Megatrend applications like 5G wireless technologies, electric vehicles, and advanced mobile devices demand miniaturization and extra functionality. Therefore, fabricating the next MtM device generation requires tools with new technical specifications. These are very different to the "More Moore" mainstream semiconductor industry with respect to resolution, overlay, depth of focus (DOF), wafer bow and backside alignment.

MEMS, sensors and power devices have more relaxed specifications, so that mask aligner tools are sufficient at lower cost. However, megatrend applications are pushing devices with more stringent requirements, with lithographic features below 1µm. This would pave the way towards greater adoption of stepper tools.

Wafer-to-Wafer (W2W) bonding is fueled by MtM devices. It's currently supported by CMOS Image Sensors (CIS) based on fusion bonding, which enables Phase Difference Auto Focus (PDAF) as well as faster shooting. Nevertheless, W2W process growth will be led mainly by potentially integrating hybrid bonding with no Through-Silicon Vias (TSVs). Such processes could be used in new consumer CIS approaches such as global shutter and Time-of-Flight (ToF) technology and also the automotive industry in advanced driver-assistance systems (ADAS).

Looking ahead, emerging mainstream products such as 3D NAND memory and 3D Systems on Chips (SoCs) are expected to reshuffle the W2W business in the next few years. They will replace die-to-wafer (D2W) and wire bonding, in order to maximize the number of memory cells and yield and solve stacking layer limitations.

We had expected W2W production to pick up earlier for 3D DRAM stacked memories. However in reality, cost and technical aspects today firmly limit adoption of W2W to replace D2W assembly methods.

This report presents a comprehensive overview of the status of the three equipment types used for MtM devices, along with a more in-depth analysis of technology trends and impacts made by the megatrend applications.
BONDING AND LITHOGRAPHY EQUIPMENT MARKET FOR MORE THAN MOORE DEVICES

The overall semiconductor equipment market is worth several billion dollars. By contrast, the permanent bonding, temporary bonding and debonding and lithography equipment market for the MtM industry is a small niche representing millions of dollars. However, megatrend markets push MtM devices to new levels of complexity, resulting in big investments. Consequently, the total equipment market for these process steps generated revenue of more than $400M in 2017. It is expected to peak at ~$750M by 2023, with a 10% compound annual growth rate (CAGR) over this period. This is mostly driven by lithography, followed by W2W permanent bonding.

The new lithography equipment market for MtM devices is mostly driven by advanced packaging. This sector accounts today for almost 60% of the overall MtM lithography tools market and will continue dominating this industry with stepper technology. Meanwhile, a high percentage of lithography equipment revenue for MEMS and sensors, CIS and power devices comes is generated by retrofitted tools coming from the legacy semiconductor industry. Nevertheless, new lithography systems will be shipped to meet smaller alignment and feature sizes, where older tools will face limitations.

The W2W bonding market is mostly driven by CIS imaging and is expected to be fueled by emerging CIS products. However, new mainstream semiconductor applications such as 3D NAND and 3D SoC will also strongly push W2W bonding market growth over the next five years.

Temporary bonding and debonding still represents a rather small niche reaching more than $55M revenue in 2017. Yet it’s been already applied in numerous MtM areas such as 3D TSV platforms, fan-out wafer level packaging (FO WLP), MEMS and sensors, power devices and photonics applications.

From a technology point of view, laser debonding represents the dominant technology widely used today for FO WLP and 2.5D interposer packaging. It is expected to remain the leading process, mainly supported by the major memory manufacturers such as Samsung, SK Hynix and Micron. These companies are expecting to transition from mechanical debonding/slide-off debonding to laser debonding for the next generation of HBM2 memory due to yield issues and to support the future high volume production forecasted by end of 2019. This report offers a detailed analysis of the MtM equipment market forecast by volume and value, for the 2017-2023 timeframe, broken down by MtM segment application and by technology.

