Advanced Packaging Platforms: Equipment & Materials

A comprehensive survey of Equipment & Materials business, Covering main trends, industry / market structures and market metrics

Advanced Packaging & Manufacturing Team

FROM TECHNOLOGIES TO MARKET
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Advanced Packaging Platforms

Wafer-level packages have emerged in many different varieties

- **Wafer-Level Interface / Encapsulation**
  - LED & Sensors
  - WLOptics

- **Wafer-Level Electrical Redistribution**
  - 3D WLP
    - For MEMS & sensors (also called 3D SiP)
  - WL CSP
    - ‘Fan-in’
  - FOWLP
    - ‘Fan-out’

- **Flip-chip & Wafer-Level Stacking / Integration**
  - Embedded die in PCB / laminate
  - 3D IC & TSV
  - 2.5D Interposer
  - FC wafer bumping on BGA

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Report Objectives

- This is a research update on the Equipment & Materials markets for 3D & WLP applications

- This report’s objectives are to:
  - Provide detailed information regarding equipment & materials used in 3D IC & WLP
    - to update the market status of the Equipment & Materials markets for 3D & WLP applications
  - Better understand WLP manufacturing technological trends
  - Better understand equipment & materials industries for each process step in the 3D IC & WLP applications
  - Provide an overview of who is doing what, specificities and market share of each market
  - Gives market metrics both at equipment/material levels for 3D IC & WLP applications
  - Gather and update all the information necessary to benchmark and compare all the different alternatives offered by the current equipment and material toolbox for wafer level packaging
  - Provide an overview of the technological trends of the equipment & materials technologies

- The following applications are not included:
  - Leadframe-based Packages
  - Thinned, Stacked WB Packages
  - Wire-Bond Ball Grid Array Packages & PoP/PiP
  - Equipment & materials used
    - for Wafer Level Optics
  - Panel will be mentioned in the report but forecast related to this field will not be included
Transforming IC Packaging Supply Chain*

* Existing business models represented in red, new business models in orange
Involvement of the FE and BE equipment suppliers

- All the companies from R&D institutes to IP providers, equipment and materials suppliers, foundries, OSATs, IDMs, OEMs, substrate makers have strategically positioned themselves in the “Middle-End” due to its high growth potential.

- This evolution will lead to more investment in new equipment and materials

- The motivations for introducing new manufacturing tools to fulfill 3D technology’s requirements drive considerably the entrance of a lot of equipment coming from the front-end and back-end areas in the ‘Middle-End’ space and create a battlefield between both equipment vendors coming from Front-End and Back-End area who are willing to gain market share in the “Middle-End” space

- migration for equipment suppliers towards Middle-End space

- Depending on the products and applications needs, a trade-off between performance and cost will be needed for the processes that have applications in both front-end and back-end and adopted in 3D integration process flow as well (for instance, lithography, cleaning, deposition, etching etc),
  - Supporting the trends of miniaturization, front-end tools would be preferred for achieving more aggressive features; however, they are typically more expensive.
  - On the other side, the back-end equipment generally exhibits lower cost but can face scaling issues when semiconductor ICs continue to reduce in chip and feature size...
Equipment & Material Demand in the ‘Mid-End’

- The wafer-level-packaging market remains a huge business opportunity and shows the greatest potential for significant future growth in the semiconductor industry.
  - That can be explained by the fact that devices are becoming more and more complex which drives the investment in new equipment modifications and new materials development.
2013 Global Equipment Market for 3D TSV & WLP

<table>
<thead>
<tr>
<th>Process</th>
<th>Market Share</th>
<th>Vendor</th>
<th>Market Share</th>
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<tbody>
<tr>
<td>Wafer bonding</td>
<td>~$XM</td>
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<td>TB &amp; Debond</td>
<td>$XM</td>
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<td>Spin coating/Developer</td>
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<td>Dicing</td>
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<td>Inspection/Metrology</td>
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<td>Grinding &amp; CMP</td>
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</tbody>
</table>

**TOTAL: $932M**

- **Others:** ~$XM
  - Rudolph
    - ~$XM; X%
  - SMEE
    - ~$XM; X%
  - Nikon
    - ~$XM; X%
  - Canon
    - ~$XM; X%
  - SUSS
    - ~$XM
    - X%
  - Ultratech
    - $XM
    - X%
Competitive environment

→ Major suppliers of other type of equipment are also included in this report

*SUSS provides Projection scanner which is between mask aligner and projection stepper
Lithography Equipment Market
3D & WLP Market share per equipment supplier

