YOLE Développement

STATUS OF THE ADVANCED PACKAGING INDUSTRY 2020

Market & Technology Report - July 2020

OSATs, foundries, and IDMs all want to impact the growing advanced packaging market.

WHAT'S NEW

- Updated forecast of the semiconductor market, including memory and non-memory components
- Key system-level demand forecast: mobile & consumer, automotive, telecom & infrastructure
- Update of our advanced packaging market data (2019 - 2025):
  - > By revenue, wafer, and unit forecasts
  - > By advanced packaging platform: flip-chip, fan-out, fan-in, 3D stacked, embedded die
  - > By different application segment
- Summary of COVID-19's impact on all forecasts
- Analysis of the "U.S. - China effect" on the semiconductor business and supply chain
- Revised supply chain analysis, with focus on the impact of foundries entering the advanced packaging business
- Wafer-starts share and evolution, by manufacturers from different business models (IDM, OSAT, foundry) and by different advanced packaging platforms
- Updated financial analysis of the top 25 OSATs (2019 -2013), by different parameters: revenue, YoY growth, R&D, capex, gross profit, gross margin, net income, etc.
- M&A data update and different scenarios for OSATs, covering 2019 - 2025

KEY FEATURES

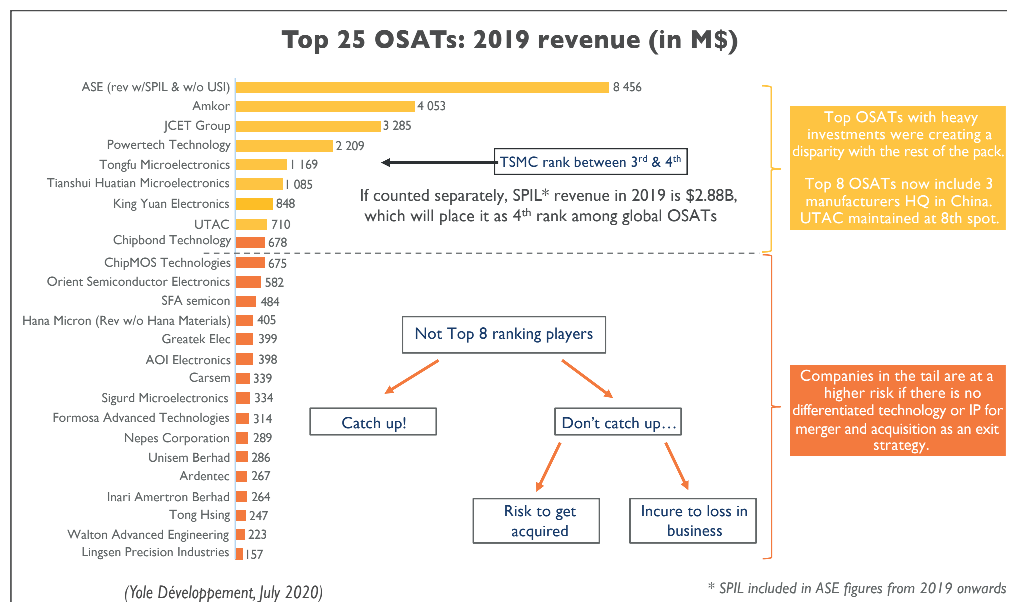
- Advanced packaging market overview
- Drivers and dynamics, disruptions, and opportunities
- Market forecast
- Technology trends and forecasts
- Revenue, wafer, and unit forecasts, per platform and applications segment
- Future development, per platform
- Impact of front-end scaling
- Supply chain analysis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

PLAYERS ACROSS THE SEMICONDUCTOR SUPPLY CHAIN ARE MAKING A STRONG PUSH INTO THE ADVANCED PACKAGING BUSINESS

Once the traditional, exclusive domain of OSATs and IDMs, today a paradigm shift is occurring in the assembly / packaging segment of the semiconductor manufacturing supply chain. Players from different business models (foundries, substrate/PCB suppliers, EMS/ODMs) are entering this market and cannibalizing OSATs' share. Advanced packaging (AP) is moving from a package substrate platform to silicon, a shift that is providing opportunities for giants like TSMC, Intel, and Samsung to flex their muscles in the AP segment and emerge as key innovators of new AP technology. TSMC especially has emerged as the leader in terms of developing an innovative advanced packaging platform from fan-out (InFO) to 2.5D Si interposer (CoWoS), to 3D SoIC. Based on current packaging revenue rankings, TSMC is #4 among OSATs.

