Advanced Packaging
Quarterly Market Monitor Q1 2022
Market and Technology Product Brochure
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  o JCET
  o AMKOR
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  o CHINA WLCSP
  o HUATIAN

• Yole Group of companies related reports
• Yole Développement presentation
Gabriela PEREIRA
Gabriela Pereira is a technology and market analyst working in the advanced packaging team within the Semiconductor, Memory and Computing Division at Yole Développement (Yole). Gabriela focuses on advanced packaging platforms. Gabriela’s experience in the semiconductor field includes working at Amkor Technology, first for her master’s thesis and then as a R&D Engineer, where she collaborated on several package development projects. Gabriela holds a master’s degree in Metallurgical and Materials Engineering from the University of Porto, Portugal.

Stefan CHITORAGA
Stefan Chitoraga is a technology and market analyst specializing in packaging and assembly at Yole Développement (Yole). As part of the Semiconductor, Memory and Computing division, Stefan focuses on advanced packaging platforms and processes, substrates, and PCBs. He is involved daily in the production of technology and market reports and custom consulting projects. Stefan holds a bachelor’s in Electronics and Computer Science for Industry Applications from the Polytech Grenoble (France).
Santosh Kumar is currently working as the principal analyst and director of packaging, assembly and substrates for Yole Développement’s activities in Korea. Based in Seoul, Santosh is strongly involved in market, technology and strategic analyses of microelectronic assembly and packaging technologies and presents his vision of the industry at numerous conferences as well as through paper and patent publication. Santosh Kumar received bachelor’s and master’s degrees in engineering from the Indian Institute of Technology (IIT), Roorkee and University of Seoul respectively.

Yik Yee Tan

Yik Yee Tan is a Senior Technology & Market Analyst, Semiconductor Packaging & Assembly at Yole Développement (Yole), within the Semiconductor, Memory & Computing division. Based in Malaysia, Yik Yee follows the semiconductor packaging industry and its evolution. Based on her technical expertise and market knowledge, she develops technology & market reports and is engaged in dedicated custom projects. Prior to Yole, Yik Yee Tan worked as a failure analyst and interconnect principal at Infineon Technologies (Malaysia) and later as an open innovation senior manager at onsemi (Malaysia). While at onsemi, Yik Yee was deeply involved in numerous innovative advanced packaging projects. Yik Yee Tan holds a Ph.D. in Engineering Science from Multimedia University (MMU, Malaysia).
EXECUTIVE SUMMARY

Packaging industry dynamics: 2021 top players revenues
2021 was a great year for Advanced Packaging with ASE continuing to dominate market revenues, followed by Amkor. Intel kept its third position in the ranking, followed by JCET and TSMC. Yole’s quarterly advanced packaging monitor provides a top 30 Outsourced Semiconductor Assembly and Test (OSAT) company ranking for revenues in 2021 and year-on-year (YoY) growth. 2021 had larger YoY revenue growth compared to 2020, with the fastest growing OSATs being mainly Chinese.

The Advanced Packaging (AP) market’s total revenue reached $32.1B in 2021 and is expected to record a 10% Compound Annual Growth Rate (CAGR) reaching $57.2B in 2027. 5G, automotive infotainment/advanced driver assistance systems (ADAS), artificial intelligence (AI), data center and wearable application megatrends continue to move AP forward. In this monitor, quarterly data update on key advanced package types is presented, including Flip Chip Chip Scale Packaging (FCCSP), Flip Chip Ball Grid Array (FCBGA), Wafer Level Chip Scale Packaging (WLCSP)/Fan-In, Fan-Out packages, 3D-stacked packages, and System-in-Package (SiP).

Capital expenditure (capex) highlights – Investments and expansion
In the last two years, the top AP players have invested over one third of the market’s value projected for 2027. Yole’s quarterly advanced packaging monitor tracks the 2022 AP capex ranking, which in total is expected to reach $15B, 26% higher than the previous year. Intel and TSMC remain as the top capex contributors. They keep investing in new advanced packaging sites, mainly for 3D packaging development and hybrid-bonding. Third place is held by ASE, which will keep supporting its strategic alliance with TSMC. Both companies are not competing but rather supporting each other. TSMC assures enough available capacity to avoid competition from Intel, while ASE can secure its dominance as the top OSAT. Yole provides a detailed view on the top players’ investments and strategies. We also analyze hybrid bonding technology’s status, and how will it evolve to a larger production scale in the future.

