Status of Panel Level Packaging & Manufacturing

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Source: Fraunhofer IZM
ABOUT THE AUTHORS

Biography & contact

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• Santosh Kumar is currently working as Senior Technology & Market Research Analyst at Yole Développement. He worked as senior R&D engineer at MK Electron Co. Ltd where he was engaged in the electronics packaging materials development and technical marketing. His main interest areas are advanced electronic packaging materials and technology including TSV and 3D packaging, modeling and simulation, reliability and material characterization, wire bonding and novel solder materials and process etc. He received the bachelor and master degree in engineering from the Indian Institute of Technology (IIT), Roorkee and University of Seoul respectively. He has published more than 20 papers in peer reviewed journals and has obtained 2 patents. He has presented and given talks at numerous conferences and technical symposiums related to advanced microelectronics packaging.

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Amandine is in charge of the equipment & material fields for the Advanced Packaging & Manufacturing team at Yole Développement. She graduated as an engineer in electronics, with a specialization in semiconductor and nanoelectronic technologies. In the past, she worked for Air Liquide with an emphasis on CVD and ALD processes for semiconductor applications.

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- Definitions, Limitations & Methodology
- Glossary
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- Applications targeted with Panel
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  - Industrial players activity
  - Key R&D players activity
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  - Overview of the players and positioning within the supply chain
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- 2014-2020 Total Market forecast

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- Drivers to switch from wafer to panel for FO WLP
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- Key challenges/unmet needs
- 2014-2020 Market forecast

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- Embedded die players
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• 2014-2020 Market forecast

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REPORT OBJECTIVES (1/2)

• This technology and market report on Panel Manufacturing approaches for certain advanced packages in the semiconductor industry, and is being authored now, because:
  • Growing interest in moving from wafer to panel format for certain advanced packaging platforms in the industry because of potential cost reductions and processing benefits
  • It is a competitive market which is attracting new entrants from supply chains

• The objectives of this report are to:
  • Provide an overview of the panel packages technologies
  • Describe the key applications that could use the panel infrastructure
  • Identify the panel packages solutions and players supporting these packages
  • Identify the current and future industrial players for each packaging technology based on Panel Level
  • Provide market data and forecasts on panel products & equipment market for panel technologies
  • Determine the competitive landscape for each segment
REPORT OBJECTIVES (2/2)

• Additional objectives of this report are to:
  • Assess the market for panel manufacturing, providing a forecast for 2014-2020 in terms of revenue and wafer starts
  • Create a roadmap of the players involved
  • Analyse packages technologies based on the Panel Level and trends
  • Identify trends in overall equipment & materials for panel processing
  • Identify manufacturing challenges related to the panel infrastructure
  • Provide an overview of the technological trends for panel equipment tools and materials solutions

• The following applications, where panel processes are also required, are not included:
  • Display applications
  • Photovoltaic
WHO SHOULD BE INTERESTED IN THIS REPORT?

• **Equipment & material suppliers:**
  - To identify new business opportunities and prospects
  - To understand the differentiated value of your products and technologies in this market
  - To identify technology trends, challenges and precise requirements related to panel infrastructure
  - To evaluate your panel packaging technologies’ market potential
  - To position your company in the market
  - To monitor and benchmark your competitors

• **R&D organizations and investors:**
  - To evaluate the market potential of future technologies and products for new applicative markets
  - To identify the best candidates for technology transfers
  - To monitor global activity and consolidation currently occurring in the semiconductor equipment and materials business in order to identify new partners and targets, and make the right decisions before committing to one particular supplier

• **IDMs, CMOS foundries and OSAT players:**
  - To understand technology trends related to panel packaging platforms
  - To spot new opportunities and define diversification strategies
FROM WAFER SIZE TO PANEL

Semiconductor technologies

- Standard thin film technology equipment
- Line/Space: 2/2 µm for fine pitch

Trade-off between standard wafer size and Panel size

PCB Substrate industry

- Standard PCB equipment & materials
- Line/Space down to 15 µm
- Standard size: large area
  - 24” X 24”/24” X 18”
- Double sided routing

