

# FAN-OUT WLP AND PLP APPLICATIONS AND TECHNOLOGIES 2021

Market & Technology Report - June 2021

*TSMC's Fan-Out success with Apple and high-performance computing are pushing Intel, Samsung, ASE, and all other competitors to find new innovative solutions.*

## WHAT'S NEW

- Market shares of manufacturers within each market class (UHD FO, HD FO, and Core FO) for 2020
- Market shares of Flip-Chip vs. Fan-Out Packaging (AiP)
- Market shares of IC Substrate vs. Fan-Out Packaging (within smartphones)
- More fabless & OEMs are engaged in UHD FO
- New players
- New status updates of key players
- UHD FO supply chain: what will drive the activity in the future?
- New flavor of technologies available
- Exciting developments leading to more technology breakthroughs

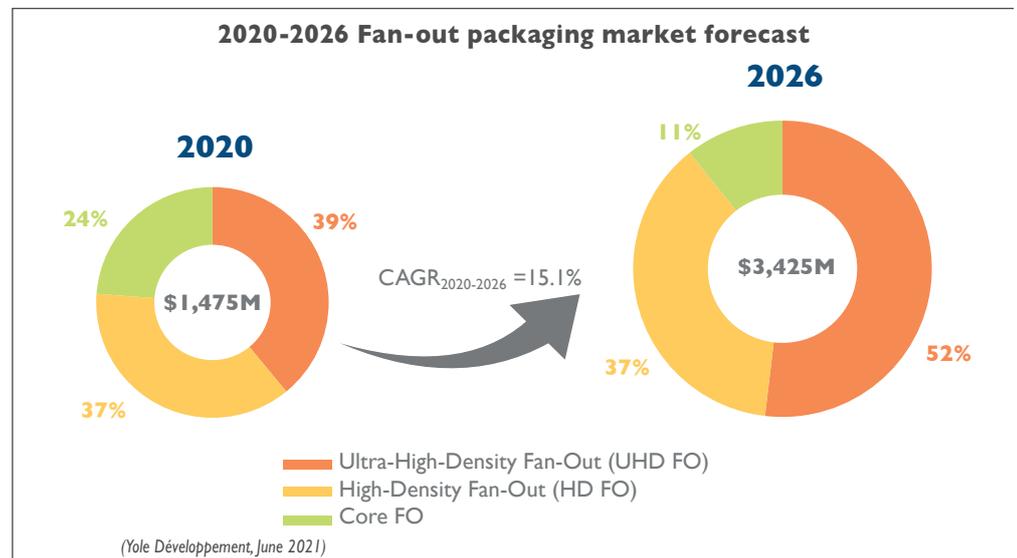
## KEY FEATURES

- Market valuations based on top-down and bottom-up model in package units, revenue, and wafer production volumes
- Market shares based on production projections
- Supply value chain analysis
- State-of-the-art technologies and trends
- Fan-Out Panel Level Packaging
- End-user application adoption details

## FAN-OUT PACKAGING MARKET GROWTH MAINLY DRIVEN BY UHD AND HD PRODUCTS

As part of advanced packaging, Fan-Out (FO) solutions have become critical and effective for foundries and IDMs, increasing device performance and bandwidth and reducing the gap between Si and substrate. OSATs are also following this trend, offering innovative Fan-Out packaging solutions that help solve front-end challenges with the slowing of Moore's Law, resulting in bigger dies to improve performance. In the 2021 report, Yole Développement (Yole) shows that the FO packaging market is experiencing strong growth of 15.1% CAGR<sub>2020-2026</sub>, from \$1,475M in 2020 to \$3,425M by 2026. This is led by High-Density Fan-Out (HD FO) and Ultra-High-Density Fan-Out (UHD FO) - fueled by the adoption of high-performance applications. More specifically, in 2020, Fan-Out revenue was heavily dominated by APE

applications for smartphones and smartwatches. In 2021, more revenue is expected from the UHD domain due to HPC applications for cloud infrastructure. 5G, autonomous driving, and the artificial intelligence revolution will shape the packaging trend of the next decade, with a denser multilayer RDL-build-up approach being one of the solutions helping to meet More-than-Moore requirements. UHD Fan-Out will play a key role and is, therefore, going to experience the fastest growth compared to the other Fan-Out categories. This report should help industry players to understand the evolution of the Fan-Out packaging market and technology, its roadmap, its importance, and its solutions for the next high-performance applications. It also describes what capabilities each FO platform is offering.



## TSMC IS DOMINATING THE FO MARKET, BUT ASE AND OTHERS ARE CATCHING UP

TSMC is the FO market leader by revenue. This is attributed to the penetration of the inFO package into the APE for Apple's iPhone, which generated a new market segment, HD FO, in 2016. Till now, Apple still uses TSMC's inFO for its latest iPhones.