Meanwhile, other top OSATs such as ASE/SPIL, Amkor, and JCET are investing in various advanced SiPs and fan-out technology to gauge their competition and increase their advanced packaging market share. IC substrate & PCB manufacturers, EMS companies, and display industry players are also entering the AP arena via panel-level fan-out packages, SiPs, and embedded dies (and passives) in organic substrates. This trend will continue in 2020 and beyond. All these supply chain shifts and their related implications, as well as a production overview of >25 major packaging suppliers per advanced packaging platform, are summarized and analysed in this report.

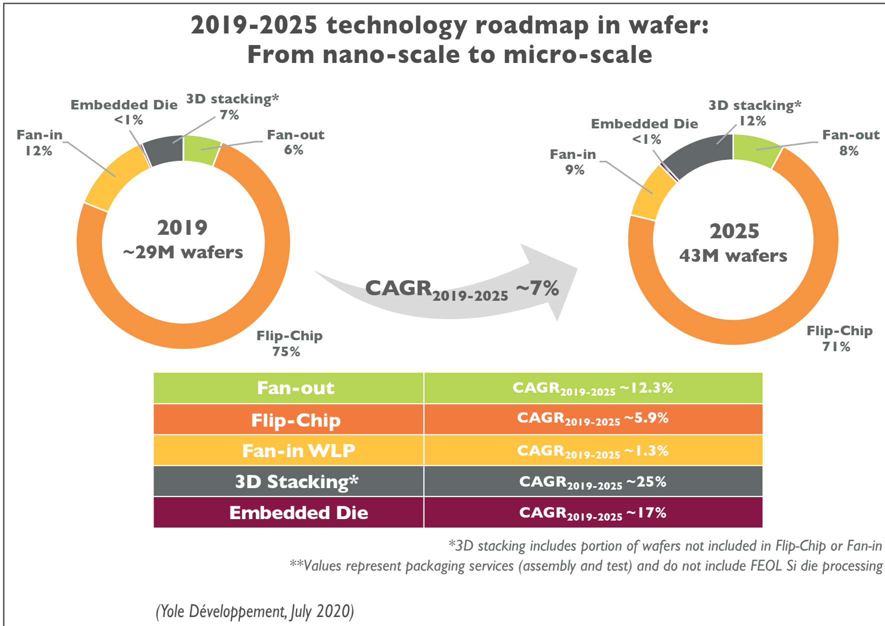
Deeper insight into financial performance enables us to create a link between technology evolution, supply chain shifts, and the overall success of individual players in this changing landscape. Furthermore, this report offers a closer look at the 2013 - 2019 financial evolution of the top 25 OSATs. Yole Développement (Yole) experts also investigate the various facets of the U.S.-China trade war and its potential effect on the semiconductor supply chain (including assembly and packaging) and consider whether a clear-cut winner/loser scenario will emerge.



STRONG GROWTH CONTINUES IN THE ADVANCED PACKAGING MARKET

In 2019 the total IC packaging market was $68B. Advanced packaging (AP) accounted for $29B and is expected to grow at a $CAGR_{2019-2025}$ of 6.6%, reaching $42B in value in 2025. At the same time, the traditional packaging market will grow at a $CAGR_{2019-2025}$ of 1.9% and the total packaging market will grow at $CAGR_{2019-2025}$ of 4%, reaching $43B and $85B in value, respectively. With a $CAGR_{2014-2025}$ of 6.1%, the advanced packaging market is expected to more than double its revenue – from $20B in 2014 to ~$42B in 2025. This is almost triple the expected growth for the traditional packaging market, estimated at a 2.2% $CAGR_{2014-2025}$.

