

# STATUS OF THE ADVANCED PACKAGING INDUSTRY 2019

## Market & Technology Report - July 2019

*Despite the semiconductor industry's slowdown, advanced packaging is growing at an impressive 8% CAGR (2018 - 2024).*

### WHAT'S NEW

- Updated forecast of the semiconductor market including memory & non-memory components
- Update of advanced packaging market data (2018-2024):
  - > By revenue, wafer, and unit forecasts
  - > By advanced packaging platforms: flip-chip, fan-out, fan-in, 2.5D/3D IC, embedded die
- Analysis of US-China effect on semiconductor business & supply chain
- Included 2018 - 2024 revenue, wafer, and unit forecasts, by various application segments: consumer & mobile, automotive & transportation, telecom & infrastructure, medical, industrial, defense & aerospace
- Updated supply chain analysis with focus on impact of foundry entry into advanced packaging business
- Wafer starts share by manufacturers from different business model (IDM, OSAT, foundry) by different advanced packaging platform and its evolution
- Updated financial analysis of the top 25 OSATs (2018-2013) by different parameters: revenue, YoY growth, R&D, Capex, gross profit, gross margin, net income etc.
- M&As data update and different scenarios for OSATs for 2019-2024

### REPORT KEY FEATURES

- Advanced packaging - market overview
- Drivers and dynamics
- Future applications
- Disruptions and opportunities
- Technology trends and forecasts
- Revenue, wafer, and unit forecasts, per platform
- Future development, per platform
- Impact of front-end scaling
- Supply chain analysis
- Production overview, per player (IDM, OSAT, foundry)
- Supply chain analysis and shifting business models
- Financial analysis of the top 25 OSATs

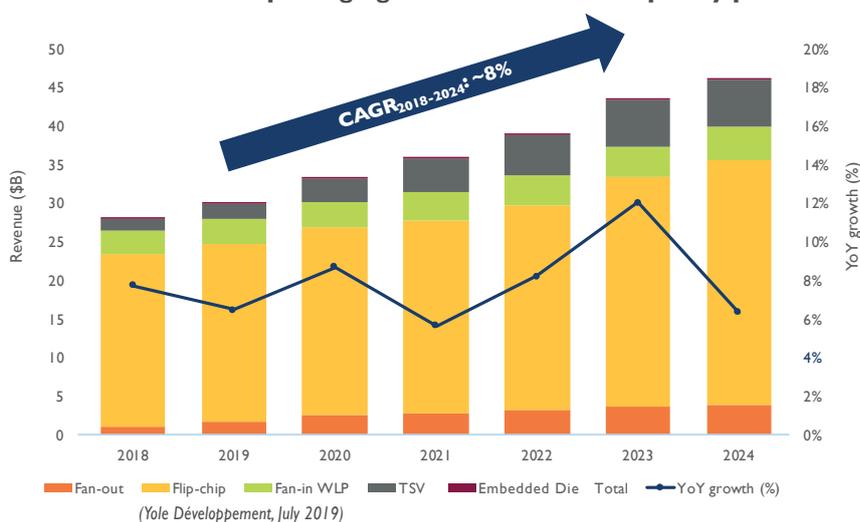
## THE ADVANCED PACKAGING MARKET'S MOMENTUM INCREASES AMIDST STRONG GROWTH

The semiconductor industry is at a turning point. The slowdown in CMOS scaling, coupled with escalating costs, has prompted the industry to rely on IC packaging to extend the benefits of the More-than-Moore era. Thus, advanced packaging has entered its most successful period, boosted by widespread needs for better integration; the slowdown of Moore's law; and megatrends in transportation, 5G, consumer, memory & computing, IoT (and IIoT), AI, and HPC.

After experiencing double-digit growth and achieving record revenue in 2017 and 2018, Yole Développement (Yole) expects a slowdown (negative YoY growth) in the semiconductor industry for 2019. However, advanced packaging is expected to maintain its growth momentum, with ~ 6% YoY growth. Overall, the advanced packaging market will grow at an 8% CAGR, reaching ~\$44B in 2024. Conversely, during the same period the traditional packaging market will grow at a 2.4% CAGR, and the total IC packaging business will exhibit a 5% CAGR.

