Dedicated to comprehensive quality and customer support

AMKOR TEST SERVICES
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**AMKOR TESTS A VARIETY OF DEVICES, ACROSS MANY MARKETS**
A HISTORY OF QUALITY

With knowledge gathered from decades of supporting Tier 1 and emerging industry leaders, Amkor understands that test solutions must address advanced technology, quality, performance and cost of test. Through early engagement in each customer’s product lifecycle, Amkor helps define test strategies and intelligent equipment selection to provide differentiated test solutions.

WHO IS AMKOR?

Amkor provides comprehensive test services that complement wafer level and package assembly

Amkor is the #1 RF test services supplier for sub-6 GHz. Amkor has ongoing joint efforts with test equipment suppliers and customers to enable 5G product production testing

We are the #1 OSAT supplier for Automotive and Artificial Intelligence (AI) processor testing

Amkor has a vast array of test capabilities and rich experience in device testing

Markets
  ▶ Automotive & Industrial, Communications, Networking, Computing and Consumer

Applications
  ▶ Analog/Mixed signal, digital, imaging, memory, power/discrete, PMIC, RF, sensors & actuators and SoC(s), including products designed per 3GPP (5G) RF standards

Advanced Packages
  ▶ 2.5/3D, Cavity MEMS, fine pitch Cu pillar, MCM (Multi-Chip Module), advanced SiP, SWIFT®, WLCSP, WLCSP+, WLFO
ACCURATE AND THOROUGH TEST SERVICES
Wafer probe, final test, strip test, film frame test, system level test, opens/shorts test, burn-in and complete end-of-line

24/7
Operation of fully networked test floors

TEST DEVELOPMENT
Software & hardware for probe, strip, final and system level test

TESTING FOR COMMERCIAL, INDUSTRIAL & AUTOMOTIVE DEVICES
Discrete, power, mixed-signal, memory, RF, MEMS and SiP devices

OUR SITES ARE STRATEGICALLY LOCATED
near leading foundries, major customer sites and co-located to support probe with bump/WLCSP and test with assembly

TESTED ANNUALLY
>6 Billion units
>6 Million wafers

LOCATIONS & SERVICES

PORTUGAL
- Wafer probe
- Communication, Memory experience, RF
- WLFO
- UFLEX RF, Rack & Stack, T5XXX
- Test development

SHANGHAI
- Wafer probe/Package test, Film frame test, System level test
- Communication, Memory
- Bumping, FC, CSP, MLF®, PBGA
- 93K, UFLEX, FLEX, J750, Magnum, T5XXX
- Test development

KOREA
- Wafer probe/Package test, Film frame test, System level test
- Automotive, Consumer, Communication
- Bumping, FC, CSP, MLF®, TSV, TMV®, TQFP
- 93K, UFLEX, FLEX, J750, T5XXX, T2K
- Test development

JAPAN
- Wafer probe/Package test
- Automotive, Consumer, Memory
- FC, PBGA, QFN
- 93K, UFLEX, FLEX, J750, T2K, Magnum, T65XX
- Test development

PHILIPPINES
- Wafer probe/Package test, Film frame test, System level test, MEMS test
- Automotive, Consumer, Memory
- MLF®, Leadframe, QFP, Burn-in
- 93K, FLEX, J750, T2K, Magnum, ETS, LTX, D10, ASLX
- Test development

TAIWAN
- Wafer probe/Package test, Film frame test
- Communication, Consumer, Networking
- Bumping, FC, WL CSP
- 93K, UFLEX, FLEX, J750, T2K, ETS, LTX, T6XXX, STS

MALAYSIA
- Package test
- Power, Discrete
- TO-220FP, SO8-FL, TSON8-FL, SONXXX-FL
- TESEC, CATS, ITS, Tsuruga
- Test development

TESEC, CATS, ITS, Tsuruga

>6 Million wafers

Software & hardware for probe, strip, final and system level test

>6 Billion units

Software & hardware for probe, strip, final and system level test

Software & hardware for probe, strip, final and system level test

Software & hardware for probe, strip, final and system level test

Software & hardware for probe, strip, final and system level test
Amkor has an extensive equipment fleet and continues to invest in new capabilities required to test the latest devices.