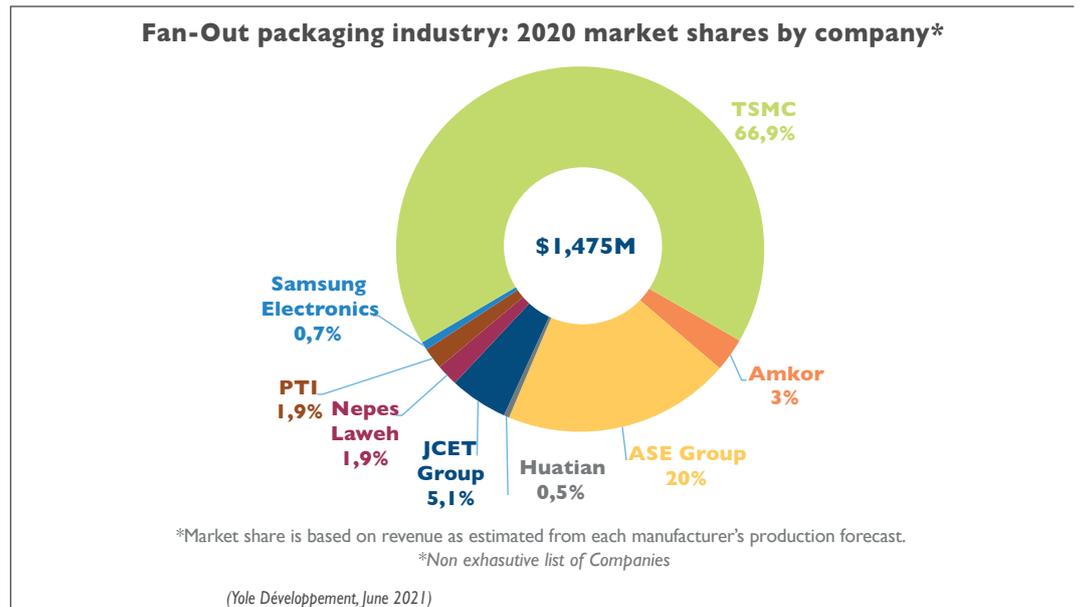
Today, heterogeneous integration is the defining trend of the next decade, with FO positioned as one of the key packaging

solutions to solve front-end problems (slowing Moore's Law). TSMC is aware of that and is diversifying its portfolio in advanced packaging, giving great importance to UHD FO solutions. This strategy positions TSMC as a company encompassing two business models. First, it is a foundry producing front-end dies with advanced technology nodes. Second, it creates advanced packaging solutions to improve its dies' performance and bandwidth, acting as an

OSAT. This strategy, combined with huge CapEx for continuous development of new solutions, makes TSMC the biggest player in this field. Integrated Fan-Out System on Wafer (InFO\_SoW) is one of its latest solutions that could be used by Cerebras for its Wafer Scale Engine (WSE) starting in 2021. Moreover, TSMC is expected to invest heavily to support devices for 5G deployment and HPC applications. After TSMC, ASE has the second-largest share of the market in UHD FO. It announced significant CapEx for its wafer-level packaging business, remaining a top OSAT after the acquisition of SPIL and USI. It has produced

FOCoS for Huawei networking chips since 2016, which is a significant achievement. ASE's participation in an OSAT alliance with Siemens should strengthen its position in the coming years. Other important players, such as Samsung, PTI, and JCET, will possibly penetrate the UHD FO market in the coming years and gain more market share.

In summary, with its foundry dominant globally, its strong InFO product line-up and increased investment in its package infrastructure and innovative solutions, TSMC is in a robust position to keep and even expand its leadership.

