ~500 I/O. PTI successfully commenced FOPLP PMIC in Low Volume Manufacturing (LVM) for MediaTek's automotive radar application.

For packaging houses to remain attractive for key fabless players like Qualcomm and MediaTek, cost-reduction is necessary. To this end, SEMCO, PTI, ASE/Deca, and Nepes have invested in Fan-Out at panel-level by leveraging existing facilities and capabilities to achieve economy-of-scale production. Currently, only SEMCO and PTI have been able to kick-start production because the yield for panel-level processing requires optimization and new technology qualification for HVM.

Fan-Out packaging: latest milestones and developments



*Potential and non-exhaustive list of companies

(Yole Développement, January 2019)

FAN-OUT PACKAGING: BUSINESS MODEL EVOLUTION

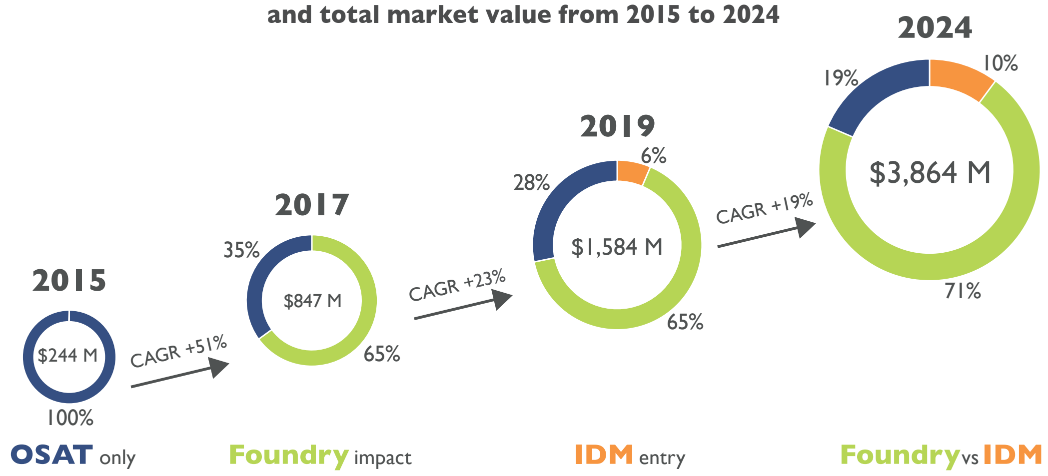
Currently, all key OSAT/foundry/IDM players have Fan-Out packaging solutions in the market. The Fan-Out landscape remains dynamic, with more opportunities to maximize performance at a lower cost - hence the adoption of Fan-Out by various business models. In a mega-trends-driven era, Fan-Out platforms are increasingly viewed as one of the top options amongst leading package technologies.

In 2015, the Fan-Out market was small and consisted mostly of standard devices like Baseband (BB), RF, and Power Management Unit (PMU). But after TSMC's 2016 game-changer with inFO for Apple's iPhone APE, market value increased 3.5x by 2017. Thus the HD FO market segment was created, reducing the market-share ratio of OSATs.

Since then, SEMCO/Samsung (IDM) has joined the Fan-Out packaging market as a new entrant and expanded it into the consumer market. Moving forward, TSMC is betting on inFO to secure new high-end packaging projects in mobile, HPC, and networking. While SEMCO/Samsung continues to gain ground on TSMC in the HD FO market and generate value in core FO, OSATs will keep competing for business - but under price pressure from fabless. In this scenario, PTI may emerge as a Fan-Out packaging leader due to FOPLP's cost-effectiveness and a possible HD FOPLP breakthrough for multi-die with logic + memory, etc.

Fan-Out packaging market value is expected to grow at a 19% CAGR from 2019 - 2024, reaching a market size of $3.8B. Meanwhile, the love-hate relationships and politics surrounding OSATs, IDMs, and foundries will continue to unfold. Any big change in Fan-Out strategy will have a ripple effect on the entire supply chain.

