Manufacturing Market™ INSIDER

Inside the 3D IC Integration Market

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# Developments in Advanced Packaging Lead to a New Generation of Suppliers

We are witnessing a trend toward modularization of subsystems for smartphones, which will, no doubt, spill over to other digital product categories as well. Given demand for thinner and lighter form factors, OEMs increasingly require design flexibility and faster time to market, as well as more flexible and integrated assembly processes that lower costs.

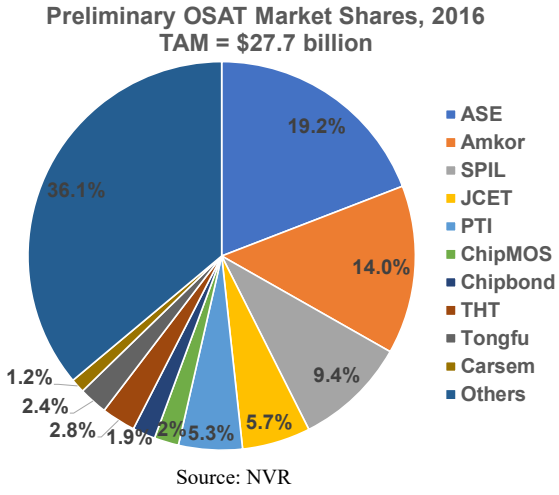
**Apple** is just one of the brands aggressively looking to embrace such modularization. By increasing the number of SiP modules per device, important efficiency gains can be made. The same goes for further component integration into flexible circuit assembly, embedded antennas, etc. Meanwhile, a new generation of module manufacturers is emerging to follow up on this trend, involving both the IC and PCB assembly sectors.

First, let's define the "3D IC Integration Market." These devices include wire bonded, stacked chip solutions, but also systems in package (PoPs, PiPs, MCMs, and stacked WLPs). This semiconductor product category also incorporates embedded devices, both passives and die. Assembly processes used today in this particular segment are either wire bond (74%), wire bond and flip chip (11%), all flip chip (14%), or flip chip and TSV (1%). Driven by the growing popularity of stacked packages and SiPs, flip chip interconnect and the emerging TSV technology will gain share from wire bond, and will reach about 35% by the end of 2020.

Because these methods of flip chip mounting are directly compatible with surface-mount technology, the assembly process now uses both dedicated flip chip bonders and integrated SMT placement platforms that combine die-bonding and chip-mounting functions.

This combined IC packaging and SMT workflow is being used in the production of FCIP-related SiPs, including DRAM and MEMS, as well as embedded devices. Therefore, advanced PCB assembly technology is moving upstream into the IC packaging world with mixed interconnect technologies that address converging and increasingly modularized SMT and microelectronics assemblies.

Clearly, digital applications, particularly smartphones and wearables, are the driving force behind miniaturization and modularization on the die level, be it in the form of 2.5D stacks, 3D TSV, or intermediary steps such as SiP. Yet automotive and industrial electronics will reinforce this trend, supported by the adoption of the Internet of Things, which puts an additional premium on reduced capex, materials costs, labor costs, cycle time, and floor space.




Source: NVR

Increasingly, OEMs/IDMs like Apple and **Samsung** work directly with foundries and OSATs to reach a higher level of integration between wafer, package, and substrate. And Chinese OEMs such as **Huawei**, **ZTE**, and **Lenovo** are building their own ecosystems, asserting firm control over integrated design manufacturing, fabless design, foundry, outsourced assembly and test, and PCB assembly operations. *In essence, 3D IC integration triggers widespread industry consolidation.* Building the new supply chain involves considerable M&A activity, aimed at critical control points across the value chain, to generate future flows of revenue and opportunity.

## Some articles in this issue

The table at the bottom of this page shows five-year averages of the revenues, growth, and profitability of the top 15 foundries, along with the top 30 OSATs, EMS/ODMs, and back-end semiconductor production equipment (SPE) vendors. SPE suppliers have been consolidating in a low-growth environment where product and process complexity have gone up faster than the productivity improvements of their tools. Some EMS providers can afford to look upstream to the OSAT world in order to move up the technology curve and beat razor-thin margins. And many OSATs may want to stop worrying about price erosion, and get some help funding the capex required to capture margin from the foundries.

Back-end semiconductor and SMT equipment vendors like **ASMP** and **Siemens**, and **K&S** and **Assembléon** have already merged and streamlined product portfolios and supply chains to extend their market reach and capture higher margins. Some are now shipping 20–25% of their equipment to clients in the IC assembly industry. Customers include foundries such as **TSMC**, IDMs like **Intel** and **Micron**, OSATs (**Amkor**, **STATS ChipPAC**, and **Signetics**), PCB manufacturers (**AT&S**, **LG Innotek**, and **Unimicron**), and emerging modules players such as **Nari Technology** and **Wistron NeWeb**.