China’s OSAT ecosystem
It has been noted that the biggest revenue growth in AP is happening inside the Chinese OSAT ecosystem. The Chinese government has been heavily investing as it wants to grow and strengthen regional semiconductor development and supply.
This monitor quarterly update includes a study of the top 10 Chinese OSATs. The top three Chinese OSATs are part of the world’s top 10 OSATs and contributed 85% of the top 10 Chinese OSATs’ revenue in 2021. Chinese OSATs are mainly investing in Advanced Packaging platforms instead of traditional packaging. The top players are especially targeting high-end technologies for the future.

Find more on www.i-micronews.com
WHAT’S NEW

• End-systems updated in all modules.
• FCBGA, FCCSP and UHD FO ASPs were revised and updated to reflect substrate price increase.
• CIS forecast was updated impacting overall 2.5D & 3D forecast.
• 2.5D & 3D Stacked packaging platforms segmentation update.
• UTAC revenue was updated, YoY and the OSAT ranking was updated accordingly.
• More Chinese OSATs were added to the list of main players to get a better understanding of the strengthening of this growing ecosystem.
• Study on top 10 Chinese OSATs was added.
• New commercial products using advanced packaging technology were announced or released.

KEY FEATURES

• Direct access to the analyst providing opportunity for Q&A
• Packaging Industry dynamics highlights & analyst point of view
• Quarterly data update on key advanced package types, including FCCSP, FCBGA, WLCSP/Fan-In, Fan-Out packages, 3D-stacked packages, and SiP
• Market forecast through 2027, in $US, units and wafers
• ASP analysis, per market segment
• End-product/device application mix
• Key process/technology mix
• Supplier market shares (TSMC, Semco, Samsung Electronics, Amkor, JCET, ASE w/SPIL, PTI, Nepes, SPIL, Huatian, TFME, SK Hynix, Sony)
• Demand forecast through 2027, by category (i.e., mobile, consumer, telecom, infrastructure)
• CapEx and capacity, per supplier
COMPANIES CITED IN THIS ANALYSIS*


*Non-exhaustive.
ADVANCED PACKAGING MONITOR - MARKET SEGMENTATION

Market is sized by packaging platforms* for each modules

Fan-Out Packaging -- Module I
- Core FO
- HD FO
- UHD FO
- Multi-die
- IC Substrate

WLCSP Fan-In Packaging -- Module II
- Fan-In

System-in-Package (SiP) -- Module III
- FC + WB
  - Mainly RFs
  - Multi-die
  - IC Substrate
- FC
  - Mainly RFs
  - Multi-die
  - IC Substrate

SiPs are also included in the FO/2.5D/3D/BGA. Not including those in this module to prevent oversizing the market.

FCBGA Packaging -- Module IV
- FC of BGA
  - Multi-die
  - IC Substrate

FCCSP Packaging -- Module V
- FC of CSP
  - Multi-die
  - IC Substrate

2.5D/3D Stacked Packaging -- Module VI
- CIS
- 3D NAND
- 3D SoC
- Embedded Si Bridge
- Active/Passive Si Interposer
- 3DS
- HBM

Packaging platforms*: Assembly, Bumping, RDL, TSV, bonding, integration processing like back grinding, die singulations etc are generally included in market sizing.
IC Substrate is not generally included in market sizing unless stated otherwise.
Die ASP and Final package testing ASP is not included in market sizing.
In 2021 TSMC kept its 5th place in top advanced packaging player revenue ranking and Intel kept its 3rd position. ASE is still dominating the business followed by Amkor.