Yole's report, Status of the Advanced Packaging Industry 2019, explores the field of advanced packaging and represents a comprehensive yearly overview of the latest market and technology developments. The report first summarizes the drivers for advanced packaging and the latest market dynamics, and then examines packaging technology evolution with the help of short- and long-term roadmaps. Also included is an analysis of the trends and challenges related to advanced packaging technology, supported by detailed roadmaps for the various packaging platforms. Furthermore, this report provides a deep analysis of the supply chain, including player positioning and strategy/production per player (revenue, wafers). This supply chain analysis includes a thorough financial inquiry of the top 25 OSATs. The report concludes by providing revenue, wafer, and unit forecasts per packaging platform, along with a review of future production and possible developments during the 2018 - 2024 timeframe.

2018-2024 advanced packaging revenue forecast – Split by platform



## FLIP-CHIP CURRENTLY CONSTITUTES THE BULK OF THE ADVANCED PACKAGING BUSINESS, BUT 3D IC STACKING AND FAN-OUT ARE THE FASTEST-GROWING ADVANCED PACKAGING PLATFORMS

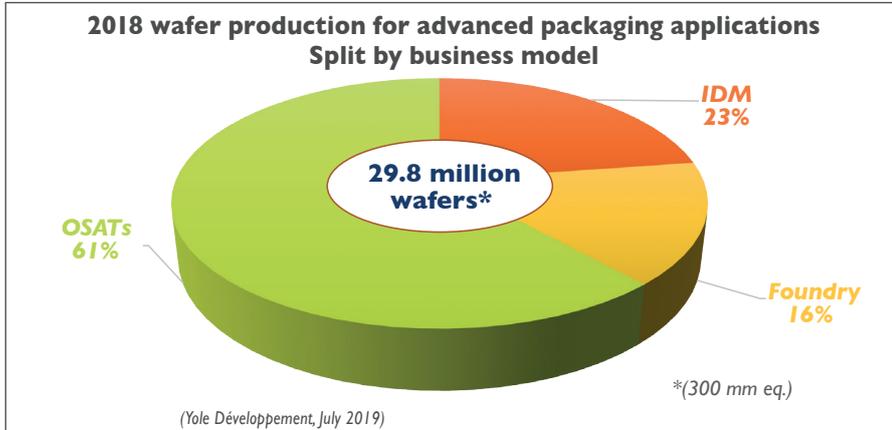
In 2018, flip-chip constituted ~81% of the advanced packaging market. However, by 2024 its share will decrease to ~72%. Of the different advanced packaging platforms, 3D IC stacking and fan-out will each grow at a rate of ~ 26%, and their adoption will continue increasing across various

applications. No other technology can provide the performance and integration level reached by actual stacking technologies based on TSV, hybrid bonding, or a combination of both. The high-end TSV market's growth is led by 3D memory (HBM and 3D DDR DRAM), 2.5D interposer-based die

partitioning, and logic-memory integration. The HBM business is enjoying high growth, led by AI/ML, HPC, and data centres. Fan-out packaging is being utilized in more applications (BB, PMIC, RF, APE, memory) while simultaneously penetrating new markets. In

fact, the fan-out packaging market is expected to show strong growth, with players from different business models all entering the market. Led mostly by mobile, fan-in WLP will grow at a 6.5% CAGR over 2018 - 2024. Embedded die, though small in market-size (<\$25M in 2018), is expected to grow at a 49% CAGR over the next five years, with demand driven by markets like telecom & infrastructure, automotive, and mobile.

In terms of applications, mobile & consumer constituted 84% of the total advanced packaging market in 2018. This application will grow at a 5% CAGR (2018 - 2024), accounting for 72% of advance packaging units by 2024. In terms of revenue, telecom & infrastructure is the advanced packaging market's fastest-growing segment (~28%), and it will double its market share from 6% in 2018 to 15% by 2024. Meanwhile, the automotive & transportation segment will increase its share from 9% to 11% by 2024.