Likewise, we have seen early merger activity in the OSAT and EMS space. **ASE Group (ASE)** owns **Universal Scientific Industrial (USI)**, a global EMS provider with annual revenue of $3 billion and a leading manufacturer of wireless modules for mobile devices. Together, they now offer customers a complete SiP solution, focused on biometric touch, sensors, wireless, power management, camera modules, RF front end, and lighting, and encompassing design to manufacturing and logistical integration. USI claims a 10–15% global market share in Wi-Fi SiP modules (Wi-Fi + Bluetooth + FM), and 50% allocation from Apple. Lenovo is another key customer.

ASE, also, is the majority partner in a joint venture (JV) with Japan's **TDK** in Kaohsiung, Taiwan, to manufacture IC embedded substrates, utilizing TDK's SESUB technology, which can realize a 60% reduction in the size of PMIC boards. Previously, most of the individual process steps used in embedded technologies were done by discrete semiconductor companies, with parts being shipped around the world. Thus, ASE and TDK have integrated, front to back, the entire process from bumping, to substrate, all the way up to assembly. The JV company may also provide part of TDK's production capacity for IC embedded substrates.

More than any other company, **Foxconn** seems to be taking the lead in building a vertically integrated mixed business model in its recent bid to acquire **Siliconware Precision Industries (SPIL)**, which has also been pursued by ASE. Foxconn clearly wants to position itself as the leading supplier of both EMS and IC module packaging services, and control and dominate the revenue real estate that comes from higher margin IC packaging services. Previously, it acquired **ShunSin Technology**, an SiP module manufacturer of RF power amplifiers, LNA and MEMS products, optical transceivers, and solar photovoltaic concentrator modules. SiP accounts for 85–90% of its revenue. Apple, **Avago**, **Qorvo,** and **Skyworks** are among its main customers.

Evidently, the need for miniaturization requires lower cost, which serves as an enabler of these vertically integrated manufacturing models. How far up the supply chain these companies will go remains to be seen, but *MMI* has observed that there is considerable activity in this space currently.

**Jabil Circuit** is active in the SiP module business, as evidenced by its acquisition of **AOC Technologies** in optical networking modules, and other internal investments in RF modules and in semiconductor photonics.

In an interview, Dan Gamota, Jabil's Vice President, observed that "EMS and IC packaging is an area that we are actively observing and have been watching for quite a while. Miniaturization is creating opportunities in different domains such as communications and networking, optics and cameras, automotive, consumer lifestyle products, wearables, aerospace, and healthcare, which are all benefiting from miniaturization and module integration. In some cases, we develop the capabilities in-house and in other situations we are better served through M&A activities."

In 2015, Jabil also expanded its diversified integration capabilities by acquiring **Kasalis**, a leading active alignment provider for camera and gesture-recognition modules.

Others, including **Flex**, **Sanmina,** and **Celestica**, have quietly initiated semiconductor packaging assembly and test projects, responding to the need of high-profile OEMs and IDMs for smaller, lighter, and faster packaging solutions. Also, many more ODMs are exploring modules and are pioneering in SiP, an area that traditionally has been dominated by OSATs. They seek to develop new or hybrid manufacturing models capable of contributing to faster time to market and lowering cost by creating miniature SiP modules. This is to be done all under one roof, rather than by three separate operations, as is currently the case.

**ASUSTeK**, which has a strategic ownership position in **Pegatron**, indirectly controls **AzureWave**, a wireless module provider, and **Kinsus Connect**, a major IC substrate supplier. AzureWave produces wireless communication and digital image processing–related module products. Its main customers include ASUSTeK, Pegatron, Google, and Xiaomi. In 2015, AzureWave became the supplier of the 3x3 MIMO Wi-Fi module card for Apple's iMac and Mac Pro. Also, it supplied Wi-Fi SiP modules for iPhones and iPads in 2016.

| | Revenue ($M) | CAGR | Gross Margin | Operating Margin | Net Margin | Capex / Sales | Net Debt / Equity |
|---|---|---|---|---|---|---|---|
| FOUNDRY | $2,250 | 11.6% | 32.4% | 23.4% | 20.1% | 31.5% | -5.9% |
| OSAT | $887 | 3.3% | 17.8% | 8.0% | 4.4% | 17.1% | 29.4% |
| EMS | $6,635 | 2.6% | 7.4% | 2.9% | 2.2% | 1.8% | -14.6% |
| SPE | $1,374 | -5.5% | 25.2% | 7.3% | 4.9% | 4.4% | 9.2% |

Source: NVR

Meanwhile, Kinsus has gained significant traction in the communication IC market, involving FC-CSP, WB-CSP, and SiP. Its major customers include **Qualcomm**, **Broadcom**, **Altera**, **Xilinx**, and **MediaTek**.

**Compal Electronics** has been building a strategic relationship with **ChipBond**, which also controls **Chipmore**, both OSATs. In addition, Compal controls **Arcadyan**, previously a JV company owned by **Philips** and **Accton**, which provides broadband access, multimedia and wireless technology, and wireless equipment and devices to telecom operators and consumer electronics vendors and retailers. Major products include broadband (AD, IP-STB, and LTE, 60–65% of sales) and AP/gateway and Wi-Fi modules.