Primary testers, probers and handlers include:

### TESTERS

<table>
<thead>
<tr>
<th>APPLICATION</th>
<th>MIXED SIGNAL</th>
<th>POWER ANALOG</th>
<th>RF</th>
<th>MEMORY</th>
<th>CIS</th>
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<tbody>
<tr>
<td></td>
<td>A93K (PS400/800), T657X, I-FLEX, J750, SX-37XX</td>
<td>A93K (PS1600), T2000, UFlex, Diamond</td>
<td>A93K (PS1600), ETS88/364, T2000 IPS, UFlex, J750EX/HF</td>
<td>I-FLEX RF, PAX, NI-STS</td>
<td>IP750, T2000iSS</td>
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<td>J750, EVA100</td>
<td>A93K (PS1600), ETS88/364, T2000 IPS, UFlex, J750EX/HF</td>
<td>T537X, T558X, Magnum 1, Magnum 2, Magnum 2x</td>
<td>Magnum VU, Magnum VUx</td>
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TESTERS FOR NAND

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<tr>
<th>Data Transfer Rate (bps)</th>
<th>Tester Model Name/Spec.</th>
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<tbody>
<tr>
<td>16G</td>
<td>PCIe Gen4</td>
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<td>11.6-16.0 Gbps (UFS 3.x)</td>
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<td>8G</td>
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<td>5.8 -8.0 Gbps (UFS 2.x)</td>
<td>PCIe Gen3</td>
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<td>5G</td>
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<tr>
<td>2.9 Gbps (UFS)</td>
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<td>4G</td>
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<td>3G</td>
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<td>1.33 Gbps (Toggle 4.0)</td>
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<td>800M</td>
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<td>800 Mbps (Toggle 3.0)</td>
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<td>500M</td>
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<td>533 Mbps (Toggle 2.0)</td>
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<td>400M</td>
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<td>200 Mbps (Toggle 2.0)</td>
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<tr>
<td>100M</td>
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<tr>
<td>133 Mbps (Toggle 1.0)</td>
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**PROBERS**

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<th>FABRIC</th>
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<td>300 MM WAFER PROBE</td>
<td>±1.5 µm</td>
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<td>*UF3000</td>
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<td>*OPUS3</td>
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<td>±1.5 µm</td>
<td>*UF3000EX</td>
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<td>&lt;1.0 µm</td>
<td>*PRECIO-SP</td>
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<td>200 MM WAFER PROBE</td>
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<td>≥2.0 µm</td>
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<td>FILM FRAME PROBE</td>
<td>≥2.0 µm</td>
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<td>&lt;2.0 µm</td>
<td>**WDF12DP/+</td>
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<td>**FP3000 FD12</td>
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*Tri-Temp option, **Tri-Temp option for FFP
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<tr>
<th>Application</th>
<th>PICK &amp; PLACE</th>
<th>TURRET</th>
<th>GRAVITY</th>
<th>MEMORY</th>
<th>STRIP/FILM FRAME</th>
<th>SLT</th>
<th>SENSOR/ACTUATOR</th>
<th>CUSTOM</th>
<th>TOTAL SOLUTION</th>
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<td>*MT9510</td>
<td>NS70xx</td>
<td><strong>NS80xx</strong></td>
<td>TW152</td>
<td><strong>HT9045</strong></td>
<td>*<strong>ECLIPSE</strong></td>
<td>*<strong>M4871(GS1)</strong></td>
<td>TW153</td>
<td>*<strong>TW154T</strong></td>
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<td><strong>HT9045</strong></td>
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<td><strong>HT9046LS</strong></td>
<td><strong>NX1032XS</strong></td>
<td>*<strong>TW154T</strong></td>
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<td>*SO2000</td>
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<td>STRIP/FILM FRAME</td>
<td>*InStrip</td>
<td>FH1200</td>
<td>SH5000/5300</td>
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<td>SO3000</td>
<td>*Jaguar</td>
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<td>SLT</td>
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<td>TW SL301-N</td>
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<td>Titan/MAGNUS</td>
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<td>SLT</td>
<td>Chroma 3260 (x6)</td>
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<td>SENSOR/ACTUATOR</td>
<td>CUSTOM</td>
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<td>TOTAL SOLUTION</td>
<td>InStrip – accel/Gyro</td>
<td>OSAI (x140) – pressure</td>
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<td>SENSOR/ACTUATOR</td>
<td>PM35 (x8) – microphone</td>
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<td>NX32 (x8) – microphone</td>
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<td>XD248 (x4) – e-compass</td>
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<td>SENSOR/ACTUATOR</td>
<td>NX16 (x1) – Hall sensor</td>
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<tr>
<td>SENSOR/ACTUATOR</td>
<td>PM35 (x8) – humidity/temp</td>
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</table>