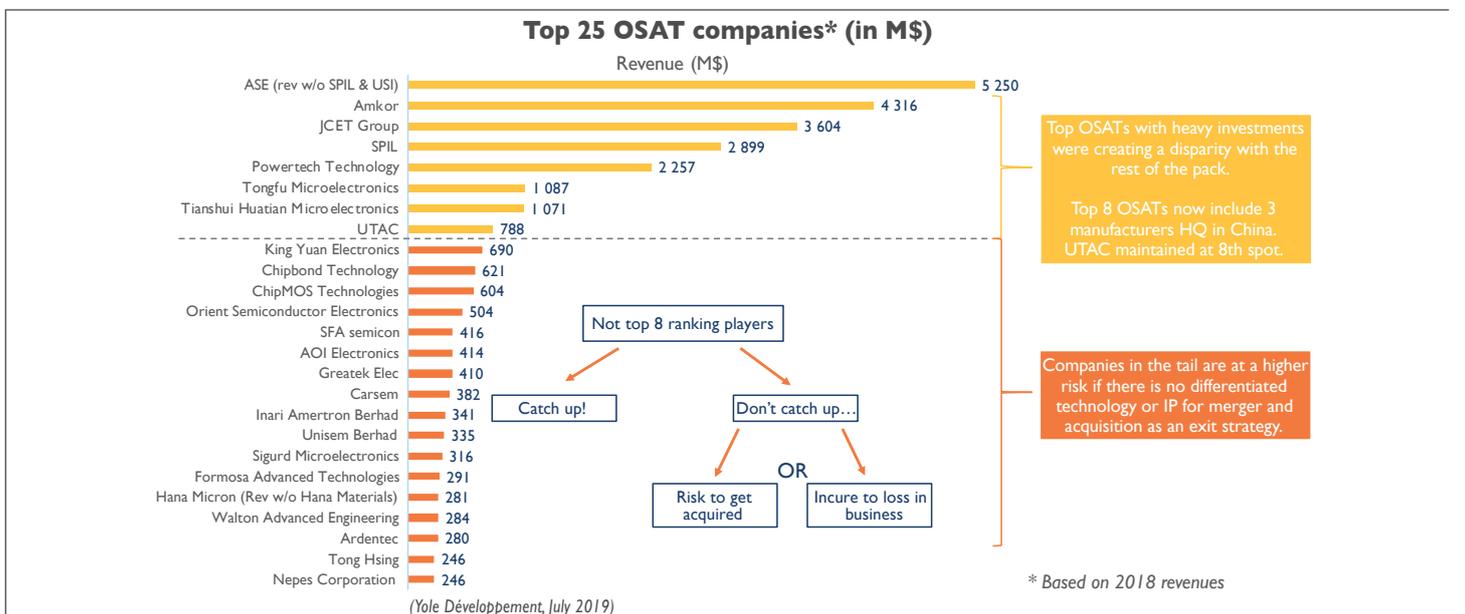


## CHANGES IN THE SEMICONDUCTOR SUPPLY CHAIN, SHIFTING BUSINESS MODELS, AND UNCERTAINTY RELATED TO US-CHINA TRADE CREATES OPPORTUNITIES FOR SOME, WHILE POSING A THREAT TO OTHERS

Amidst an evolving business environment, the semiconductor supply chain is undergoing change at various levels. Some players have successfully managed to expand into a new business model and significantly impact the IC manufacturing chain, while others have failed to take off. Different players have different motivations to move or expand into new businesses - for example, software players like Google, Microsoft, Facebook, and Alibaba are designing their own processors in order to have system-level integration/customization and control of the supply chain up to assembly level. The biggest change is marked by foundries expanding into the advanced packaging business. Though they are relative newcomers, their impact has been significant. TSMC leads for innovation in the fan-out and 3D advanced packaging platforms, with various offerings such as InFO (and its variants), CoWoS, WoW, 3D SoIC, and more. For TSMC, advanced packaging has become a full-fledged business, and the company expects \$3B revenue from

its advanced packaging activities in 2019, which would put place them fourth among OSATs. Elsewhere, UMC is a key supplier of Si interposers for 2.5D packaging, and recently partnered with Xperi to optimize and commercialize ZiBond and DBI technologies for a wide range of semiconductor devices. Meanwhile, XMC provides 3D IC TSV packaging for image sensors and high-performance applications. Overall, these players are instrumental in moving packaging from substrate to a silicon platform.