Compal also works with **Aptos**, previously a JV company owned by **UMC** and **Hon Hai**, in which **Toshiba** now holds a major stake through **Global NAND Flash**, its second largest fab. Aptos is mainly engaged in packaging and testing of NAND flash–related products and expanding into the microSD assembly field. Through innovative research and development, Aptos has also successfully developed and integrated various system-in-package technologies and applications in the past few years.

Other examples include **Acer**, the cradle of TSMC, which has a strategic relationship with **Wistron** and **Qisda**. Wistron NeWeb (WNC), which designs and manufactures wireless connectivity products aimed at the smart home, automotive connectivity, and mobile communications markets.

Further, TSMC and **Delta Electronics** jointly control **Cyntec**, a leading component maker for miniaturized and highly integrated products. Cyntec, the world's largest notebook power choke maker, successfully penetrated the communication arena, including tier-one and Chinese handset makers, by supplying 0201/01005 resistors, small chokes, RF components, etc.

Finally, there is **Quanta Computer**, which controls **Quanta Microelectronics (QMI)**, a company that designs and manufactures SiP modules for handheld devices, PCI-E modules for PCNB, mini-PCI modules for embedded applications, and USB dongles. QMI also offers highly integrated solutions with Wi-Fi, Bluetooth, GPS, and DVB-H functions in a single module.

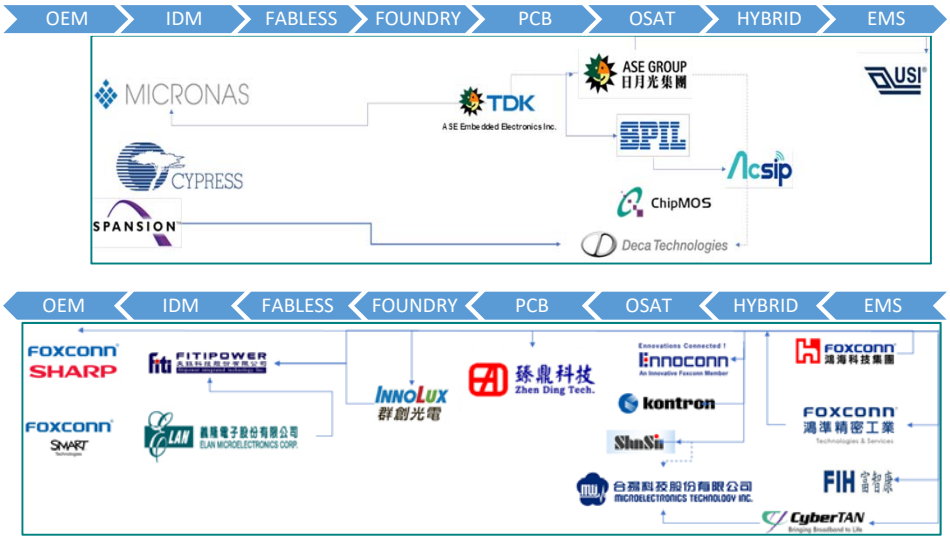
So, who will assemble these SiPs? Currently, the leading suppliers are the OSATs, of which ASE is the market leader (see chart showing OSAT market share, page 1). These subcontractors are familiar with the design tools for modules or packages, including electrical and thermal modeling and antenna design, and have a history of obtaining die from many sources. Also, they have fine-pitch wire, die, and flip chip bonding capabilities, and provide EMI shielding and package test capability.

On the other hand, EMS suppliers have good ability to purchase and manage materials through the supply chain, can provide components from multiple sources, and have high-throughput SMT machines capable of bare die, flip chip bonding, and passive device placement. There is no technical reason why EMS companies could not perform SiP and embedded die assemblies.

Vertical integration has been a consistent industry trend over the last decade. As mentioned, there has been a major battle raging between ASE and Foxconn over the assets of SPIL, while the industry is preparing for a volume ramp-up of fan-out wafer-level packaging (FO-WLP), which will probably materialize in 2018. SPIL has been evaluating various vertical cooperation opportunities since 2010 and ASE has been exploring growth potential, focusing on its EMS and testing and packaging capability.

Before the introduction of SiP, the key EMS process was to mount components onto PCBs, enabled by surface-mount technology. Upstream and downstream alliances can help generate potential synergies with OSATs and the development of SiP and other semiconductor modules underlying innovative products such as the next iPhone.

In the next issue, *MMI—3DICIM* will focus attention on **Samsung, LG Electronics, Panasonic, Toshiba, Fujitsu,** and the China axis, particularly companies such as **BYD, China Resources, China Electronics, Datang,** and **Nantong Huada Microelectronics**.




Source: NVR

ASE Group is moving downstream into the EMS world (USI) and upstream into the embedded PCB world (TDK), while pursuing vertical integration in the OSAT space (SPIL) and diversification into modules territory (AcSiP) to expand its market.