*Tri-Temp, **Active Thermal Control (ATC), ***Both
CAPABILITY HIGHLIGHTS

There are many benefits to partnering with Amkor for full turnkey solutions, including wafer processing, advanced bump, wafer probe, assembly, final test, system level test, burn-in and end-of-line services.

WAFER PROBE
- Wafer testing sizes include 8” and 12” with 14, 10, 7 and 5 nm process technologies
- HS Logic, mixed signal, analog, high power (>100A) and RF including NB-IoT & 5G FR1 and FR2 standards
- Multiple probe card technologies: Cantilever (<1 GHz), vertical (up to 40,000 probes), pogo, membrane (>4 GHz), MEMS and dual-level CoW
- Many topologies: Al pad, fine pitch Cu pillar WLCSP, bump and film frame
- 40 µm pitch and 25 x 25 µm² pads/bumps
- Prober capabilities: alignment to ±1 µm and -55°C to +200°C temperature range

PROBE TECHNOLOGY

PROBE TECHNOLOGY

PROBE TECHNOLOGY

FINAL TEST
- Automatic Test Equipment (ATE)
- Singulated up to x16/x32 parallelism
- Massively parallel NAND
- Socket pin technologies for packages supporting 5G RF standards in 24-52, 60 and 77 GHz FR2 frequency bands
- OTA waveguides to support AiP and AoP RF channels
- Digital HS SerDes data rates up to 32 Gbps
- Strip, massively parallel
- Leadframe (x308), saw MLF® film frame, InCarrier

SYSTEM LEVEL TEST
- Synchronous & asynchronous
- Specialized solutions
- SiP – using distributed test flows – 2.5/3D in-situ

BURN-IN
- Development Services
- Automotive (MCC & UniFusion)
- Analog (Shikino Hightech)
- MCU (Shikino Hightech)
- SoC (STK)
- Memory (STK, JEC, AEHR) – Small MLF® strip
- NAND (B6700)
LOWERING THE COST OF TEST

In an effort to lower the cost of test, Amkor also offers massively parallel strip test and full test software and hardware development.

MASSIVELY PARALLEL STRIP TEST

For applications with long test times and lifecycles such as serial EEPROM, microcontrollers, power management and op amps, parallel testing in a strip format is cost effective. By utilizing Amkor’s highest density leadframe (XDLF) process, high parallelism is achieved – up to 300 units per touch down.

TEST DEVELOPMENT ENGINEERING

Some customers develop their own complete test solutions and offload to Amkor for production. Amkor can enable co-development, or full development, of complete test software and hardware solutions. Engage with us early in the product design for maximum impact, or come to us later in the product lifecycle for significant cost savings with migrations to more cost effective testers and/or higher parallelism.

Working collaboratively with customers, Amkor ensures:

▶ Novel low cost
▶ One-stop accountability
▶ Turnkey with bump and assembly

Whether a customer needs to bring up NPI or reduce costs and achieve higher throughput, Amkor offers full service test development and draws upon a large existing tester fleet. New testers are only recommended as a last resort.

TYPICAL TEST DEVELOPMENT CYCLE TIMES

Month 0

Planning

Proposal SOW P.O.