- 24”x24” – HDI PWB
- 18”x24” - HDI PWB
- 16”x20” – PCB substrates
- 10”x14” - flexible PWB
Key platforms identified to be considered as panel level packaging & manufacturing

**SUBSTRATE LESS**
- FOWLP

**ADVANCED SUBSTRATES**
- Silicon Interposer*
- Glass interposer
- Organic Interposer
- Hybrid Interposer
- Embedded interposer

* Si interposer (2.5D) having fine features (<2/2um) for the high end applications will remain in the wafer format. There are some talks in industry to use the low cost polycrystalline silicon in panel format as the interposer. However, the activities on it are very limited. In this report, Si interposer is not covered in detail and we will give the brief overview of the potential and activities of low cost Si interposer to be used in panel format.
MOVING TO PANEL BENEFITS

Moving to panel: higher economies of scale

Moving from wafer to panel format has major cost and productivity advantages due to higher efficiency and economies of scale.
PANEL TECHNOLOGIES

Key packages segments based on panel level integration

Organic interposer

Glass interposer

FO WLP Panel

Hybrid interposer

Embedded die

Panel Packages

5 main available panel technologies for Advanced Packaging
APPLICATION TARGETED BY THE PANEL TECHNOLOGY

Applications targeted depending on the L/S resolution requirement

The applications are driving the segmentation of the RDL technology requested

- 2 µm Line/Space (L/S): FPGA, CPU/GPU, networking, servers
- 8 µm Line/Space (L/S): RF, Power Management module IC, baseband
- 20 µm Line/Space (L/S): Mobile, consumer, Wifi, RF, Transducers

TECHNICAL GAPS BETWEEN THE WAFER AND PCB INFRASTRUCTURES filled by the panel infrastructure

- There is a big gap in terms of technical features between the front-end and Back-end/PCB infrastructures
The panel packaging industry will reach $109M by 2017.

Revenue forecast for panel level packaging (in M$)
(Detailed breakdown includes glass panel interposer, embedded die and FO WLP Panel)

The panel packaging industry will reach $109M by 2017.

Revenue forecast for panel level packaging (in M$)
(Detailed breakdown includes glass panel interposer, embedded die and FO WLP Panel)
RESOLUTION TRENDS (L/S: LINE/SPACE): PACKAGING AREA ROADMAP

Organic panel interposer
Glass panel interposer
FO WLP Panel
Hybrid interposer
Embedded die

10/10 μm
8/8 μm
15/15 μm
25/25 μm


More details in the report

## PLAYERS POSITIONING INVOLVED IN THE PANEL LEVEL INFRASTRUCTURE

<table>
<thead>
<tr>
<th>Business models</th>
<th>Panel Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSATs</td>
<td>Organic interposer, Glass interposer, Hybrid interposer, FOWLP Panel Level, Embedded die</td>
</tr>
<tr>
<td>Substrate makers</td>
<td>Amkor, ASE Group, Deca Technologies, J-DEVICES, Samsung, Unimicron, Daeduck, Kyocera, NOK, NTK, Schott, TAIYO YUDEN</td>
</tr>
<tr>
<td>R&amp;D institute</td>
<td>Fraunhofer, IZM, ITRI, TDK, EPCOS, Infineon, ST, Intel</td>
</tr>
<tr>
<td>IDM</td>
<td>Amkor was actively involved in organic interposer but recently the interest has slowed down</td>
</tr>
</tbody>
</table>
# PANEL MANUFACTURING ADOPTION