IC substrate and PCB manufacturers like SEMCO, Unimicron, AT&S, and Shinko are entering the advanced packaging arena with panel-level fan-out packages and embedded dies (and passives) in organic substrates, and are eating the lunch of OSATs - especially those involved in the advanced packaging business. To remain competitive, we will see lots of M&A activity in the OSAT sector in the coming years, at various levels: consolidation amongst big players, the merger or acquisition of two midsize players with complementary



services offerings (i.e. between pure packaging and testing players), and small OSATs (or WLP houses) being acquired by big players. Niche WLP players like Deca Technologies and LB Semicon are strong candidates for acquisition.

Trade tension between the U.S. and China could potentially disrupt semiconductor growth and cast uncertainty over the supply chain. The picture is still unclear and there is lots of confusion, intermingled with many “ifs” and “buts”. Multiple scenarios are possible depending on whether there is an all-out trade war or if a new trade deal is reached, either with concessions from each side or the status quo being maintained. It is also possible that this trade war will see assembly supply chains shifting from China to Taiwan, Korea, and Southeast Asia.

Once the traditional domain of OSATs and IDMs, a paradigm shift is occurring today in the packaging/

assembly sphere. Players from different business models (foundries, substrate/PCB suppliers, EMS/DMs) are arriving and cannibalizing OSATs' share. All of these supply chain shifts and their implications, along with the production of >25 major packaging suppliers per advanced packaging platform, are summarized and analysed in Yole's report. Deeper insight into financial performance enables us to create a link between technology evolution, supply chain shifts, and the overall success of individual players in this changing landscape. Furthermore, this report offers a closer look at the financial evolution of the top 25 OSATs over 2013 - 2018. Yole also investigates the various facets of the US-China trade war and its potential effect on the semiconductor supply chain (including assembly and packaging), taking into account whether a clear-cut winner/loser scenario emerges.

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- 6.4 The Buyer shall be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Buyer shall bear related financial consequences in their entirety.
- 6.5 The Buyer shall define within its company a contact point for the needs of the contract. This person will be the recipient of each new report. This person shall also be responsible for respect of the copyrights and will guaranty that the Products are not disseminated out of the company. In the context of Bundle and Annual Subscriptions, the contact person shall decide who within the Buyer, shall be entitled to receive the protected link that will allow the Buyer to access the Products.
- 6.6 Please note that whether in Bundles or Annual Subscription, all unselected reports will be cancelled and lost after the 12 month validity period of the contract.
- 6.7 As a matter of fact the investor of a company, external consultants, the joint venture done with a third party, and so on cannot access the report and should pay a full license price.

## 7. TERMINATION

- 7.1 If the Buyer cancels the order in whole or in part or postpones the date of mailing, the Buyer shall indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Buyer of such delay or cancellation. This may also apply for any other direct or indirect consequential loss that may be borne by the Seller, following this decision.
- 7.2 In the event of breach by one Party under these conditions or the order, the non-breaching Party may send a notification to the other by recorded delivery letter upon which, after a period of thirty (30) days without solving the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

## 8. MISCELLANEOUS

All the provisions of these Terms and Conditions are for the benefit of the Seller itself, but also for its licensors, employees and agents. Each of them is entitled to assert and enforce those provisions against the Buyer. Any notices under these Terms and Conditions shall be given in writing. They shall be effective upon receipt by the other Party. The Seller may, from time to time, update these Terms and Conditions and the Buyer, is deemed to have accepted the latest version of these terms and conditions, provided they have been communicated to him in due time.

## 9. GOVERNING LAW AND JURISDICTION

- 9.1 Any dispute arising out or linked to these Terms and Conditions or to any contract/orders entered into in application of these Terms and Conditions shall be settled by the French Commercial Courts of Lyon, which shall have exclusive jurisdiction upon such issues.
- 9.2 French law shall govern the relation between the Buyer and the Seller, in accordance with these Terms and Conditions.