MORE THAN MORE DEVICES LEAD TO A MUCH BROADER BONDING AND LITHOGRAPHY LANDSCAPE

When looking at the competitive landscape, the MtM equipment market is diversified, with groups of equipment vendors coming from different angles.

As such, the bonding equipment market is highly concentrated under the control of specialist equipment suppliers, like EVG and SUSS MicroTec. These companies have developed expertise in very specific equipment lines where legacy equipment suppliers do not have the capabilities to support such processes. The exception is Tokyo Electron Limited (TEL), which is very active in the permanent bonding equipment.

In contrast, the lithography equipment landscape for MtM devices is fragmented in different ways since it is served by two main company types:

- Specialist equipment vendors like Veeco, EVG, SUSS Microtec, SMEE, who offer brand new lithography tools specifically for the MtM industry
- Top-tier semiconductor equipment suppliers like ASML, Canon, Nikon, mostly supporting refurbished equipment

However, the equipment landscape is currently evolving towards greater diversification in both bonding and lithography.

For instance, Asian equipment vendors have recently created strong price pressure and could reshuffle the MtM equipment market. New Chinese local players benefit from strong subsidies from local governments. They have entered the market and started competing with the top players. SMEE today is the dominant Chinese company, holding around 70% market share of the domestic LED market in terms of volume, providing low-cost bonding and lithography.

Some other Asian equipment suppliers include Korean company EO Technics, and Taiwanese company Kinyoup Optronics, offering laser debonding processes mostly dedicated to FO WLP.

Meanwhile, in the quest to acquire market share in the MtM industry, large semiconductor Front-End or Back-End equipment suppliers have adopted different strategies. They are expanding their lithography activities through acquisitions of other companies to diversify and complete their product portfolio. For example, ASML spin-off Liteq was acquired by Kulicke & Soffa, Veeco bought Ultratech and KLA Tencor purchased Orbotech.

Finally, Canon, a key front-end lithography equipment supplier, is challenging MtM suppliers by developing...
brand new tools at a reasonable cost. In addition, they recently skipped a step in the bonding business by leveraging their physical vapor deposition (PVD) capabilities to launch a permanent bonding tool based on metal interfaces.

This report quantifies and details the competitive landscape and major bonding and lithography equipment supplier markets by MtM devices.

**TABLE OF CONTENTS**

- Introduction, definitions and methodology
- Executive summary
- Introduction to More than Moore (MtM) devices
- Equipment overview for MtM devices
- 2017-2023 Global equipment market forecast
- Introduction to More than Moore (MtM) devices
- Executive summary
- Litography equipment vendors benchmark-MtM
- Bonding equipment
- Temporary bonding and debonding equipment market forecast
- 2017 Market share of the equipment vendors in the More than Moore area
- Wafer-to-Wafer permanent bonding, lithography, temporary bonding & debonding
- Wafer-to-Wafer permanent bonding
- W2W permanent bonding technologies overview and applications
- MEMS permanent bonding
- SOI permanent bonding
- Emerging applications
- 3D NAND, 3D SoC, 3D stacked DRAM
- Temporary bonding and debonding equipment technology roadmap
- Temporary bonding and debonding drivers and applications
- Temporary bonding and debonding equipment suppliers – landscape
- Carrier wafers
- Conclusions
- Appendix

**COMPANIES CITED IN THE REPORT**

AGC, AML, AustriaMicroSystems (AMS), Amkor, ASE Group, ASML, ASM Pacific, AST, Ayumi industry, Applied Materials, Broadcom/Avago,BondTech, Canon, Corning, Delphi Laser, ERS, EVG, EO Technics, Infinion, Georgia Tech, ITRI, LAM Research, KLA Tencor/Orbotech, Kulicke & Soffa, JEC/Statschipex, Micron, Mitsubishi Heavy Industries, Murata, Nepes, Nikon, Qorvo, Qualcomm, On Semiconductor, ORC, PlanOptik, PowerTech Technology (PTT), Screen, Samsung, Shin Etsu, SK Hynix, Skyworks, SOITEC, SPILT Microelectronics, SUSS MicroTec, Shanghai Micro Electronics Equipment Co (SME), SUMCO, SunEdison, Kingroup Optronics, Rudolph, Tazmo, Okmetic, TOK, Tokyo Electron Limited (TEL), TSMC, Ushio, Veeco, Via Mechanics...