2013 Market Share Lithography Equipment Vendors

TOT ~ $ xxx M

- Canon
- SMEE
- Rudolph
- Ultratech
- Other
- SUSS
Main materials for Advanced Packaging

- Underfill
- Dielectric materials
- RDL
- Copper TSV
- Bump plating
- Dielectric materials
- Wide I/O memory stack
- Assembly Materials
- Dielectric materials
- Metallization materials
2013 Global Materials Market for 3D TSV & WLP

TOTAL: $789M

- Strippable plating resists
  - $XXM

- Permanent dielectric resists
  - $XXM

- Others
  - $XM, X%

- AZ Electronic Materials
  - $XXM; X%

- JSR Micro
  - $XM; X%

- Shin Etsu
  - $XM; X%

- Sumito Bakelite/ Promerus
  - $XM; X%

- DOW Chemical
  - $XM
  - X%

- Fujifilm
  - $XM; X%

- HD Microsystems/ Dupont
  - $XM
  - X%

- Cleaning chemistries
  - $XXM

- Slurries for CMP
  - $XXM

- Solder paste
  - $XXM
Main dielectric passivation applied to all Advanced Packaging platforms applications are Polyimide (PI) and BCB.

- PI is the key polymer material used for Wafer-Level-Packaging applications, mainly driven by flip chip applications.
  - Flip-chip wafer bumping with electroplated solder and copper pillars which are in high volume in the CPU / GPU / ASIC / FPGA space and today entering in high volume the mobile baseband / APE / RF PA Transceiver / PMU spaces

- BCB is also a very popular material in WLP applications, mainly supported by the WLCSP applications.

- However, PBO becomes a promising material for WLCSP and we are expecting demand for PBO to keep growing for WLCSP and 2.5D/3D IC applications

- WPR is being replaced because of its thermal stability issues
More slides extracts
Who Should be Interested in this Report?

- **Equipment & material suppliers:**
  - Identify new business opportunities and prospects
  - Understand the differentiated value of your products and technologies in this market
  - Identify technology trends, challenges and precise requirements related to permanent bonding
  - Evaluate the market potential of your permanent bonding technologies
  - Position your company in the market
  - Monitor and benchmark your competitors

- **IDMs, CMOS foundries and OSAT players:**
  - Understand technology trends related to permanent bonding when used in MEMS, LED, CIS and Advanced Packaging
  - Spot new opportunities and define diversification strategies

- **R&D organizations and investors:**
  - Monitor the global activity and consolidation currently occurring in the semiconductor equipment and material business in order to identify new partners and targets, and make the right decisions before committing to one particular supplier
About the author of this report

Amandine Pizzagalli

- Amandine is in charge of equipment & material fields for the Advanced Packaging & Manufacturing team at Yole Développement after graduating as an engineer in Electronics, with a specialization in Semiconductors and Nano Electronics Technologies. She worked in the past for Air Liquide with an emphasis on CVD and ALD processes for semiconductor applications.

  Contact: pizzagalli@yole.fr
Our latest market reports...

- 3D IC Business Update 2014
- Permanent Wafer Bonding
  Application Trends & Technology Update
- Thin Film PZT for Semiconductor
  Application Trends, Technology update, Key Players, Tools and Metrics

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The company is involved in the following areas:

- 30 full time global analysts with technical, marketing and management background
- 35000 interviews per year

Field of Research
Overview of Our Main Services

- **Market research & marketing analysis**
  - Identification of new applications, services and markets
  - Set-up market segmentation analysis
  - Proposal of marketing and action plans

- **Technical & reverse costing analysis**
  - Technical comparison of new processes at material or device level
  - Detailed analysis of the cost structure of a specific technology
  - Analysis of technology evolutions and industrial implementation

- **Strategic analysis**
  - Analysis of positioning to create value
  - Development of action plans to improve company performance
  - Support in implementation and fund raising

- **Business Development**
  - Contact with interesting companies and possible partners
  - Set up meetings (face to face or by phone)
  - Follow up in order to implement the decision taken

- **Specific Services for Investors**
  - Evaluation and analysis of business plans
  - Evaluation of production infrastructure
  - Expertise and due diligence before M&A
  - Technology brokerage

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  - Providing forum and journalistic support with publishing articles
  - Organizing and coordinating webcasts
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....Some of our Customers
Mainly supported today by flip-chip wafer bumping, 3D WLP, and WLCSP; the long term growth of the equipment & materials business will be supported by the expansion of 3D TSV stack platforms.