Foxconn/Hon Hai is aggressively moving upstream from the traditional PCB assembly world into IC modules (ShunSin), embedded PCBs (Zhen Ding), and even IDM/OEM to pursue higher margins.

# *Industry News*

## Standard Proposed to Link Fabs and EMS Facilities

The industrial Internet of Things is poised to take a step linking the wafer fab to the PCB factory.

As contract manufacturers move beyond processes such as wire bonding to bumping, they are starting to buy equipment used in wafer fabs. The shift is motivating vendors to call for the electronics manufacturing service (EMS) sector to adopt automation standards already in use in fabs.

"EMS companies continue to increase their manufacturing volume of products with components such as bare die, MEMS, and optical devices, requiring more IC-like assembly equipment, precision placement processes, greater cleanliness, and two-way communications between tools and factory systems, blurring the distinction among EMS companies, OSATs, and foundries," said Dan Gamota, vice president of strategic capabilities, engineering, and technology at **Jabil Circuit**.

Some customers say they want the thread of data that follows their products through the design and fabrication stages to continue to flow through to final systems assembly.

"All of this now demands production tools that can communicate using a standard protocol," Gamota said. "It could serve the industry best if we started with something established that has shown its capacity to evolve, like a light version of the SEMI Generic Model (GEM) for Communications and Control of Manufacturing Equipment," he said. Gamota called for adopting a version of the GEM standard because technology is evolving faster than companies' ability to start on something this fundamental from scratch.

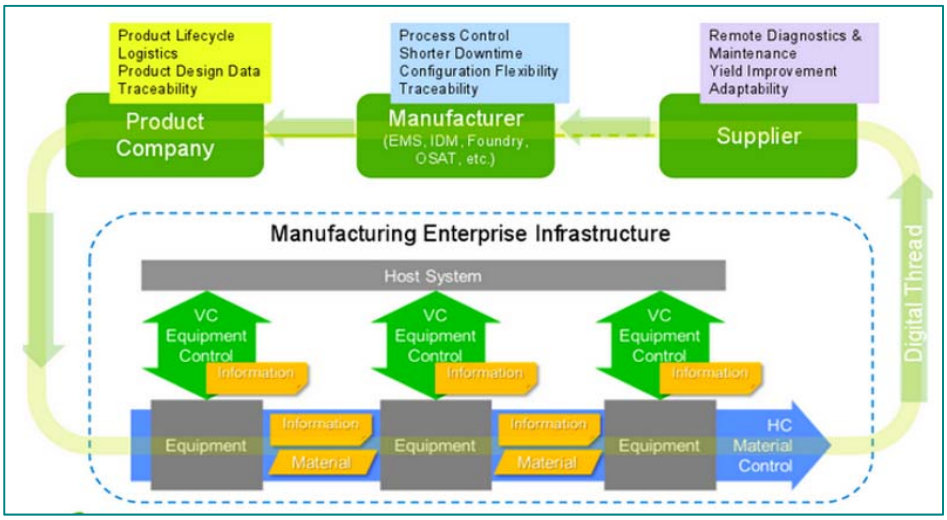
The IPC packaging trade group recently conducted a survey on the topic through its connected-factory subcommittee. A key takeaway was the need for standards that keep up with the accelerating pace of technology change.

The SEMI trade group is sharing the survey results with PCB partners in Taiwan, Japan, and Korea. It hopes to organize a roundtable later this year. Last year, the Taiwan group released a proposal for a standard based on GEM.

A SEMI initiative in smart manufacturing is already working on sharing learning and extending established models from the wafer fab to final assembly.

The group is starting work on a guide to ease the integration of advanced automation for chip packaging. It also formed a collaboration to demonstrate cost savings in the fab from shared development of deep learning software to tackle common problem areas.

"Automating a packaging facility is an overwhelming task to start," said Hem Takiar, vice president of packaging engineering at **SanDisk**, who led the effort to automate SanDisk's packaging operation. "Integration of communication with suppliers and customers has to be an integral part of factory automation," he said.




## Jim Walker Discusses New Semiconductor Industry Business Models

Jim Walker, previously with **Gartner**, recently gave a plenary talk at the IMAPS Device Packaging Conference on the state of the semiconductor industry. His presentation contained some interesting perspectives on emerging new business models.

Projections for 2020 show wireless and computer will still account for about 50% of the overall market activity; automotive, storage, and industrial will show significant growth (7–9%) between now and then and account for ~30% of the total market combined.

Consolidation will continue: "…with semi companies sitting on $135 billion in cash and profit margins decreasing, there is a need to diversify into new markets." Specifics include:

– IoT-related M&A activity will drive consolidation in MCU, analog, and sensor technologies.

– Companies will initiate sales of unprofitable divisions and product lines to prepare for M&A.

– China will continue to buy or invest in US and EU companies, even as governments impose restrictions.

The industries' maturation will result in traditional business model changes.