Due to the impact of Covid-19, the AP market is expected to decrease by 6.8% YoY in 2020. However, Yole Développement (Yole) expects this market to rebound in 2021, with ~14% YoY growth. The highest CAGR revenue is expected from 2.5D / 3D TSV IC, ED (in laminate substrate), and fan-out (21.3%, 18%, and 16%, respectively), as high-volume products further penetrate the market: for example, FO in mobile, networking, and automotive; 3D stacking in AI/ML, HPC, data centres, CIS, and 3D NAND; and ED in automotive, mobile, and base stations. By revenue segment, the mobile & consumer market constituted 85% of total advanced package revenue in 2019, and it will grow at a 5.5% CAGR to constitute 80% of AP revenue by 2025. Telecom & infrastructure is by revenue the fastest-growing segment (~13%) in the AP market, and will increase its market share from 10% in 2019 to 14% by 2025. Meanwhile, in terms of revenue the automotive & transportation segment will grow at 10.6% CAGR from 2019 - 2025, reaching ~$1.9B in 2025.



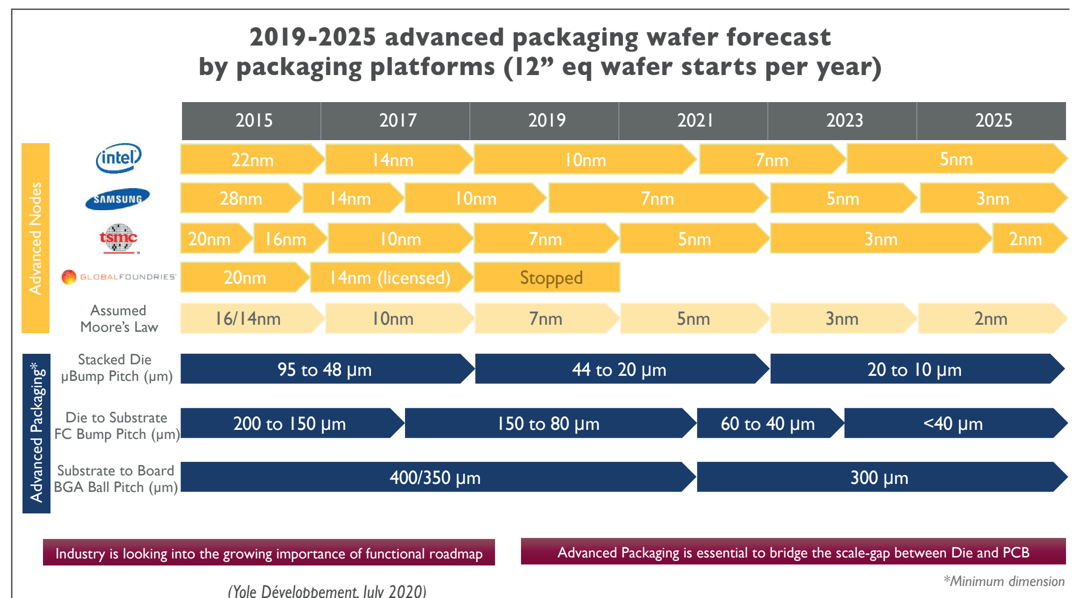
(Yole Développement, July 2020)

Yole's report explores the field of advanced packaging and presents a comprehensive yearly prospectus of the latest market and technology developments. It also offers a deep analysis of the supply chain, including player positioning, market share, and strategy/production per player (revenue, wafers). Moreover, the report includes revenue, wafer, and unit forecasts per packaging platform across various applications, along with a review of future production and possible developments during the 2019 - 2025 timeframe.

3D/2.5D STACKING AND FAN-OUT HAVE EMERGED AS THE FASTEST-GROWING ADVANCED PACKAGING PLATFORMS

Advanced packaging has become crucial for semiconductor innovation and is essential for bridging the scaling gap between die and PCB. The semiconductor industry is developing products for scaling roadmaps and functional roadmaps, with the scaling roadmap expected to continue (7nm & below) even though only three players remain, and the pace has slowed. The functional roadmap, which uses heterogenous integration and is supported by AP, has become more prominent. Indeed, advanced semiconductor packaging is observed to increase a semiconductor product's value by adding functionality and maintaining/increasing performance while simultaneously lowering cost. A variety of multi-die packaging (system-in-packages) are being developed in both the high- and low-ends for consumer, performance, and specialized applications that will address needs related to heterogeneous integration for functional performance and faster time-to-market.