TSV INTEGRATION IS CREATING GROWTH AND SIGNIFICANT INTEREST IN THE EQUIPMENT & MATERIALS INDUSTRY

Mainly supported today by flip-chip wafer bumping, the equipment market generated revenue of more than $930M in 2013. It is expected that this equipment market revenue will peak at almost $2.5B. It is fueled by the 3D IC technology with TSV interconnects, an area offering opportunities for new developments in equipment modification—equipment that is much more expensive than the tools used for established Advanced Packaging platforms (3D WLP, WLCSP, flip-chip wafer bumping). Indeed, 2015 will be the key turning point for the adoption of 3D TSV Stacks since the memory manufacturers, such as Samsung, SK Hynix, Micron, have already started to ship prototypes this year and might be ready to enter in high-volume manufacturing next year.

In addition, logic manufacturers will diversify investments from System-on-Chip to Package-on-Package and will benefit from Advanced Packaging platforms such as 2.5D interposer and FO WLP to stimulate their high-volume production.

The materials market will grow from $789M in 2013 to over $2.1B with a CAGR of 18%. Growth will mainly be driven by the expansion of the next generation Wafer-level-packaging platforms (3D TSV stacked memories, multi-layer RDL for FO WLP & WLCSP), which are becoming more complex and requiring additional and various thin layers, as well as advanced materials, to achieve better performance.

This report will present a comprehensive overview of the main equipment and materials used in the 3D & WLP applications. In addition, it includes insights on a number of equipment tools, breakdown by wafer size & revenue, by type of equipment & materials and advanced packaging applications. Moreover, it also provides details about key suppliers, market share and technological highlights that impact the 3D & WLP industry.

Equipment & materials market forecasts are calculated for 2013–2019.
Entrance of the FE and the BE equipment suppliers in the middle end area

In addition to existing tools to support all the different 3D activities and processing needs, several equipment and materials vendors have emerged. A result of the various steps involved in 3D technology is that the equipment market has become quite diversified.

Several different groups of players, each providing different expertise, have been formed:

- Top-tier semiconductor equipment suppliers coming from the Front-End area
- Specialist equipment suppliers that have developed knowledge and expertise in very specific equipment lines. They are looking to further increase their market share in their field of expertise through differentiation from Top-tier equipment suppliers.

On the other hand, the last acquisitions—SPTS acquired by Orbotech and the merger between AMAT and TEL—show an interest by these companies to provide equipment tools for the Advanced Packaging industry and thus, support as much as possible the Middle-End area.

Since the competition has increased between equipment and materials suppliers, strategic partnerships will probably be necessary to support as much as possible the current and future needs of 3D stacking.

This big change in the equipment & materials market is creating a new battle in the Middle-End area, which is going to be very interesting over the next 5 years.

This report presents a detailed analysis on the packaging industry, highlighting new strategies developed by the equipment & materials suppliers. It gives future evolution of the packaging industry and detailed analysis on the impact of the latest acquisitions on the evolution of the equipment & materials markets.

INCREASED COMPETITION IN THE LITHOGRAPHY MARKET

The lithography market has gained significant interest within the equipment market. This field has driven the entrance of new equipment suppliers.

Today if Ultratech and SUSS micro tech focused on gaining a large portion of market share in the lithography area, they might be challenged by equipment suppliers coming from the Front-End area, such as Nikon and Canon, that represent Top-tier semiconductor equipment and equipment vendors coming from the PCB industry (such as Orbotech, Ushio).

The lithography market is quite diversified and segmented into several different types of equipment suppliers. New entrants are trying to enter the lithography market with alternative solutions to mask aligners and steppers, both used in the packaging area.

Competitive landscape and market share for the major equipment & materials suppliers involved in the Packaging industry are quantified and detailed in this report.
**OBJECTIVES OF THE REPORT**

- Provide market metrics both at equipment & materials levels (from 2013 to 2019)
- Provide market share of the key equipment & materials suppliers involved in the packaging industry
- Key technical insight into future equipment & materials trends and challenges
- A forecast for the next five years, and to predict future trends for equipment & materials for 3D & WLP applications
- Better understand process flows and technological trends in package manufacturing
- Better understand equipment & materials industries for each process step