OEMs and electronics brands are being bypassed by a direct relationship between the ODM/EMS and a non-electronics brand owner/buyer who could be in any industry. This model emerged with operator-branded handsets, although those might be recognizable as **Nokia** or **Motorola**. This (brand) direct-to-ODM/EMS business model is good for chip suppliers but bad for traditional electronics companies.

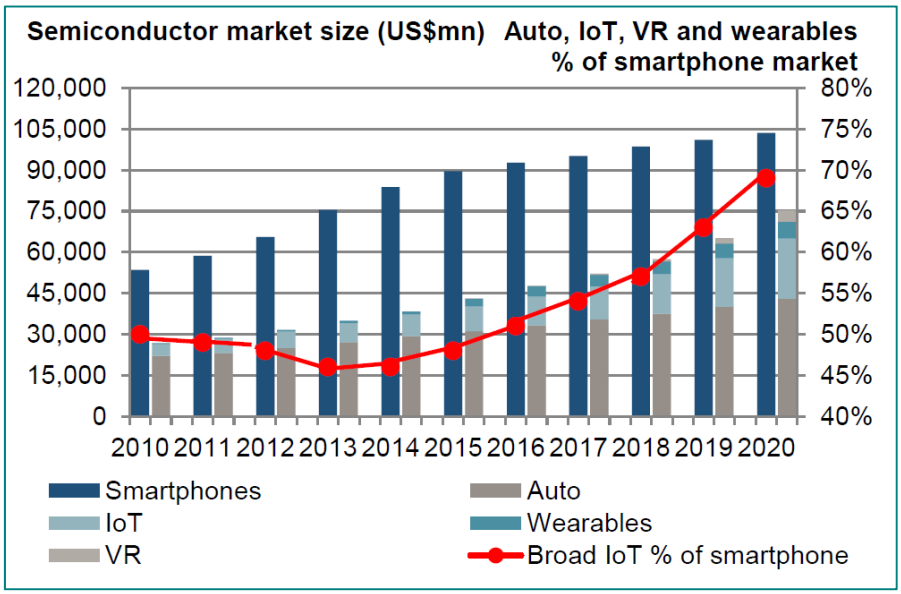
Further, chip companies are being bypassed by a direct relationship between the foundry and the EMS/ODM company and the OEM—the OEM direct model. For example, there could be chips designed by **Apple** or **Facebook** and manufactured by **TSMC**.

Walker specifically suggests we keep an eye on **Hon Hai (Foxconn)**, which appears to be building strong and broad manufacturing capabilities through acquisitions of companies like Japan's **Sharp** and is currently bidding on the **Toshiba** memory business.

Packaging accounts for almost 17% ($53 billion) of the $265 billion electronics IC market. By 2020, 55% of all packaging is expected to be done at OSATs, with foundries like TSMC (and maybe others soon) becoming competitors with their own wafer-based packaging offerings, like InFO.

Walker sees a bright future for IoT packaging, but cautions that it is composed of many small to midsized applications, not one big one like the smartphone, and thus will require many custom packaging solutions.

**New Markets Grow in Importance vs. Smartphones**
**(Credit Suisse)**




## OSAT Growth and Challenges

**Apple**'s A10 is housed in **TSMC**'s high-density fan-out packaging technology, dubbed Integrated Fan-Out (InFO). This is prompting the OSATs to race each other and develop similar packages for smartphones and other applications. But most other smartphone OEMs haven't jumped on the fan-out bandwagon just yet. Fan-out provides more I/Os than existing solutions, but it's also more expensive.

System in package (SiP) and other segments integrating multiple dies in a single package are also projected to grow in 2017. "The revenue growth rate for the OSAT industry is expected to be higher going forward, driven by the emerging demand for SiP solutions," said Scott Sikorski, vice president at the **STATS ChipPAC/JCET** group.

The overall IC market is projected to grow by 4.7% in 2017, compared to 1.3% in 2016. The total IC packaging and test service market, which includes OSATs, foundries, and IDMs, is projected to reach $56.6 billion in 2017, up 8% from 2016, according to NVR. Of that figure, the IDMs' in-house packaging and test sector is projected to have a share of $26.3 billion in 2017, up from $24.7 billion in 2016. The OSATs' packaging and test revenue is projected to reach $30.3 billion in 2017, up from $27.7 billion in 2016. In total, capital spending for the OSATs alone is expected to reach $2.4 billion in 2017, down 10% from 2016, according to Pacific Crest Securities. Among the OSATs, **ASE**'s capital spending is expected to be higher in 2017. **Amkor**'s capex is expected to be flat. The big spender is China's **JCET** group, which plans to boost its capital spending by 20% in 2017.

Customers insist that the OSATs cut their prices by 2–5% per year. "In order to put the capex in, you must have a bigger revenue base. The investments that you are making are also more expensive," said E. Jan Vardaman, president of **TechSearch**. The increase in costs fuels M&A to support the development, manufacture, and commercialization of expensive package types.

ASE, Amkor, and several companies in China are the most active players in the M&A arena.