Development

Socket Load Board Interface (3~4+ weeks)

PIB Probe Card (4~8+ weeks)

SW Development

Program Dev. (3~4+ weeks)

Debug (2~3+ weeks)

Corr./Qual. (1+ weeks)

Month 1

Month 2

Month 3

LEAD TIME PER APPLICATION

▶ Logic/Mixed: 6~8 weeks
▶ Analog: 8~10 weeks
▶ RF/MEMS: 12~14 weeks

Note: Development lead time can vary depending on customer test requirements.

TYPICAL PACKAGES

- Std Leadframe
  - TQFP up to 64 lead, 10 x 10 mm²
  - SOIC (mil): N (150), W (300), Std (208) mil
  - TSSOP up to 28 lead (3.0 and 4.4 mm body sizes)
  - PDIP up to 8 lead
  - LGA 12 x 12 mm²

- Film Frame
  - Saw MLF® up to 7 x 7 mm²

- InCarrier
  - Saw MLF® (including various sensors/actuators (MEMS))
AUTOMOTIVE & INDUSTRIAL

Amkor is the number one automotive OSAT, supporting major Asian, US and European supply chains. Products in this area include infotainment and safety requiring high levels of performance. This requires a much more comprehensive set of test requirements.

▶ High-quality, standards-compliant processes and systems
▶ Added inspections and tri-temperature multi-temperature test capabilities
  ▶ Wafer probe at -55°C to +200°C
  ▶ Final test at -55°C to +175°C
  ▶ Burn-in
  ▶ System Level Test (SLT)
▶ Leverage cold wafer probe and perform only room and hot temperature final test
▶ Supplement post assembly final (functional) test with outgoing post assembly opens/shorts testing, includes 2 and 4 wire resistance tests

CURRENT SOLUTIONS

▶ Large body SiP (Infotainment) using tri-temperature system level test
▶ ABS & Electronic Control Unit (ECU) test (MLF®, QFP)
▶ ADAS test (FCBGA)
▶ IoT (MCU, RF & sensors/actuators)
▶ Specialized test for electric vehicle components – inverters, converters

IN DEVELOPMENT

▶ mmWave radar component test – wafer & die-level
▶ Autonomous driving (Collision warning, Parking assist, Blind spot detection)
▶ Solutions for LIDAR
▶ AEC-Q100 grade zero compliant burn-in solutions
COMMUNICATIONS

More than 35% of Amkor’s revenue is derived from Communications (smartphones, tablets, handhelds and wearable devices). Our leading edge test solutions keep pace with rapid changes in cellular and connectivity technology requirements. Amkor is already well positioned for 5G wireless and its new test requirements – working with leading customers and ATE suppliers, we have 5G RF test capability in place.

▶ Leverage RF wafer probe capabilities – known good die (KGD) for WLCSP and known tested die (KTD) for SiP
▶ Multi-site x8 RF test to lower cost
▶ Augment ATE coverage with SLT (protocol test)
▶ Address complex SiP with simple SLT, including RF callbox testing
▶ SoC + Memory PoP – double side test/stack CSP – memory and logic test
▶ Advanced ATE w/32 port and multi-site, multi-channel Tx & Rx support
▶ Local RF shielding ≤60 dBm
▶ Front-end RF, SiP and IoT
▶ Asynchronous test for different RF connectivity standards
▶ Single and multiple channel beam forming, phased array, AiP/AoP support

CURRENT SOLUTIONS

▶ Memory interface test through logic or modem die
▶ DRAM test at system level test and memory fuse blow through logic die
▶ Top/bottom socket with 0.3 & 0.35 mm pitch respectively
▶ LTE-A, WLAN, Bluetooth, GPS, Zigbee
▶ RF Front-end (Antenna, switch, filter, PA, LNA)
▶ Transceiver, connectivity (Bluetooth, Zigbee, WLAN, 802.11ac, 802.11ax & 802.11be (future), GPS
▶ 5G FR1 wide-bandwidth test solutions
▶ RF MEMS, Passive-On-Glass (POG)
▶ Limited Ultra-Wide Band (UWB) test support. Improved capabilities are planned for the future
▶ Fine pitch TMV®/IP PoP
▶ Mobile AP & BB PoP
▶ Mobile modem & memory stack CSP
Amkor is a leading provider of high performance test solutions for the demanding networking and computing market – where five nines (99.999%) or higher uptime is expected. We have multiple customers supplying SiP(s), SoC(s) and components into these markets (servers, routers, switches, PCs, laptops and peripherals). Integral to these markets are storage technology and migrations from hard disk drives to solid state drives (SSD). In addition, Amkor has a strong array of NAND test capabilities.