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


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- Current status
- Overview of the major equipment suppliers
- Positioning of the different equipment suppliers, by technology
- Challenges/unmet needs
- Trends of the technology
- 2013 – 2019 market forecast from 2013 to 2019 (in $M, units)
- Breakdown details for permanent wafer bonders / C2W bonders / DRIE etching & other drilling tools / CVD / PVD / ECD plating / exposure & lithography / spray coating / cleaning / temporary bonding & de-bonding / grinding/thinning-CMP / wafer-molding / inspection & metrology
- Market share (2013)
- Breakdown details for photoresist & coatings / adhesive tapes / pre-applied & wafer-level underfills / molding compounds / plating & cleaning chemistries / slurries for CMP / temporary bonding materials / gas & precursors / sputtering targets
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- Focus on 3D WLP platform
- Case of 3DIC & TSV via middle

**AUTHOR**

Amandine Pizzagalli is in charge of equipment & material fields for the Advanced Packaging & Manufacturing team at Yole Développement after graduating as an engineer in Electronics, with a specialization in Semiconductors and Nano Electronics Technologies. She worked in the past for Air Liquide with an emphasis on CVD and ALD processes for semiconductor applications.
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2. MAILING OF THE PRODUCTS

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3.3 Payments due by the Buyer shall be sent by cheque payable to Yole Développement, credit card or by electronic transfer to

3.6 The Buyer will be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or from any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Seller shall bear related financial consequences in their entirety.

3.7 In the event of termination of the contract, or of misconduct, during the contract, the Seller will have the right to invoice at the stage in progress, and to take legal action for damages. To ensure the payments, the Seller reserves the right to require down payments from the Buyer. In this case, the need of down payments will be mentioned on the order.

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 choosing the Products and for the use and interpretations he makes of the documents it purchases, of the results he obtains, and of the advice and acts it deduces thereof. The Seller shall also be liable for (i) direct and (ii) foreseeable pecuniary loss, due to misuse of the Products or arising from a material breach of this agreement. In no event shall the Seller be liable for:

4.2 The Seller will give the Buyer a maximum of 10 password, unless an arrangement or public display; b) any claim attributable to errors, omissions or other inaccuracies in the Product or interpretations thereof.

4.3 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors. All the Products that the Seller sells may, upon prior notice to the Buyer from time to time to be modified or substituted with similar Products meeting the needs of the Buyer. This modification may result from the following situations, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.4 All the information contained in the Products has been obtained from sources believed to be reliable. The Seller does not warrant the accuracy, completeness adequacy or reliability of such information, which cannot be guaranteed to be free from errors. All the Products that the Seller sells may, upon prior notice to the Buyer from time to time to be modified or substituted with similar Products meeting the needs of the Buyer. This modification may result from the following situations, provided that the Seller ensures the substituted Product is similar to the Product initially ordered.

4.6.2 If the Product undergoes an inspection, it is acknowledged that the Products contain defects, the Seller undertakes to replace the defective products as far as the supplies allow and without indemnities or compensation of any kind for labor costs, delays, lost profit, business interruption or any other losses. That the Seller shall take action without any liability to the Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer therefore shall not use the Product for purposes such as:

4.6 The deadlines that the Seller is asked to state for the mailing of the Products are defined in the order. The price of the report may be reevaluated from time to time. The effective price is deemed to be the one applicable at the time of the order.

5. FORCE MAJEURE

5.1 The Seller shall not be liable for any delay in performance directly or indirectly caused by or resulting from acts of nature, fire, flood, accident, riot, war, government intervention, embargoes, strikes, labor difficulties, equipment failure, late deliveries by suppliers or other uncertainties which are beyond the control, and not the fault of the Seller.

6.1 The Seller agrees to produce sufficient evidence of such defects.

6.2 No refund or exchange is authorized upon receipt of Prior information to the Seller, even in case of delayed delivery. Any Product returned to the Seller will be solely responsible towards the Seller of all infringements of this obligation, whether this infringement comes from its employees or from any person to whom the Buyer has sent the Products and shall personally take care of any related proceedings, and the Seller shall bear related financial consequences in their entirety.

6.3 The Buyer shall bear the right to use the Products solely for its own internal information purposes. In particular, the Buyer therefore shall not use the Product for purposes such as:

6.4 In the case of a multisite, multi license, only the employee of the Seller shall be entitled to access on line the reports on 1-micronews.com. In this respect, the Seller will give the Buyer a maximum of 10 password, unless the multiple sites organization of the Buyer requires more passwords. The Seller reserves the right to check from time to time the correct use of this password.

6.5 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.