ASE is still in talks to merge with **SPIL**. Under the plan, the two companies will form a holding company. Last year, ASE invested $60 million in **Deca**, a subsidiary of **Cypress**. Deca is a developer of fan-out packaging technology.

In 2016, Amkor increased its ownership in **J-Devices**, Japan's largest OSAT, from 65.7% to 100%.

Recently, Amkor signed a deal to acquire **NANIUM**, a move that expands Amkor's efforts in fan-out.

In 2015, JCET, China's largest OSAT, acquired Singapore's STATS ChipPAC, a move that propelled China into the upper ranks of the OSAT business. Also, **Tianshui Huatian Technology**, China's second largest OSAT, acquired **FlipChip International**.

In 2016, **Nantong Fujitsu**, a Chinese OSAT, acquired an 85% stake in AMD's packaging and test operations in Asia. And **Tsinghua Unigroup** last year formed a JV with **ChipMOS**, a Taiwan OSAT. Yet Tsinghua's recent efforts to buy a stake in Taiwan's **Powertech** were scrapped.

### 2.5D Die Stacking

According to Raman Achutharaman, corporate vice president at **Applied Materials**, packaging can be divided into three main categories: high-end technologies like 2.5D/3D; midrange like SiP and WLP; and low cost like wire bond.

For years, the industry has been working on 2.5D to boost the bandwidth in devices which include a package, interposer with through-silicon vias (TSVs), and dies.

2.5D and 3D stacking make sense as it becomes harder to "put everything on a single system-on-chip (SoC) amid soaring design and manufacturing costs at leading-edge nodes. A portion of the road map now requires multi-die modules," said David McCann, vice president of packaging R&D and operations at **GlobalFoundries**.

Although 2.5D has gained traction in high-end applications, such as FPGAs, graphics chips, and networking applications, the big issue in becoming a mainstream technology is cost. Still, the market for TSV technology will grow at a rate exceeding 10% over the next five years, according to Yole.

**SIP and WLP**

WLP involves packaging an IC while it is still on the wafer. Basically, WLP involves two technologies: chip-scale packaging (CSP) and fan-out. In fan-out, individual dies are embedded in an epoxy material. The interconnects are fanned out in the package, enabling more I/Os. Fan-out does not have an interposer, making it cheaper than 2.5D.

Traditionally, smartphone OEMs have used package-on-package (PoP) technology, which involves stacking a memory package on top of an application processor package. Since it runs out of steam at thicknesses of 0.5 to 0.4 mm, Apple moved from PoP to TSMC's fan-out package in the iPhone 7. Still, until the cost drops, many OEMs may stick to PoP, so the fan-out market for smartphones is limited. For this reason, TSMC and the OSATs are pushing FO in a number of markets beyond the smartphone.

The total FO market, including power management, baseband, automotive, consumer, and industrial applications, is expected to grow from $244 million in 2014 to $2.5 billion by 2021.

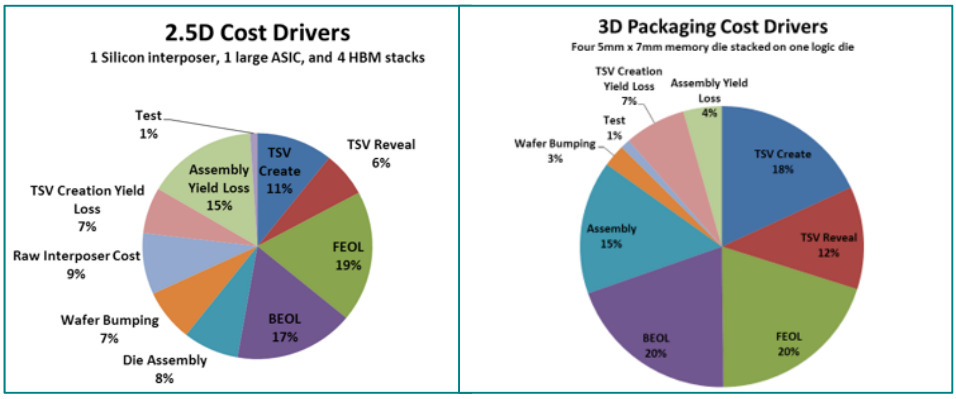
According to STATS ChipPAC's Sikorski, "New OSAT TAM for fan-out WLP will be in the area of SiP. These designs will support complex functionality, especially for mobile applications and emerging markets, such as IoT, wearables, MEMS, sensor modules, and infotainment." In WLP fan-in, the I/Os are placed over the solder balls. These packages are limited to about 200 I/Os and 0.6-mm profiles. They are low-cost solutions with small form factors, ideal for analog chips, power management ICs, and RF devices. Smartphone makers are happy to adopt them.

Fan-in is running into competition against SiPs, however, as they increasingly incorporate power management and RF devices. Whilst proliferating in the mobile market, more of the packages typically tied to WLCSP are moving into the multi-chip modules related to SiP. Integrated passive devices are ending up inside SiP modules as individual components rather than standalone WLCSP. This, in turn, has prompted analysts to lower forecasts for fan-in packages from 9% to 6% from 2015 to 2021.