- Distributed test (wafer probe, in-situ test between key assembly steps and final test (SLT and ATE) for 2.5D)
- Active thermal control for 300 watt products across tri-temperature in SLT and ATE test
- Probe solutions and wafer map management for chip on wafer (CoW)
- Dynamic burn-in
- Test during burn-in (TDBI)
- Film frame and strip test (x308 EEPROM)
- High-speed serial digital (e.g. PCIe Gen4, Gen5) testing up to 16 Gbps and 32 Gbps

MEMORY TEST TECHNOLOGIES
POWER/DISCRETES

Amkor is a world leader in power discrete devices, with test services that are closely integrated with assembly flow for shorter cycle times and reduced costs. Unique requirements include:

- High current, high voltage
- Adequate thermal capacity
- Kelvin contact-type tests
- Low Rds_on

HIGH-VOLUME PRODUCTS AT AMKOR INCLUDE:

- Intelligent power modules
- Multi-voltage FETs
- Flip chip MOSFETs
- Insulated-Gate Bipolar Transistors (IGBT)
- Diodes
- Regulators and bipolar transistors for automotive, power transmission and industrial segments

TEST EQUIPMENT OFFERINGS

<table>
<thead>
<tr>
<th>COMPANY</th>
<th>MODEL</th>
<th>TEST ITEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tesec</td>
<td>881-TT, 351-TT, 341-TT</td>
<td>DC</td>
</tr>
<tr>
<td>ERD</td>
<td>CMS-100S8 Series</td>
<td>Rg DC</td>
</tr>
<tr>
<td></td>
<td>VS240AN, DTS-241</td>
<td></td>
</tr>
<tr>
<td>Hokuto</td>
<td>AT-999 Series AM-083</td>
<td>VDSX (SUS)/VCEX (SUS)/trr trr/Vsurge</td>
</tr>
<tr>
<td>CATS</td>
<td>DV-240 Series</td>
<td>ΔVDS/ΔVBE</td>
</tr>
<tr>
<td>Minekoon</td>
<td>615-SW</td>
<td>Switching test (trr/rr/t off/t on/l Latch)</td>
</tr>
<tr>
<td>ITC</td>
<td>ITC55100C</td>
<td>UIS</td>
</tr>
<tr>
<td>Shibasoku</td>
<td>WL-22, WL-25</td>
<td>IC</td>
</tr>
<tr>
<td>Power Tech</td>
<td>QT-4100 Series QT101 Series</td>
<td>DC UIS</td>
</tr>
<tr>
<td>POWorld</td>
<td>VC6700</td>
<td>Transient test</td>
</tr>
</tbody>
</table>

HANDLERS MANUFACTURER

<table>
<thead>
<tr>
<th>Gravity</th>
<th>TESEC</th>
<th>Ueno Seiki</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turret</td>
<td>Sowa</td>
<td>KES SRM</td>
</tr>
</tbody>
</table>
SENSORS & ACTUATORS (MEMS)