Among the various AP technologies, flip-chip constituted ~83% of the market's revenue in 2019. However, its share will decrease to ~77% by 2025, whereas the share for 3D stacking and fan-out will increase from ~ 5% each in 2019, to 10% and 7% respectively by 2025. 3D stacking and fan-out will continue growing at an impressive rate of ~ 21% and 16% respectively, and their adoption will



(Yole Développement, July 2020)

further increase across various applications. The 3D stacking market's growth is led by 3D memory (HBM and 3D DDR DRAM), 2.5D interposer-based die partitioning and heterogeneous integration, 3D SoC, Foveros, 3D NAND, and stacked CIS. The fan-out packaging market is also expected to show strong growth, with players from different business models entering the market. Led mostly by mobile, fan-in WLP will grow at a 3.2% CAGR during 2019 - 2025. Embedded die, though small in market size, is expected to grow at an 18% CAGR over the next five years, with demand driven by markets like telecom & infrastructure, automotive, and mobile.

This report focuses on 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 featured is an analysis of the trends and challenges related to advanced packaging technology, supported by detailed roadmaps for the specific packaging platforms across various applications.

COMPANIES CITED IN THE REPORT (non exhaustive list)

Amkor, Analog Devices, Ardentec, Atmel, AOI Electronics, Apple, ARM, ASE, Avago, Bitmain, Broadcom, Carsem, China WLCSP, Chipbond, ChipMOS, Cisco, Cypress Semiconductor, Deca Technologies, Greatek, IC Interconnect, Fairchild, Facebook, Flip Chip International, Formosa, Freescale, Fujitsu, GlobalFoundries, Google, Hana Micron, Huawei, Inari Berhad, Intel, Intersil, J-Devices, JCET, King Yuan, Linear Technology, LB Semicon, Lingsen Precision, Maxim, MaxLinear, MediaTek, Microchip, Micron, Microsemi, Movidius, Nantong-Fujitsu, Nanium, Nepes, Nvidia, NXP, ON Semiconductor, OptoPAC, Orient Semiconductor, Powertech Technology, Renesas, Qualcomm, Rohm, Samsung, SilTech, Sigurd, SK Hynix, Softbank, SPIL, STMicroelectronics, STATS ChipPAC, STS Semiconductor, Teraprobe, Texas Instruments, Tianshui Huatian, Tong Hsing, Toshiba, TSMC, Unisem, UTAC, Walton Advanced Engineering, and more…

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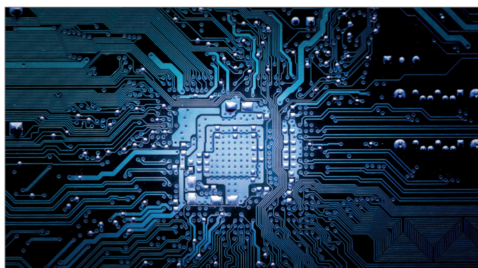
RELATED REPORTS, MONITORS & TRACKS



- Advanced Packaging Quarterly Market Monitor
- Fan-Out Packaging Technologies and Market 2020
- System-in-Package Technology and Market Trends 2020
- RF Front-End Module Comparison 2020 - *by System Plus Consulting*
- Qualcomm QET5100M Envelope Tracker Module with SEMCO's Embedded Die Packaging Technology - *by System Plus Consulting*