**Wire Bond Keeps Stitching**

Traditional wire bond packages still make up 82% of the total chip packaging market, except for the MCP segment. BGAs, quad flat packages, and a plethora of legacy packages are based on wire bond. In total, the growth rate for wire bond packages is 6%, according to **Kulicke & Soffa**, a supplier of wire bonder equipment.

The fan-out wafer-level package is considered an intermediate option between the 2.5D and the organic substrate system in package (SiP).







Whether FO-WLP can accelerate its development depends on yield and cost. With sufficient improvement, companies like **MediaTek**, **HiSilicon**, **Oppo**, and **Vivo** will join the bandwagon, and FO-WLP will likely see an explosive expansion. 2017 should be the year for trials with mobile customers, while 2018 will be the year for volume deployments, though fortunately we do not see TSMC extending into advanced packaging beyond its InFO package for Apple in 2017.

## Smartphone Shipments by Taiwan OEMs, ODMs to Decline 40% in 1Q17

*DigiTimes* reports that shipments of smartphones by Taiwan-based brand vendors and ODMs are expected to decline 39.6% year on year to below 10 million units in the first quarter of 2017. Taiwan's brand vendors and ODMs shipped a total of 13.22 million smartphones in the fourth quarter of 2016, up 7% q-o-q but down 26.3% year on year.

Most clients of Taiwan's ODMs will hold back their orders in the first quarter. **Sony Mobile Communications** will reduce its orders significantly for old models in the first quarter due to product transition, while shipments of new models by ODMs **Compal Electronics** and **Arima Communications** to the Japan-based vendor are unlikely to pick up until the second quarter.

**Wistron** will receive no more new orders from **BlackBerry** starting in the first quarter, as the Canada-based vendor has closed its handset hardware business, while orders from **LG Electronics** to Arima in the first quarter will also be lower than those placed a quarter earlier.

For all of 2016, smartphone shipments by Taiwan's brand vendors and ODMs declined 32.6% year on year to 51.59 million units, the lowest level in five years. **ASUSTek Computer**, **HTC**, and Compal were the three makers that saw their yearly shipments surpass 10 million units each in 2016, with ASUSTek taking the top spot.

## *Quarterly Results*

### Advanced Semiconductor Engineering Eying Market Share Gains

In 4Q2016, **ASE**'s consolidated sales grew 6% q-o-q, with the back-end business up 1% q-o-q on some upside across end markets. EMS was broadly in line with a +11% q-o-q increase on SiP ramps for **Apple**. Profitability was higher, with consolidated gross margin/operating profit margin at 19.9%/10.5%, which management attributed to its focus on lifting SiP profitability. For 1Q2017, ASE is guiding its back-end business down from the normal slowdown in both Android and iOS. The EMS business, also, will decline, but it is balancing its production load better through the year.

ASE is rebalancing its SiP business (three key projects) in order to improve profitability and gain new customers in 2017. The company expects to return to market share gains in 2017 in advanced packaging (flip chip and bump wafer-level packaging). Management believes ASE will outperform +3–7% y-o-y semiconductor growth in 2017, and is not seeing the softness linger into 2Q17, as reported by TSMC. Some wafer supplies may have been built up in response to the tight 28-nm stocks through last year causing slowdowns at the foundry vs. the back end; **MediaTek** noted that its inventory will increase exiting 1Q2017.

ASE expects higher capex spending to result in bigger investments in fan-out wafer-level packaging and copper pillar bumping and intends to expand FO-WLP capacity from 10k wpm to 25k wpm by 2017, compared to **JCET/STATS**' 36k wpm eWLB capacity.

ASE is reportedly among the back-end suppliers for the upcoming iPhone series, and is expected to perform relatively strongly compared with other back-end houses during the peak season, according to *MMI*'s sources. ASE estimates that orders from Apple will be more than 60 million ICs per quarter, the sources noted.

The **ASE–SPIL** deal is still in progress. Regulatory filings have been approved by the Taiwan FTC, and are now under review with China's MOFCOM. Management is also cooperating with the US FTC's investigation. The company still expects to close the deal in 2017, subject to approval by ASE, SPIL's shareholders, and relevant authorities.

### Amkor Technology: Sub-seasonal 1Q17, Likely Recovery in 2Q17

Sales improved slightly in 4Q2016, with profitability trending up. Sales were reported at US$1,022 million, down 6% q-o-q due to seasonal correction and inventory adjustments in smartphones, offsetting more stable consumer, networking, and automotive earnings. GMs were basically flat at 19.7%, excluding a 250-basis-point insurance recovery, which boosted GMs to 22.2% versus 19–23% guidance.

Based on company guidance for 1Q2017, sales will probably come in at –8–16% q-o-q due to inventory corrections and a seasonal lull in China's smartphone market. On lower utilization and higher operating expenses from the K5 ramp, gross margin and operating margin will likely decline to the 15%/3% levels, with net near break-even.

