FOR IMMEDIATE RELEASE:

Memory packaging market is showing a steady growth driven by the memory semiconductor business explosion

LYON, France – October 27, 2017: The memory industry is experiencing a strong growth phase: the total memory market is expected to increase at a ~9% CAGR\(^1\) 2016-2022, reaching about US$135 billion by 2022, with DRAM and NAND constituting almost 95% market share. Moreover, a supply-demand mismatch is pushing memory device ASP\(^2\), resulting in big memory IDMs\(^3\) reaping record profits. According to Yole Développement (Yole), the “More than Moore” market research and strategy consulting company, the total 2016 memory packaging market is estimated at about US$20 billion with a 4.6% CAGR until 2022. Therefore, memory devices are using diverse packaging from lead-frame based to TSV\(^4\).

Yole releases today a dedicated report focused on the memory business. The “Memory Packaging Market and Technology” report proposes a deep understanding of the overall market trends of different memory types, related market drivers and the key applications. This analysis proposes a detailed description of the memory packaging’s evolution and roadmap. The consulting company also proposes to discover the market forecasts of the different memory packaging technologies for the coming years, along with an estimate of future trends.

In parallel, NVIDIA Tesla P100 GPU has been deeply analyzed by System Plus Consulting, sister company of Yole, in its latest report: NVIDIA Tesla P100 GPU with HBM2. This reverse costing & engineering analysis is showing the technical evolution compared

---

\(^1\) CAGR: Compound Annual Growth Rate
\(^2\) ASP: Average Selling Price
\(^3\) IDM: Integrated Devices Manufacturer
\(^4\) TSV: Through Silicon Via
to previous memory generation and highlight the added-value of the packaging part.

What are the latest advanced packaging technology challenges for memory applications? What are the related market issues? Yole Group of Companies, including Yole and System Plus Consulting pursues its investigation towards the memory world and offers you today a deep dive into memories’ world.

“Memory demand is coming from all sectors, particularly from the mobile and computing (mainly servers) markets”, announces Santosh Kumar, Senior Technology & Market Research Analyst at Yole.

On average, DRAM memory capacity per smartphone will rise more than threefold, reaching around 6GB by 2022, while NAND capacity per smartphone will increase more than fivefold, reaching more than 150GB by 2022. For servers, DRAM capacity per unit will increase to a whopping more than 0.5TB by 2022 and NAND capacity per SSD for the enterprise market will reach more than 5TB by 2022. Growth in these markets is fueled by applications such as deep learning, data centers, networking, AR/VR, and autonomous driving.

In parallel, the automotive market which generally use low-MB memory will see the adoption of DRAM memory led by emerging trend of autonomous driving and in-vehicle infotainment. Also, the NOR flash memory market is resurgent and expected to grow at an impressive 16% CAGR, attaining about US$4.4 billion by 2022 due to its application in new areas like AMOLED display, touch display driver ICs, and industrial IoTs.

On the supply side, player consolidation coupled with the difficulty in migrating to advanced nodes due to technical challenges, along with higher investment and migration from 2D to 3D NAND, has caused a shortfall in DRAM and NAND flash supply. DRAM players want to retain high ASP and profitability to justify their huge capex investment for advanced node migration, and as such are not inclined to increase capacity.

There are many different memory device packaging options, implying a wide range of packaging technologies ranging from low pin-count SOP packages to high pin-count TSV options, all depending on product requirements like density, performance, and cost.

“We have identified five core memory device packaging platforms: viz lead frame, wire-bond BGA, flip-chip BGA, WLCSP, and TSV,” asserts Santosh
Kumar from Yole. “Each one includes many variations, along with different terminology. Ultimately, the total memory package market is expected to reach almost US$25 billion by 2022.”

In 2016, wire-bond BGA accounted for more than 80% of the packaging market in dollar terms. Also in 2016, flip-chip began making inroads in DRAM memory packaging, and is expected to grow at about 20% CAGR over the next five years, accounting for more than 10% of the total memory packaging market. Increased adoption in the DRAM PC/server segment, fueled by high bandwidth requirements, drives flip-chip growth. Samsung has already converted more than 90% of its DRAM packaging line, SK Hynix has also started converting, and other players will begin adopting flip-chip in the future. In fact, all DDR5 memory for PC/servers will eventually use flip-chip.

Spurred on by high bandwidth and memory chips’ low latency demands for high-performance computing in various applications, TSV is being employed in high-bandwidth memory devices.

“As an example, HBM2 from Samsung and developed for NVIDIA Tesla P100 GPU greatly increases memory capacity and bandwidth over the previous generation”, explains Romain Fraux, System Plus Consulting’s CTO. And he adds: “The single package 55 mm x 55 mm 12-layer BGA package includes more than 3,500 mm² of silicon area. A 3D-assembly process yields HBM2 stacks composed of four 1 GB DRAM memory dies and one buffer die, connected with via-middle TSV and micro-bumps…” (Press release).