**OBJECTIVES OF THE REPORT**

- This report is a research update for bonding and lithography equipment markets in the Moore Than Moore (MtM) area (including advanced packaging, MEMS & sensors, CMOS Image Sensors (CIS), RF, LED and power applications).

- This report's objectives include:
  - Furnish an overview of bonding and lithography technological trends and identify manufacturing challenges
  - Benchmark of the equipment toolbox used for MtM devices
  - Offer 2017-2023 market metrics in volume and value at equipment levels for bonding and lithography technologies for MtM applications
  - Discuss technology processes, specifications, and value chains
  - Describe the competitive landscape and identify key players in technology development and manufacturing

**RELATED REPORTS**

- Benefit from our Bundle & Annual Subscription offers and access our analyses at the best available price and with great advantages
  - Status of the Advanced Packaging Industry 2018
  - Status of the CMOS Image Sensor Industry 2018
  - Status of the MEMS Industry 2018
  - 5G’s Impact on RF Front-End Module and Connectivity for Cell Phones 2018

Find all our reports on www.i-micronews.com

**MARKET & TECHNOLOGY REPORT**

**AUTHOR**

Amandine Pizzagalli is a Technology & Market Analyst in Equipment & Materials - Semiconductor Manufacturing, at Yole Développement (Yole). Amandine is part of the development of the Semiconductor & Software division of Yole with the production of reports and custom consulting projects. She is in charge of comprehensive analyses focused on semiconductor equipment, materials and manufacturing processes.

Previously, Amandine worked as Process engineer on CVD and ALD processes for semiconductor applications at Air Liquide. Amandine was based in Japan during one year to manage these projects. Amandine graduated from CPE Lyon (France), with a technical expertise in Semiconductor & Nano-Electronics and has a master focused on Semiconductor Manufacturing Technology, from KTH Royal Institute of Technology (Sweden). She has spoken in numerous international conferences and has authored or co-authored more than 10 papers.
ORDER FORM
Bonding and Lithography Equipment Market for More than Moore Devices

BILL TO
Name (Mr/Ms/Dr/Pr):
Job Title:
Company:
Address:
City:
State:
Postal code/Zip:
Country:
VAT ID Number for EU members:
Tel:
Email:
Date:

PAYMENT

BY CREDIT CARD
Visa □ Mastercard □ Amex □
Name of the Card Holder:
Credit Card Number:
Card Verification Value (3 digits except AMEX: 4 digits):
Expiration date:

BY BANK TRANSFER
Bank Info: HSBC, 1 place de la Bourse, F-69002 Lyon, France, Bank code: 30056, Branch code: 00170
Account No: 0170 200 1565 87,
SWIFT or BIC code: CCFRFRPP,
IBAN: FR76 3005 6001 7001 7020 0156 587

RETURN ORDER BY
• FAX: +33 (0)472 83 01 83
• MAIL: YOLE DÉVELOPPEMENT, Le Quartz, 75 Cours Emile Zola, 69100 Villeurbanne/Lyon - France

SALES CONTACTS
• Western US & Canada - Steve Laferriere:
  +1 310 600-8267 – laferriere@yole.fr
• Eastern US & Canada - Troy Blanchette:
  +1 704 859 0453 – troy.blanchette@yole.fr
• Europe & RoW - Lizzie Levenez:
  +49 15 123 544 182 – levenez@yole.fr
• Japan & Rest of Asia - Takashi Onozawa:
  +81 34405-9204 – onozawa@yole.fr
• Greater China - Mavis Wang:
  +886 979 336 809 – wang@yole.fr
• Specific inquiries: +33 472 830 180 – info@yole.fr

*One user license means only one person at the company can use the report.