Business should normalize after Q1, and Amkor's target for 2017 could slightly outgrow semis due to greater Chinese sales (5% of sales in 2016, compared to 30% for Taiwan peers), and automotive sales (25% of sales), plus adding fingerprint IC customers and SiP (20% of sales) with rising RF content.

In February, Amkor announced it would acquire **NANIUM** in order to strengthen its FO-WLP capabilities. NANIUM has a solid 12" WLP production line. The company will add 1% in sales by adding NANIUM's single-die fan-out to its portfolio in 2Q2017.

Capex for 2017 will be maintained at US$500 million, implying about US$200 million free cash flow and some debt repayment.

### Powertech Technology: Rebound Expected After 1Q17 Seasonal Decline

PTI's sales were up 7% q-o-q in 4Q2016, with strength across the board. Gross margin was up to 22.7% on higher utilization, although operating margins went down to 16.4% on higher R&D expenses and capacity ramp-up.

1Q2017 will probably see a q-o-q decline due to a seasonal slowdown in logic IC assembly and fewer working days, offsetting its ramp-up of Xian DRAM production and healthy NAND demand. Momentum should pick up in April and grow in 2Q2017.

PTI management hopes to outperform its back-end growth projection of 7% in 2017. The company should continue to outgrow the industry, with drivers including (1) the ramp-up of Xian assembly with **Micron** from 5% of sales to 10% of sales by mid-2017; (2) the addition of **Intel** turnkey assembly, test, and SSD SMT assembly (~3–5% sales); (3) the 3D-NAND ramp-up from **Toshiba**; and (4) ongoing margin improvement and logic capacity expansion at its subsidiary, **Greatek**.

### Jiangsu Changjiang Electronics Technology Reviews Placement Plan

JCET guided net income for 2016 of Rmb99–114 million, up 90–120% y-o-y from a low base of FY2015. The miss from consensus is likely due to the higher expectation of **STATS** and SiP business. Improved growth for STATS in 4Q2016, excluding **Apple** SiPs, was supported by recovering major customers' orders.

Singapore STATS almost reached break-even in October. JCET has successfully phased in **HiSilicon** orders to Korea STATS and expected mass production in 2Q2017. This could improve Korea STATS's utilization and mix in 2H2017.

## Tianshui Huatian Technology: Fingerprint and Margin Improvement

TSHT revenue reached Rmb5.5 billion, while net income was Rmb387 million, beating expectations thanks to higher utilization and better margin.

Q4 saw new capacity additions, a higher utilization rate, and strong fingerprint orders, positive drivers for growth in 1Q2017. Capex is expected to remain flat in 2017 for advanced packaging. The LED business will probably turn around in 2017.

In 4Q2016, revenue declined moderately (by 1% q-o-q), but was supported by Huawei Mate 9 fingerprint demand and full production capacity in Kunshan. Gross margin improved, thanks to better mix and higher utilization, the effects of which will linger in 1Q2017. Positive growth drivers are the 20–30% capacity increase in 2016, improving market demand for fingerprint and MEMS.

Capex is expected to remain flat in 2017 versus 2016 (Rmb1.1 billion), given continuous capacity growth in Xian and Kunshan in advanced packaging.

The acquired LED business, **MIC Optoelectronics**, consolidated as of June 2016, registered a loss of Rmb 10–20 million in 2016. Management expects the LED business to turn around as China's LED industry further recovers.

## ASM Pacific Technology Benefits from Multiple Upgrade Trends

The introduction of iPhone 8 should drive demand for finer-pitch and smaller-form-factor components and printed circuit boards. This will trigger a replacement cycle for surface-mount technology (SMT) equipment, starting in 2017.

ASMP will benefit by gaining share in China's SMT market for high-end smartphones. Management expects the SMT division to contribute U$208 million in sales revenue, which adds up to 18% y-o-y growth in SMT revenue for 2017. Gross margin should improve due to insourcing efforts and merger synergy paying off.

Meanwhile, the market for advanced packaging (fan-out WLP and SiP) will grow about 18% through 2018. OSAT expansion in flip chip and bumping demand should drive 10% growth for ASMP's IC assembly and test equipment in 2017.

ASMP will likely benefit from global semiconductor capex trends, although demand from Chinese OSATs (**JCET**, **TSHT**, **TFME**) may decrease significantly in 2017. The majority of investments in SiP and eWLB were already made in 2016. Still, management strongly believes that China's OSATs will put more focus on advanced packaging, including flip chip and 12" bumping, and gradually move in two main directions: FO-WLP and SiP.

Based on current camera demand trends, analysts forecast 64% growth of camera image sensor (CIS) equipment revenues from 2016 to 2018, driven by dual-cam upgrades in Apple and Chinese smartphones, further camera demand from advanced driver assistance systems (ADAS) and video surveillance, and share gain in customers. This should support ASMP's offering of camera image sensor packaging and camera module assembly equipment.

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