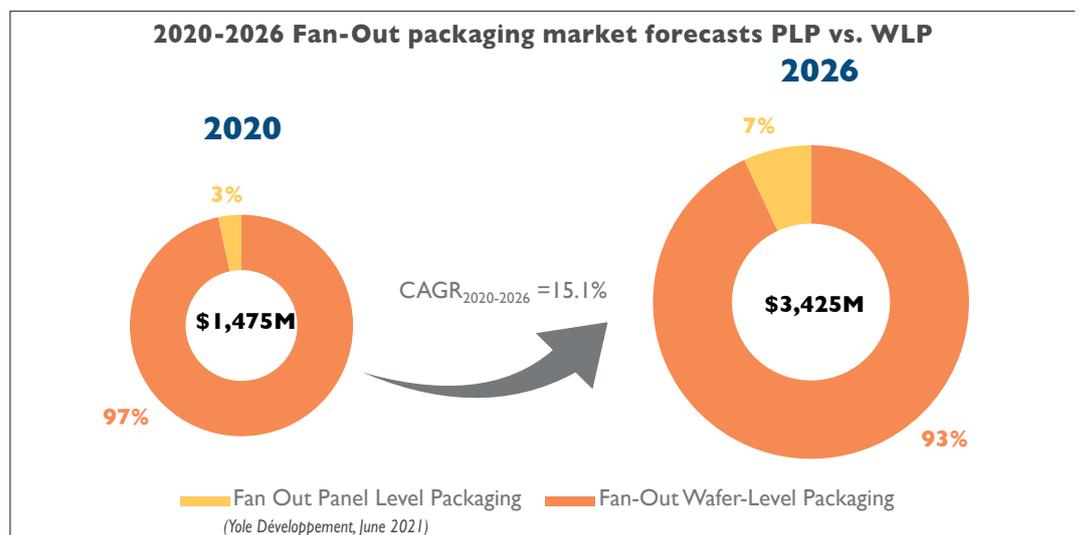


**FAN-OUT PANEL LEVEL PACKAGING IS GAINING TRACTION**

Fan Out Panel Level Packaging (FOPLP) is a new reality in 2021 as its potential is growing significantly due to its ability to scale heterogeneously with large-die trends. Ideally, it is good to go as large as possible. But it is well-known that panel warpage increases with panel size. Yield is known to be better with a smaller panel since it is easier to process, test, and inspect. Hence, it is essential to find the right balance between features and panel size considering the manufacturability of the end-product. In addition,

the constant need to scale smaller feature sizes will make the yield harder to manage, and cost could be negatively impacted. However, with improved equipment and processes, producing small features at panel-level with good yield is possible.

Today, Samsung Electronics has successfully used HD FOPLP for its smartwatches. This Korean giant is in a strong position because it is manufacturing its own processors based on in-house packaging solutions. Nepes is also developing its FOPLP business thanks



to its decision to license M-Series and acquire the production fab from Deca Technologies. ESWIN - a newly established Chinese OSAT - is investing in FOPLP only and is currently actively qualifying and preparing to set up an FOPLP line. PTI is concentrating its attention on FOPLP success by being one of the OSATs to enter the FOPLP market space as a memory back-end specialist. It should slowly ramp up with buy-in from more customers.

In summary, panel makers entering the Fan-Out packaging market are still in line to achieve large-die high-end products with good L/S and high reliability. High volume manufacturing depends on a killer application that does not yet exist. Nevertheless, FOPLP development is active, progress is ongoing, and FOPLP is expected to gain volume at the expense of Fan-Out Wafer-Level Packaging (FOWLP), which will, however, continue generating the major part of the combined revenue.

**REPORT OBJECTIVES**

- Identify and describe which technologies can be classified as 'Fan-Out packaging'
- Clearly define the different market classes of Fan-Out packaging
- Analyze key market drivers, benefits, and challenges of Fan-Out packages by application
- Describe the different existing technologies, their trends, and roadmaps
- Analyze the supply chain and Fan-Out landscape
- Update the business status of Fan-Out technology markets
- Provide a market forecast for the coming years, and estimate future trends

**COMPANIES CITED IN THE REPORT (non exhaustive list)**

3D-Plus, 3M, AGC, Amkor, Ajinomoto, AKG, Analog Devices, Apple, ASE, A\*Star (IME), AT&S, Atotech, Aurora semiconductors, BASF, BK Ultrasound, Blackberry, Boschmann, Brewer Science, Broadcom, Bosch, Cerebras, China Mobile, Cirrus Logic, Cypress, Deca Technologies, Denso, Dialog Semiconductor, Dow Dupont, Evatec, Fitbit, Freescale (NXP), Fujifilm, Global Foundry, Global Unichip Corp. (GUC), Google, Hella, HiSilicon, Hitachi chemicals, Huawei, Huatian, Infineon, Intel, Lenovo, LG Electronics, Marvell, Maxim IC, Mediatek, Medtronic, Nagase ChemteX, Nanium (Amkor), Nepes, Nepes Laweh, Nephos, Nokia, NXP, Oppo, Onda, Powertech Technology Inc, Qualcomm, Qorvo, Rena, Rohm, Samsung, Schmoll maschinen, SEMCO, SEMSYSCO, Shinko Electric, Sivers IMA, Spectrum, SPIL, STATS ChipPAC (JCET), STMicroelectronics, Synaptics, Synergy, Texas Instruments, TSMC, Unimicron, Xilinx, Xiaomi and more...