About Yole Développement
Founded in 1998, Yole Développement 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 as well as IP and patent analysis. With a strong focus on emerging applications using silicon and/or micro manufacturing, the Yole group of companies has expanded to include more than 80 collaborators worldwide covering MEMS and image sensors, Compound Semiconductors, RF Electronics, Solid-state lighting, Displays, Software, Optoelectronics, Microfluidics & Medical, Advanced Packaging, Manufacturing, Nanomaterials, Power Electronics and Batteries & Energy Management.

The “More than Moore” market research, technology and strategy consulting company Yole Développement, along with its partners System Plus Consulting, PISEO and KnowMade, support industrial companies, investors and R&D organizations worldwide to help them understand markets and follow technology trends to grow their business.

Consulting and Analysis
• Market data & research, marketing analysis
• Technology analysis
• Strategy consulting
• Reverse engineering & costing
• Patent analysis
• Design and characterization of innovative optical systems
• Financial services (due diligence, M&A with our partner)
More information on www.yole.fr

Reports
• Market & technology reports
• Patent investigation and patent infringement risk analysis
• Tear downs & reverse costing analysis
• Cost simulation tool
More information on www.i-micronews.com/reports

Contacts
For more information about:
• Consulting & Financial Services: Jean-Christophe Eloy (eloy@yole.fr)
• Reports: David Jourdan (jourdan@yole.fr) Yole Group of Companies
• Press Relations & Corporate Communication: Sandrine Leroy (leroy@yole.fr)

PRODUCT ORDER - Ref YD18038

Please enter my order for above named report:
☐ One user license*: Euro 5,990
☐ Multi user license: Euro 6,490
- The report will be ready for delivery from November 5, 2018
- For price in dollars, please use the day’s exchange rate. All reports are delivered electronically at payment reception. For French customers, add 20% for VAT

I hereby accept Yole Développement’s Terms and Conditions of Sale(*)
Signature:

(*) Our Terms and Conditions of Sale are available at www.yole.fr/Terms_and_Conditions_of_Sale.aspx
The present document is valid 24 months after its publishing date: October 4, 2018

Shipping Contact
First Name: ____________________________ Last Name: ____________________________
Email: ____________________________ Phone: ____________________________

More information on www.i-micronews.com
Definitions: “Acceptance”: Action by which the Buyer accepts the terms and conditions of sale in their entirety. It is done by signing the purchase order which mentions “I hereby accept Your Terms and Conditions of Sale”.

“Buyer”: Any business user (i.e. any person acting in the course of its business activities, for its business needs) entering into the following general conditions to the exclusion of consumers acting in their personal interest.

“Contracting Parties” or “Parties”: The Seller on the one hand and the Buyer on the other hand.

“Intellectual Property Rights” (“IPR”) means any right resulting from any invention, know-how, trade secret, trade marks, registered designs, models, patterns, inventions, commercial secrets and know-how, technical information, company or trading names and any other intellectual property right resulting from the fact that they have been registered or not and including any pending registration of one of the above-mentioned rights.

“License”: For the reports and databases, 3 different licenses are proposed. The buyer has to choose one license:

- User license: one person of at least 18 years old and acting in the course of his professional activities.
- Multi-user license: the report can be used by unlimited users within the company. Joint-ventures are not included.
- Corporate license: purchased under “Annual Subscription” or “Multi-year Subscription”, the report can be used by unlimited users within the company. Joint-Ventures are not included.

“Products”: Depending on the purchase order, reports or databases on MEMS, CSC, Optics/OMEMS, Nano, Bio, to be defined in the contract, and the evolution of the work in progress.

1. SCOPE
1.1 The Contracting Parties undertake to observe the following general conditions as agreed by the Buyer and the Seller.

2. MAILING OF THE PRODUCTS
2.1 Product shall be mailed to the Buyer as follows:

- within 30 days from the order for Products already released;
- 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 reserves the right to send an e-mail to the Buyer if the Seller can propose a pre-release discount to the Buyer

- The Seller shall by no means be responsible for any delay in receipt of article 2.2 above, and including incases where a new event or access to new contradictory information would be deemed to have been accepted.