### Top OSAT Ranking by 2020 Revenue [US$M]

<table>
<thead>
<tr>
<th>Brand Name</th>
<th>2020 Revenue</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASE (w/ SPIL &amp; w/o USI)</td>
<td>9,415</td>
</tr>
<tr>
<td>Amkor</td>
<td>5,051</td>
</tr>
<tr>
<td>Intel</td>
<td>4,200</td>
</tr>
<tr>
<td>JCET Group</td>
<td>4,054</td>
</tr>
<tr>
<td>TSMC</td>
<td>2,500</td>
</tr>
<tr>
<td>Powertech Technology</td>
<td>2,712</td>
</tr>
<tr>
<td>Tianshu Huatian Microelectronics</td>
<td>1,649</td>
</tr>
<tr>
<td>King Yuan Electronics</td>
<td>1,031</td>
</tr>
<tr>
<td>UTAC</td>
<td>864</td>
</tr>
<tr>
<td>ChipMOS Technologies</td>
<td>819</td>
</tr>
<tr>
<td>Chipbond Technology</td>
<td>793</td>
</tr>
<tr>
<td>Hana Micron (w/o Hana Materials)</td>
<td>680</td>
</tr>
<tr>
<td>SFA semicon</td>
<td>527</td>
</tr>
<tr>
<td>Greatek Elec</td>
<td>323</td>
</tr>
<tr>
<td>Orient Semiconductor Electronics</td>
<td>493</td>
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<tr>
<td>Payton Technology</td>
<td>464</td>
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<tr>
<td>Sigurd Microelectronics</td>
<td>442</td>
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<tr>
<td>Carsem</td>
<td>423</td>
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<tr>
<td>LB Semicon Inc</td>
<td>407</td>
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<tr>
<td>AOI Electronics</td>
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<tr>
<td>Tong Hsing</td>
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<tr>
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<tr>
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<tr>
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<tr>
<td>Wafer Level CSP</td>
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<td>Chipmore Technology</td>
<td>168</td>
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<tr>
<td>China Resources Microelectronics</td>
<td>139</td>
</tr>
<tr>
<td>Forehope</td>
<td>115</td>
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</table>

### Top OSAT Ranking by 2021 Revenue [US$M]

<table>
<thead>
<tr>
<th>Brand Name</th>
<th>2021 Revenue</th>
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<tbody>
<tr>
<td>ASE (w/ SPIL &amp; w/o USI)</td>
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<tr>
<td>Intel</td>
<td>5,300</td>
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<td>JCET Group</td>
<td>4,814</td>
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<td>TSMC</td>
<td>4,500</td>
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<td>Powertech Technology</td>
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<tr>
<td>Tianshu Huatian Microelectronics</td>
<td>2,934</td>
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<tr>
<td>King Yuan Electronics</td>
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<tr>
<td>UTAC</td>
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<td>ChipMOS Technologies</td>
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<td>Chipbond Technology</td>
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<tr>
<td>Sigurd Microelectronics</td>
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<tr>
<td>Orient Semiconductor Electronics</td>
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<td>Hana Micron (w/o Hana Materials)</td>
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<td>SFA semicon</td>
<td>837</td>
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<tr>
<td>Carsem</td>
<td>717</td>
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<td>Tong Hsing</td>
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<td>LB Semicon Inc</td>
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<td>Payton Technology</td>
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<td>Formosa Advanced Technologies</td>
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<td>Npees Corporation</td>
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<td>Inari</td>
<td>348</td>
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<td>China Resources Microelectronics</td>
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<td>Forehope</td>
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<td>Walton Advanced Engineering</td>
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<td>Lingsen Precision Industries</td>
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<tr>
<td>Chipmore Technology</td>
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<tr>
<td>Wafer Level CSP</td>
<td>244</td>
</tr>
<tr>
<td>Hana Micron (w/o Hana Materials)</td>
<td>220</td>
</tr>
</tbody>
</table>