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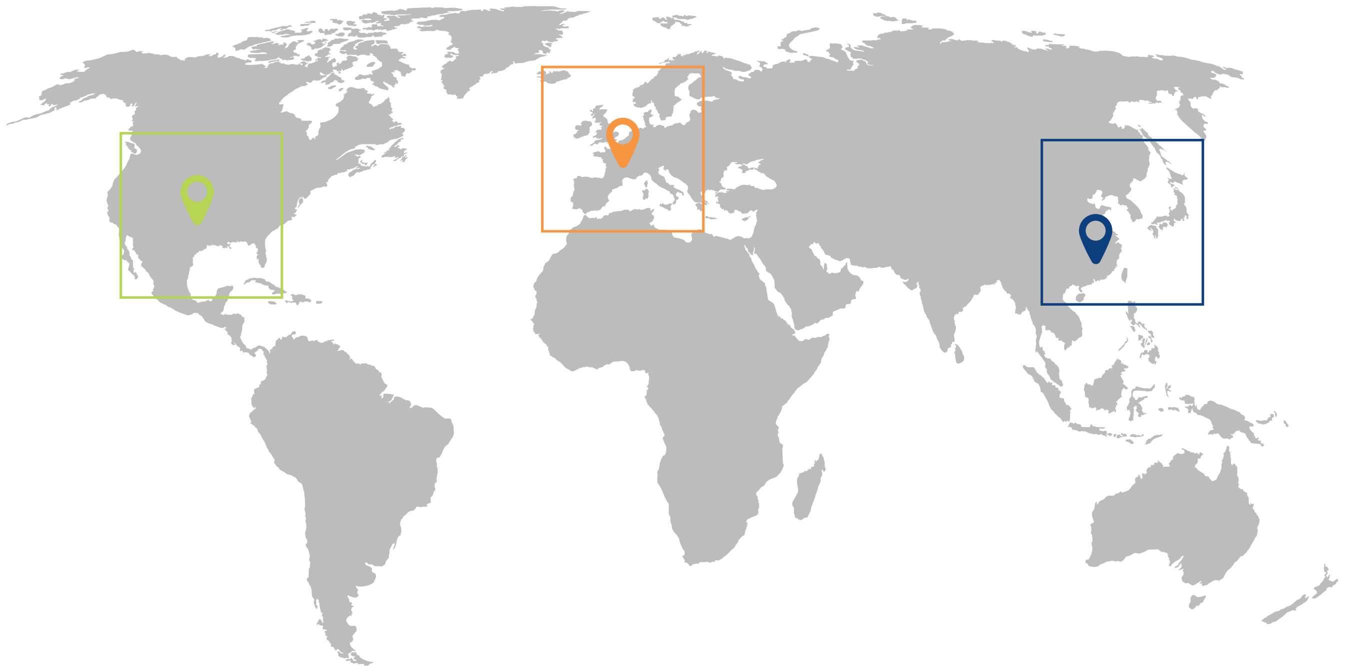

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ABOUT YOLE DEVELOPPEMENT

Founded in 1998, Yole Développement (Yole) has grown to become a group of companies providing marketing, technology and strategy consulting, media and corporate finance services, reverse engineering and reverse costing services. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 120 collaborators worldwide covering MEMS and Image Sensors, Compound Semiconductors, RF Electronics, Solid-state Lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Power Electronics, Batteries & Energy Management and Memory.
The "More than Moore" market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and Blumorpho, supports industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

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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.

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6.3 If the Buyer would like to use data coming from a Product for presentations, press announcements and any other projects, the Buyer needs to contact Yole Développement's Public Relations Director (info@yole.fr) to get an official authorization and confirm that the data are up to date. In return the Seller will make sure to provide up-to-date data under a suitable public format.

6.4 The Buyer shall be solely responsible towards the Seller for any infringement of the obligation described in Article 6.3 above, whether such infringement originates from the Buyer's employees or any person to whom the Buyer has sent the Products. Furthermore, the Buyer shall initiate and personally take care of any related proceedings in coordination with the Seller, and the Buyer shall bear the related financial consequences in their entirety.

6.5 The Buyer shall define within its Company an identified user who shall serve as a contact person for the License purchased by the Buyer. This person will be the recipient of each new report. This person shall also be responsible on behalf of the Buyer, for compliance with all copyrights and other obligations relating to the protection of the Seller's IP rights and general compliance with the terms of the License purchased by the Company. In the context of Bundle and Annual Subscriptions, the contact person shall decide within the Buyer which person(s) shall be entitled to receive the protected link that will allow the Buyer to access the Products.

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..

7. TERMINATION

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 incurred by the Seller, pursuant to such cancellation or postponement.

8. MISCELLANEOUS

8.1 All the provisions of these General Terms and Conditions of Sale are for the benefit of the Seller, but also for that of its licensors, resellers and agents. Each of them is entitled to assert and enforce these provisions against the Buyer.
Any notices under these Terms and Conditions shall be given in writing and shall be effective upon receipt by the other Party.

8.2 The Seller may, from time to time, update these General Terms and Conditions of Sale, and the Buyer, shall be deemed to have accepted the latest version of such General Terms and Conditions of Sale, once they have been duly communicated to the Buyer by the Seller.

9. GOVERNING LAW AND JURISDICTION

9.1 Any dispute arising out or linked to these General Terms and Conditions of Sale or to any Licenses or Products purchased in application thereof shall be submitted to the French Commercial Court of Lyon, which shall have exclusive jurisdiction upon such issues.

9.2 French law (without reference to any applicable conflict of law provisions) shall apply to these General Terms and Conditions of sale and any agreement between the Buyer and the Seller made pursuant thereto.