Products for today’s Internet of Things (IoT) require an MCU, RF transmitter/receiver, sensors and actuators. The test solution needs to cover conversion of physical real-world analog signals into electrical data and processing of the data to determine if the product is good or not.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>TEST APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetometer</td>
<td>3-Axis, 0 to 10 gauss, 0.1 accuracy</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>3-Axis, Low-g, High-g, Strip test</td>
</tr>
<tr>
<td>Gyroscope</td>
<td>3-Axis yaw rate, Gyroscope test</td>
</tr>
<tr>
<td>Microphone</td>
<td>Sound stimulus for both top-port/bottom-port</td>
</tr>
<tr>
<td>Pressure</td>
<td>0 to 20 bar, Strip test, Bench characterization</td>
</tr>
<tr>
<td>Inertial Combos</td>
<td>6-10 Degrees of Freedom (DoF)</td>
</tr>
<tr>
<td>Optical</td>
<td>Auto-focus, Microdisplay, Picoprojectors</td>
</tr>
<tr>
<td>RF Devices</td>
<td>Timing devices, Switch/Varicaps, BFilters, Duplexers</td>
</tr>
<tr>
<td>Emerging MEMS</td>
<td>Energy harvesting, Microfluidics, Ultrasonic gesture recognition</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>PARALLELISM</th>
<th>CURRENT SPECIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inertial</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetometer</td>
<td>x4</td>
<td>10 Gauss</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>x72</td>
<td>X, Y or Z/20g Z/X/Low-g</td>
</tr>
<tr>
<td>Gyroscope</td>
<td>x72</td>
<td>90/sec. 6 DoF, 9 DoF</td>
</tr>
<tr>
<td>RF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oscillator/Filter</td>
<td>x8</td>
<td>&lt;6 GHz, jitter ~300 fs</td>
</tr>
<tr>
<td>Switch</td>
<td>x8</td>
<td>&lt;6 GHz, IL -0.5 dB, isolation -30 dB</td>
</tr>
<tr>
<td>Optic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR</td>
<td>x32</td>
<td>Regions UV-A to UV-B</td>
</tr>
<tr>
<td>RGB + UV</td>
<td>x32</td>
<td>Up to 600 nm wavelength</td>
</tr>
<tr>
<td>Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microphone</td>
<td>x35</td>
<td>SNR 70 dB, THD 130 dB</td>
</tr>
<tr>
<td>Humidity/Temperature</td>
<td>x8</td>
<td>±1% RH</td>
</tr>
<tr>
<td>Pressure/Temperature</td>
<td>x140</td>
<td>±1.5°C±500 hPa</td>
</tr>
<tr>
<td>Gas</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Ultrasonic</td>
<td>x4</td>
<td>300 mm range</td>
</tr>
</tbody>
</table>
OTHER TEST SERVICES AND PROCESSES

FULL END-OF-LINE PROCESSING

▶ Bake
▶ Scan
▶ Pack
▶ Ship
▶ Finished good services

ROBUST FACTORY AUTOMATION (CIM/CAM)

▶ High levels of quality and efficiency
▶ RFID and hardware control
▶ Auto test program loading
▶ Utilization monitor
▶ Yield monitor
▶ Data analysis
▶ Report automation

OPERATIONAL EXPERIENCE

▶ Fully automated production environments
▶ Fast and accurate operation by skilled operator and system

TECHNICAL SUPPORT

▶ Advanced solution for advanced package (PoP/TSV/FCSP/FCBGA)
▶ High quality advanced equipment and quick technical support

EQUIPMENT CAPACITY

▶ Full range of services: Laser mark/FVI/bake/tape & reel/dry-pack
▶ Various material suppliers for tape & reel and packing

EXTENSIVE FAILURE ANALYSIS

Non-Destructive Analysis

▶ E/L Bench test
▶ X-ray
▶ Scanning acoustic tomograph

Destructive Analysis

▶ Decapsulation
▶ Grinder: X-section
▶ Microscope
▶ Field emission scanning electron microscope

Die-Level Analysis

▶ Photo emission and OBIRCH
▶ Thermal emission

GLOSSARY

ABS: Anti-lock Braking System
ADAS: Advanced Driver-Assistance Systems
ATE: Automatic Test Equipment
CoW: Chip on Wafer
CSP: Chip Scale Packaging
EEPROM: Electrically Erasable Programmable Read-Only Memory
GPS: Global Positioning System
LIDAR: Light Detection and Ranging
LNA: Low Noise Amplifier
MCP: Multi-Chip Packaging
NAND: Non-volatile storage memory
PMIC: Power Management Integrated Circuit
SiP: System in Package
SLT: System Level Test
SoC: System on Chip
UFS: Universal Flash Storage
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