Key players pushing the panel manufacturing platform

<table>
<thead>
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<th>Fabless</th>
<th>OSATs</th>
<th>Substrate makers</th>
<th>IDMс</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOWLP on panel</td>
<td>Qualcomm</td>
<td>J-DEVICES</td>
<td>J-DEVICES</td>
<td>AT&amp;S</td>
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<tr>
<td></td>
<td>MediaTek</td>
<td>ASE GROUP</td>
<td></td>
<td>TDK</td>
</tr>
<tr>
<td>Embedded die</td>
<td>Qualcomm</td>
<td>ASE GROUP</td>
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<td></td>
<td></td>
<td>J-DEVICES</td>
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<td>TDK</td>
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<tr>
<td>Glass interposer</td>
<td></td>
<td>triton</td>
<td></td>
<td>Unimicron</td>
</tr>
<tr>
<td>Organic interposer</td>
<td></td>
<td>Amkor Technology</td>
<td></td>
<td>Unimicron</td>
</tr>
<tr>
<td>Hybrid interposer</td>
<td></td>
<td>XILINX</td>
<td></td>
<td>Unimicron</td>
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</table>

OVERVIEW OF EQUIPMENT VENDORS OFFERING TOOLS FOR PANEL PACKAGING

Major competitors for steppers

Major competitors for Scanner & Laser ablation

Major competitors for PVD

Major competitors for Laser Direct Imaging

Major competitors for Plating

Major competitors for Pick & Place

Major competitors for steppers
### Type of equipment available of the market

<table>
<thead>
<tr>
<th>Suppliers</th>
<th>Panel Packages that can be processed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lithography</strong></td>
<td></td>
</tr>
<tr>
<td>RUDOLPH</td>
<td>Glass interposer</td>
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<tr>
<td>orbotech</td>
<td>Organic interposer</td>
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<tr>
<td>SOSS MicroTec</td>
<td>FO WLP</td>
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<tr>
<td>SCREEN</td>
<td></td>
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<tr>
<td>Ushio</td>
<td></td>
</tr>
<tr>
<td><strong>Plating</strong></td>
<td></td>
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<tr>
<td>ATOTECH</td>
<td>Glass interposer</td>
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<tr>
<td>RAMGRABER</td>
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<tr>
<td><strong>PVD</strong></td>
<td></td>
</tr>
<tr>
<td>Tango Systems</td>
<td>Organic interposer</td>
</tr>
<tr>
<td>Systems, Inc.</td>
<td>FO WLP</td>
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</table>
## EQUIPMENT & MATERIALS SUPPLIERS INVOLVED IN THE PANEL INFRASTRUCTURE

### Embedded die

<table>
<thead>
<tr>
<th>Process steps</th>
<th>Equipment</th>
<th>Materials</th>
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<tbody>
<tr>
<td>Cu plating</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>Pattern</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>Cu Etching &amp; Test</td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
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</tbody>
</table>

More details in the report
OUR LATEST REPORTS

Status of the Advanced Packaging Industry: 2015

Coming Soon

Flip Chip

Fan-in WLP Market and Industrial Trends

Coming Soon

Thinning & Dicing

Fan-Out and Embedded Die Technologies & Market Trends

Coming Soon

AlN Thin Film Markets and Applications

Coming Soon

3D Business Update

FIELDS OF EXPERTISE

Yole Développement’s 30 analysts operate in the following areas:

- Imaging
- Photonics
- MEMS & Sensors
- MedTech
- Compound Semi.
- Manufacturing
- LED
- Advanced Packaging
- Power Electronics
- Batteries / Energy Management
4 BUSINESS MODELS

○ Consulting and Analysis
  • Market data & research, marketing analysis
  • Technology analysis
  • Strategy consulting
  • Reverse engineering & costing
  • Patent analysis

○ Financial services
  • M&A (buying and selling)
  • Due diligence
  • Fundraising
  • Maturation of companies
  • IP portfolio management & optimization

○ Reports
  • Market & Technology reports
  • Patent Investigation and patent infringement risk analysis
  • Teardowns & Reverse Costing Analysis
  • Cost Simulation Tool

○ Media
  • i-Micronews.com website
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Patent assessment
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OUR GLOBAL ACTIVITY

40% of our business

30% of our business

30% of our business
SERVING THE ENTIRE SUPPLY CHAIN

- Our analysts provide market analysis, technology evaluation, and business plan along the entire supply chain.

Integrators and end-users

Device makers

Suppliers: material, equipment, OSAT, foundries...

Financial investors, R&D centers
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