The 2016 TSV market was only less than 1% of the total memory market, but this will grow to more than 30% CAGR, reaching about 8% of memory packaging in dollar terms by 2022. Also, WLSCP packaging is used in NOR flash and niche memory devices and is expected to grow at a more than 10% CAGR, but in terms of value will remain only less than 1% of the market by 2022.

For mobile applications, memory packaging will mostly remain on the wire-bond BGA platform. However, it will soon begin moving towards the multi-chip package (ePoP for example) for high-end smartphones. NAND flash devices’ main requirement is high storage density at low cost. NAND are stacked using wire bonding in order to provide high density in a single package.
NAND flash packaging will remain in wire bond BGA form and will not migrate to flip-chip. However, Toshiba will start using TSV packaging in NAND devices to increase data transfer rate for high-end applications. After Toshiba, Yole believes Samsung and SKHynix will bring TSV packaged NAND devices to market.

The market research and strategy consulting company Yole, will attend SEMICON Europa (Nov. 14-17 - Munich, Germany) and will make some presentations focused on its activities (SEMICON Europa agenda). One of them titled "Advanced Packaging: A very dynamic ecosystem!" will deliver the technical challenges and market issues with a dedicated part on the memory business. Yole’s speaker will be Andrej Ivankovic, Market & Technology Analyst, Advanced Packaging & Manufacturing. Save the date in your agenda and meet Yole’s team on booth B1-1434.

A description of the Advanced Packaging for Memories report including table of content, list of companies mentioned in the report and more is detailed on i-micronews.com, advanced packaging reports.
ABOUT THE REPORTS:

Memory Packaging Market and Technology report
Wire bond is still the dominant interconnect for memory packaging, but flip-chip is making inroads into mainstream memory packaging. - Produced by Yole Développement (Yole) part of Yole Group of Companies.

Companies cited in the report:

Author:
Santosh Kumar works as a Senior Technology & Market Research Analyst at Yole Développement, the “More than Moore” market research and strategy consulting company. He is involved in the market, technology, and strategic analysis of microelectronic assembly and packaging technologies. He received a bachelor’s degree and a master’s degree in Engineering from the Indian Institute of Technology (IIT) Roorkee and the University of Seoul, respectively. He has published more than 40 papers in peer-reviewed journals and has obtained two patents. He has presented and given talks at numerous conferences and technical symposiums related to advanced microelectronics packaging.

NVIDIA Tesla P100 Graphics Processing Unit (GPU) with HBM2 reverse costing & engineering report
TSMC CoWoS – Samsung HBM2 - 2.5D and 3D Packaging. Targeted for High Performance Computing (HPC) and deep learning, the NVIDIA Tesla P100 is the world’s first artificial intelligence supercomputing data center GPU… - Produced by System Plus Consulting, part of Yole Group of Companies.

This report includes a physical analysis, manufacturing process flow, cost analysis and estimated price analysis as well as a detailed company profile and the description of the supply chain.

Authors:
Romain Fraux is Chief Technology Officer (CTO) at the company System Plus Consulting, specialized in the reverse costing analysis of electronics, from semiconductor devices to electronic systems. Supporting industrial companies in their development, Romain and his team are offering a complete range of services, costing tools and reports. They deliver in-depth production cost studies and estimate objective selling price of a product, all based on a detailed physical analysis of each component in System Plus Consulting laboratory. Thanks to his deep technical expertise and his knowledge of the industrial landscape, Romain performs costing analyses of MEMS devices, Integrated Circuit and Advanced Packaging. He has significant experience in the modeling of the manufacturing costs of electronics components as well. Romain has spoken in more than 20 industry conferences worldwide over the last 10 years. Romain holds a BEng from Heriot-Watt University of Edinburgh (Scotland) in addition to a master’s degree in Microelectronics from the University of Nantes (France).

Yvon Le Goff has joined System Plus Consulting in 2011, in order to setup the laboratory of System Plus Consulting. He previously worked during 25 years in Atmel Nantes Technological Analysis Laboratory as fab support in physical analysis, and 3 years at Hirex Engineering in Toulouse, in a DPA lab.

ABOUT SYSTEM PLUS CONSULTING – WWW.SYSTEMPLUS.FR
System Plus Consulting specializes in the cost analysis of electronics, from semiconductor devices to electronic systems. Created more than 20 years ago, System Plus Consulting has developed a complete range of services, costing tools and reports to deliver in-depth production cost studies and estimate the objective selling price of a product. System Plus Consulting engineers are experts in Integrated Circuits - Power Devices & Modules - MEMS & Sensors - Photonics – LED - Imaging – Display - Packaging - Electronic Boards & Systems.
Through hundreds of analyses performed each year, System Plus Consulting offers deep added-value reports to help its customers understand their production processes and determine production costs. Based on System Plus Consulting’s results, manufacturers are able to compare their production costs to those of competitors. System Plus Consulting is a sister company of Yole Développement. More info on www.systemplus.fr.

**ABOUT YOLE DEVELOPPEMENT – WWW.YOLE.FR**

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 and 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. For more information, visit www.yole.fr and follow Yole on LinkedIn and Twitter.

- 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)

###