Fan-Out packaging: business model evolution and total market value from 2015 to 2024



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STRONG GROWTH IN A MARKET THAT IS MORE FRAGMENTED THAN EVER

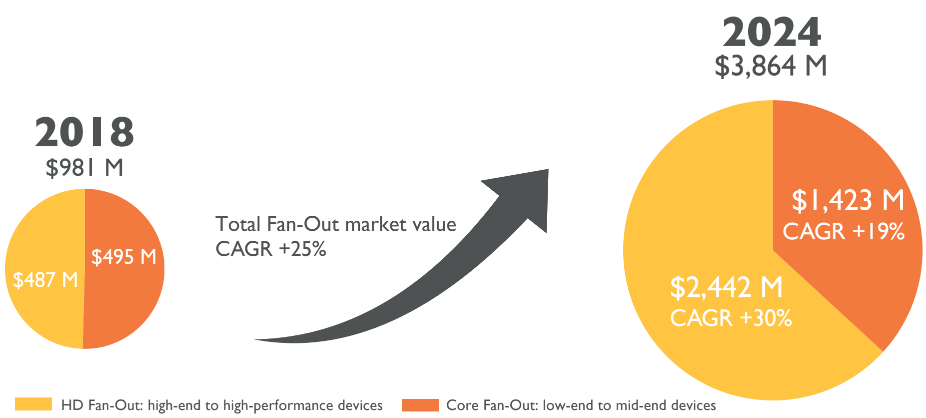
The core FO market confirmed its stability in 2018, with significant new entrants joining via FOPLP. Although FOWLP players are the default choice due to a long history of established qualifications, mid-end devices may be too costly for FOWLP players. Hence, FOPLP players will emerge as a cost-effective options for the core market's new demands. We foresee fabless being "spoiled" by FOPLP margins, and beginning to demand the same benefits for existing business. Moving forward, a price war between FOWLP and FOPLP is inevitable.

HD FO growth has never been bigger, due to TSMC possibly doubling its capacity in order to acquire new business in the coming years. Also, SEMCO/Samsung has already confirmed FOPLP with APE, and it will not be long before this is rolled out in Samsung smartphones to challenge TSMC for Apple's APE business.

Key fabless players like Qualcomm and MediaTek will continue to push packaging houses for Fan-Out solutions at lower cost, especially in higher-end devices. PTI is the only potential option for achieving this, and in the process could reach a new milestone with high-end memory Fan-Out packaging. This being said, it will be hard to achieve and hence may only materialize much later, in 2022.

Will Fan-Out packaging continue to cannibalize and put flip-chip, advanced substrate, and interposer

Fan-Out packaging landscape: business model evolution



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manufacturers out of business? Fan-Out packaging's key benefit is the ability to integrate dies together flexibly, and at thinner dimensions. Fan-Out can displace 2.5D interposers with fine L/S Fan-Out packaging on substrate. It can also displace flip-chip and advanced substrate. Such is the potential of Fan-Out packaging technology, and it is already underway in the APE business via TSMC's inFO-APE and SEMO's FOPLP.

OBJECTIVES OF THE REPORT

- Identify and describe technologies classifiable as "Fan-Out"
- Update the business status of Fan-Out technology markets
- Analyze, by application, the key market drivers, benefits, and challenges for Fan-Out packages
- Describe the different existing technologies, including their trends and roadmaps
- Review the Fan-Out supply chain and landscape
- Provide a market forecast for the coming years, and a prediction of future trends

COMPANIES CITED IN THE REPORT (non exhaustive list)

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Favier Shoo is a Technology and Market Analyst in the Semiconductor & Software division at Yole Développement, part of Yole Group of Companies. Favier is engaged in the development of technology & market reports as well as the production of custom consulting.

After spending 7 years at Applied Materials as a Customer-Application-Technologist in advanced packaging marketspace, Favier had developed a deep understanding of the supply chain and core business values. Being knowledgeable in this field, Favier had given trainings and held numerous technical review sessions with industry players. In addition, he had obtained 2 patents.

Prior to that, Favier had worked at REC Solar as a Manufacturing Engineer to maximize production capacity.

Favier holds a Bachelor in Materials Engineering (Hons) and a Minor in Entrepreneurship from Nanyang Technological University (NTU) (Singapore).

Favier was also the co-founder of a startup company where he formulated business goals, revenue models and marketing plans.

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