2.3 Upon signing the purchase order which mentions “I hereby accept Yole's Terms and Conditions of Sale”, the Buyer agrees to produce sufficient evidence of such acceptance, and the Seller reserves the right to request the Buyer to provide such evidence.

3. PRICE, INVOICING AND PAYMENT
3.1 Prices are given in the orders corresponding to each Product sold on a unit basis or corresponding to annual subscriptions. They are all exclusive of taxes. The price includes 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 losses that may be borne by the Seller.

3.2 The Buyer shall be responsible solely to the Seller for all infringements of this obligation, whether this infringement concerns from its employees, an agent, a franchisee, a representative, a sub-lessee, or any other person connected to the Buyer.

4. LIABILITIES
4.1 The Buyer and/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.

4.2 The Seller shall only be liable for (i) direct and (ii) foreseeable pecuniary loss, caused by the Products or arising from a material breach of this agreement.

4.3 In no event shall the Seller be liable for:

- damages of any kind, including without limitation, incidental or consequential damages (including, but not limited to, damages for loss of profits, business interruption and loss of programs or data contained therein), except for damages caused by its own negligence;
- the Buyer's website or the Products, or any information provided on the website, or in the Products;
- any assumptions or inaccuracies in the Product or interpretations thereof.

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.

4.5 All the information contained in the Products is intended to be used by the Buyer for its own internal information purposes. In particular, the Buyer shall not use it to any other party other than employees of its company.

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 difficulties which are beyond the control, and not the fault of the Seller.

6. PROTECTION OF THE SELLER'S IPR
6.1 All the IPR attached to the Products are and remain the property of the Seller and shall be protected under French and international copyright law and conventions.

6.2 The Buyer agreed not to disclose, copy, reproduce, redistribute, resell or publish the Product, or any part of it, to any other party other than employees of its company. The Buyer shall have the right to use the Products solely for its own internal information purposes. In particular, the Buyer shall therefore not use the Product for purposes such as:

- Information storage and retrieval systems;
- Recordings and re-transmitters over any network (including and without limitation, those of sale);
- Use in any time-sharing, service bureau, bulletin board or similar arrangement or public display;
-continent any Product on any other online service (including bulletin boards or the Internet);
- Licensing, leasing, selling, offering for sale or assigning the Product.

6.3 The Buyer shall be entitled to assign the rights to use the Products to any other party other than employees of its company.

6.4 The Seller shall define within its company point of contact for the needs of the contract. This person will be the recipient of each new report in PDF format. This person shall also be responsible for representing the Seller and for advising the Buyer that the Products are disseminated out of the company.

6.5 In the context of annual subscriptions, the person of contact shall decide who will receive the mailings. The Seller shall not enable access on the reports on I-micronews.com. In this respect, the Seller will give the Buyer a maximum of 10 passwords, except that 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.

6.6 In the context of a multi-site organization, only the employee of the Buyer can access the report or the employee of the companies in which the Buyer have 100% shares. As a matter of fact, the investor or a company, the joint venture done with a third party etc...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 will indemnify the Seller for the entire costs that have been incurred as at the date of notification by the Seller of such delay or cancellation. This may also apply for any other direct or indirect consequential losses that may be borne by the Seller.

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 from sending the problem, the non-breaching Party shall be entitled to terminate all the pending orders, without being liable for any compensation.

8. MISCELLANEOUS
8.1 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. All amendments to these Terms and Conditions shall be in writing. They shall be effective upon receipt by the other Party.

8.2 The Seller may, from time to time, update these Terms and Conditions, and the Buyer shall be deemed to have accepted the latest version of these terms and conditions upon providing any information communicated to him in due time.

9. GOVERNING LAW AND JURISDICTION
9.1 Any dispute arising out of or linked to these Terms and Conditions, or to their interpretation, shall be subject to the application of all the provisions of this 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.