### YoY 2021/2020 Growth [%]

<table>
<thead>
<tr>
<th>Brand Name</th>
<th>YoY Growth [%]</th>
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</thead>
<tbody>
<tr>
<td>Forehope</td>
<td>179.3%</td>
</tr>
<tr>
<td>China Resources Microelectronics</td>
<td>144.0%</td>
</tr>
<tr>
<td>UTAC</td>
<td>142.1%</td>
</tr>
<tr>
<td>Tianshu Huatian Microelectronics</td>
<td>108.1%</td>
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<tr>
<td>Tongfu Microelectronics</td>
<td>106.4%</td>
</tr>
<tr>
<td>Lingsen Precision Industries</td>
<td>105.4%</td>
</tr>
<tr>
<td>Inari</td>
<td>104.3%</td>
</tr>
<tr>
<td>Tong Hsing</td>
<td>102.2%</td>
</tr>
<tr>
<td>Sigurd Microelectronics</td>
<td>101.9%</td>
</tr>
<tr>
<td>Greatek Elec</td>
<td>101.0%</td>
</tr>
<tr>
<td>Walton Advanced Engineering</td>
<td>100.2%</td>
</tr>
<tr>
<td>Chipmore Technology</td>
<td>100.0%</td>
</tr>
<tr>
<td>Wafer Level CSP</td>
<td>100.0%</td>
</tr>
<tr>
<td>Intel</td>
<td>96.0%</td>
</tr>
<tr>
<td>TSMC</td>
<td>94.3%</td>
</tr>
<tr>
<td>ArdenteC</td>
<td>92.0%</td>
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<tr>
<td>Chipbond Technology</td>
<td>92.0%</td>
</tr>
<tr>
<td>ASE (w/ SPIL &amp; w/o USI)</td>
<td>91.6%</td>
</tr>
<tr>
<td>Carsem</td>
<td>91.4%</td>
</tr>
<tr>
<td>ChipMOS Technologies</td>
<td>91.3%</td>
</tr>
<tr>
<td>Amkor</td>
<td>90.0%</td>
</tr>
<tr>
<td>JCET Group</td>
<td>89.8%</td>
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<tr>
<td>Orient Semiconductor Electronics</td>
<td>89.7%</td>
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<td>King Yuan Electronics</td>
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<tr>
<td>Unisem Berhad</td>
<td>88.6%</td>
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<tr>
<td>Npees Corporation</td>
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<tr>
<td>Formosa Advanced Technologies</td>
<td>87.9%</td>
</tr>
<tr>
<td>SFA semicon</td>
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<tr>
<td>PB Semicon</td>
<td>85.5%</td>
</tr>
<tr>
<td>Inari</td>
<td>85.5%</td>
</tr>
<tr>
<td>Lingsen Precision Industries</td>
<td>85.4%</td>
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<tr>
<td>China Resources Microelectronics</td>
<td>85.4%</td>
</tr>
<tr>
<td>Forehope</td>
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</tr>
<tr>
<td>Walton Advanced Engineering</td>
<td>85.3%</td>
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<tr>
<td>Lingsen Precision Industries</td>
<td>85.1%</td>
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<tr>
<td>Chipmore Technology</td>
<td>85.0%</td>
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<tr>
<td>Wafer Level CSP</td>
<td>85.0%</td>
</tr>
<tr>
<td>Hana Micron (w/o Hana Materials)</td>
<td>84.9%</td>
</tr>
</tbody>
</table>

In 2021 TSMC kept its 5th place in top advanced packaging player revenue ranking and Intel kept its 3rd position. ASE is still dominating the business followed by Amkor.
TOP 10 CHINESE OSATs REVENUES

- Top 3 China OSATs contributed 85% of the top 10 China OSATs revenue in 2021.
- Top 3 China OSATs are world top 10 OSATs.
- Top 10 China OSAT showing total revenue of $10M, YoY growth of 33%.
- Most of the China OSATs showing significant YoY growth.
- A total of 8 out 10 OSAT concentrated at Yangtze River Delta.
In the last 2 years, top packaging players have invested over one third of the market value. In 2022, advanced packaging Capex is expected to reach $15B, which is 26% higher than previous year and is representing almost 44% of the total advanced packaging revenues for the year. Given the fact that this represents a low margin business for OSATs, there are a few questions to answer:

Will this huge CapEx growth be sustainable in the next few years? Is there enough equipment to sustain these CapEx increase?
2021 CAPEX HIGHLIGHTS FOR ADVANCED PACKAGING PLAYERS

Estimated 2021 CapEx spending for Packaging activity by top players [M US$]

- Intel: $3,500
- TSMC: $3,049
- ASE (w/ SPII): $2,000
- Samsung: $1,500
- Amkor: $780
- JCET: $593
- Tongfu: $487

Estimated 2021 packaging CapEx split (top players)

- Intel: 29%
- TSMC: 26%
- ASE (w/ SPII): 17%
- Samsung: 13%
- Amkor: 6%
- JCET: 5%
- Tongfu: 4%

2021 advanced packaging Capex achieved about $11.9B which represents approximately 38% of total advanced packaging revenues
Advanced Packaging market revenue is expected to grow at 10.11% CAGR, from $32.1B in 2021 to $57.2B by 2027. 5G, automotive infotainment/ADAS, AI, data center and wearable application megatrends continue to move AP forward.
Advanced Packaging form factors are expected to grow at 6.35% CAGR_{2021-2027} with FCCSP and WLCSP leading in terms of total number of units and FCBGA in terms of growth rates.
Total Advanced Packaging 300 mm eq. wafer output is expected to grow at 8.12% CAGR 2021-2027 with FCCSP and FCBGA to take the major share over the next few years and 2.5D/3D growing at the fastest rate.
YOLE GROUP OF COMPANIES RELATED PRODUCTS

Reports

High-End Performance Packaging: 3D/2.5D Integration 2022

Fan-Out WLP and PLP Applications and Technologies 2021

System-in-Package Technology and Market Trends 2021

Status of the Advanced Packaging Industry 2021

Contact us for more information
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Teardown Tracks

Intel Foveros 3D Packaging Technology

YMTC’s 3D-NAND Flash Memory

Apple M1 Max System-on-Chip

Apple M1 Pro System-on-Chip
The Yole Group of Companies, including Yole Développement, System Plus Consulting, and PISEO are pleased to provide you a glimpse of our accumulated knowledge.

Feel free to share our data with your own network, within your presentations, press releases, dedicated articles, and more. But before doing so, contact our Public Relations department to make sure you get up-to-date, licensed materials.

We will be more than happy to give you our latest results and appropriate formats of our approved content.

Your contact: Sandrine Leroy, Dir. Public Relations
Email: leroy@yole.fr
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- Imaging
- Sensing & Actuating
- Display

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- Semiconductor Manufacturing
- Memory
- Computing and Software

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› Reverse costing and reverse engineering

Format
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› Excel files with graphics and data

Topics
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› Lighting & Displays
› Power Electronics & Battery
› Compound Semiconductors
› Semiconductor Manufacturing and Packaging
› Computing & Memory

110+ reports per year

QUARTERLY MONITORS

Insight
› Quarterly updated market data and technology trends in units, value and wafer
› Direct access to the analyst

Format
› Excel files with data
› PDF files with analyses graphs and key facts
› Web access (to be available soon)

Topics
› Advanced Packaging
› Application Processor
› DRAM
› NAND
› Compound Semiconductor
› CMOS Image Sensors
› Smartphones

7 different monitors quarterly updated

WEEKLY TRACKS

Insight
› Teardowns of phones, smart home, wearables and automotive modules and systems
› Bill-of-Materials
› Block diagrams

Format
› Web access
› PDF and Excel files
› High-resolution photos

Topics
› Consumer: Smartphones, smart home, wearables
› Automotive: Infotainment, ADAS, Telematics

175+ teardowns per year

CUSTOM SERVICE

Insight
› Specific and dedicated projects
› Strategic, financial, technical, supply chain, market and other semiconductor-related fields
› Reverse costing and reverse engineering

Format
› PDF files with analyses
› Excel files with graphics and data

Topics
› Photonics, Imaging & Sensing
› Lighting & Displays
› Power Electronics & Battery
› Compound Semiconductors
› Semiconductor Manufacturing and Packaging
› Computing & Memory

190 custom projects per year
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