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**RELATED REPORTS, MONITORS & TRACKS**



- HiSilicon Hi1382 Coherent Processor with ASE's FOCos
- Status of the Advanced Packaging Industry 2020
- Advanced Packaging Quarterly Market Monitor
- Fan-Out Packaging Processes Comparison 2020
- 5G Packaging Trends for Smartphones 2021

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1.3 Orders are deemed to be accepted only upon written acceptance and confirmation by the Seller, within [7 days] from the date of order, to be sent either by email. In the absence of any confirmation in writing, no order shall be deemed to have been accepted.

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- 2.1 Products are sent by email to the Buyer after Seller’s confirmation:
  - Within a few days from the Seller’s confirmation of the order for Products already released and paid; or
  - Within a reasonable time for Products ordered prior to their effective release. In this case, the Seller shall use its best endeavours to inform the Buyer of an indicative release date and the evolution of the work in progress.
- 2.2 The Seller shall by no means be responsible for any delay pursuant to Article 2.1 above, in particular in cases where a new event or access to new contradictory information would require the Seller analyst to dedicate extra time to compute or compare the data in order to enable the Seller to deliver a high quality Product.
- 2.3 The mailing of the Product will occur only upon payment by the Buyer, in accordance with the conditions contained in Article 3 above.

2.4. The mailing is operated through electronic means either by email via the sales department or automatically online via an email/password. The Buyer is responsible for ensuring that the Buyers platform has the required capacities and authorisations to receive the Product(s) emailed by the Seller. If the Product’s electronic delivery format is defective, the Seller undertakes to replace it at no charge to the Buyer provided that the Seller is informed of the defective formatting within 90 days from the date of the original download or receipt of the Product.

2.5 The person receiving the Products on behalf of the Buyer shall immediately verify the quality of the Products and their conformity with the order. Any claim for apparent defects or for non-conformity shall be sent in writing to the Seller within 8 days of receipt of the Products. For this purpose, the Buyer agrees to produce sufficient evidence of such defects.

2.6 No return of Products shall be accepted without prior written notification from the Buyer to the Seller, even in case of delayed delivery. Any Product returned to the Seller without the Buyer providing prior notification to the Seller as required under Article 2.5 above shall remain at the Buyer’s risk. In no event shall the Seller incur any liability for Products erroneously ordered by the Buyer, or for any request from the Buyer to replace a Product previously ordered by a different Product.

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3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are deemed to be inclusive of all taxes applicable in the country where the Seller is based (except for France where VAT will be added). The prices are re-evaluated from time to time by the Seller. The effective price is deemed to be the one applicable at the time of the order.

3.2 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, or made by credit card or by electronic transfer to the following account:  
HSBC, 1 place de la Bourse 69002 Lyon France  
Bank code: 30056  
Branch code: 00170  
Account n°: 0170 200 1565 87  
BIC or SWIFT code: CCFRFRPP  
IBAN: FR76 3005 6001 7001 7020 0156 587

To secure the payments due to the Seller, the Seller reserves the right to request down payments from the Buyer. In such case, the need for a down payment will be mentioned on the corresponding order.

3.3 Payment is due by the Buyer to the Seller within 30 days from invoice date, except as otherwise specifically agreed in writing by the Buyer and the Seller. If the Buyer fails to pay at the due date and fails to request and obtain from the Seller a payment extension, the latter shall be entitled to invoice interest in arrears based on the annual rate Refi of the “BCE” + 7 points, in accordance with article L.441-6 of the French Commercial Code.

3.4 The Seller publications (reports, monitors, tracks...) are due for delivery only after receipt by the Seller of any payment due by the Buyer prior to delivery.

3.5 In the event of termination of the contract by the Seller attributable to Buyer misconduct during the contract, the Seller will have the right to invoice all work performed at the time of termination, and to take legal action for damages.

## 4. LIABILITIES

4.1 The Buyer or any other individual or legal person acting on its behalf, being a business user buying the Products for its business activities, shall be solely responsible for the choice of the Products purchased as well as for the use and interpretations the Buyer makes of the documents it purchases, of the results the Buyer obtains, and of the advice and acts the Buyer bases thereon .

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4.4 Any Product that the Seller sells may, upon prior notice to the Buyer from time to time be modified by Seller or substituted with a similar Product meeting the needs of the Buyer. Such modification shall not lead to any liability of the Seller, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

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6.6 It is acknowledged and accepted by the Buyer that whether purchased in the form of Bundles or Annual Subscription, all unselected reports will be deemed cancelled and lost after a period of 12 month following acceptance of the corresponding order by the Seller in accordance with provisions of Article 1.3 above .

6.7 It is further acknowledged and agreed by the Buyer that any investor in the Buyer Company, any external consultant of the Buyer Company or any joint venture done with a third party in which the Buyer Company is involved , is not entitled to use a Product, without paying to the Seller the full price for a license to the required Product..

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