Dedicated to comprehensive
quality and customer support

Amkor Technology®

# AMKOR TEST SERVICES

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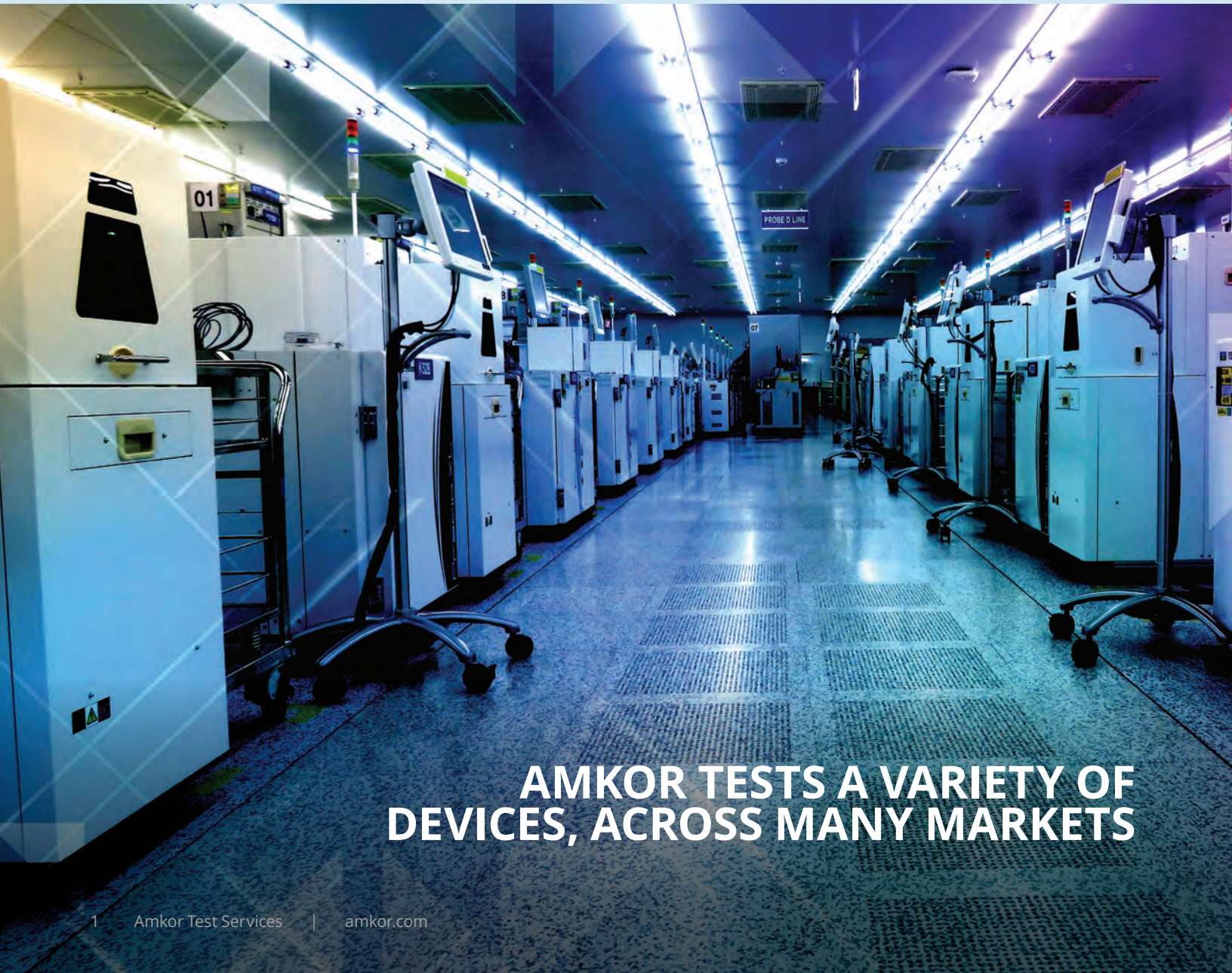



## AMKOR TESTS A VARIETY OF DEVICES, ACROSS MANY MARKETS

# 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 continues to be #1 RF test services supplier for sub-6 GHz. Amkor continues to add 5G product production testing for sub-8 GHz and mmWave frequency bands

We are the #1 OSAT supplier for Automotive

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

### Markets

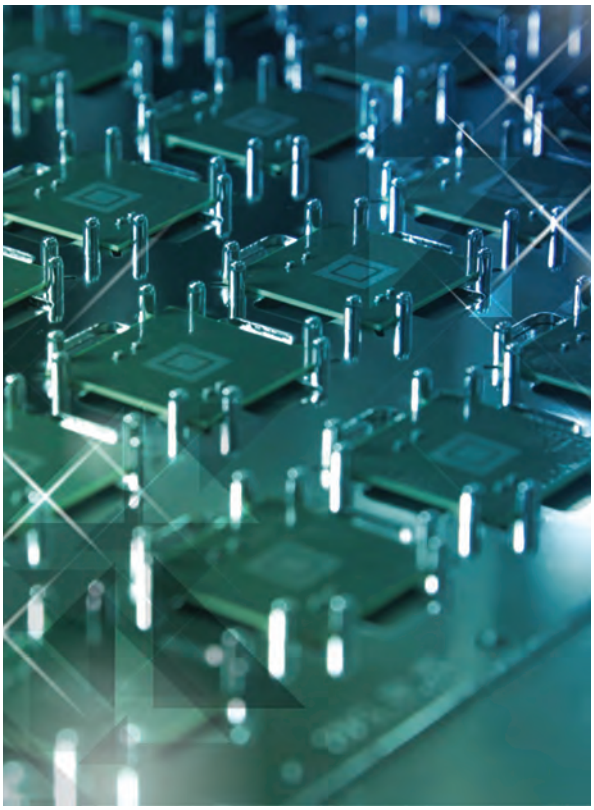
- Automotive & Industrial, Communications, Networking, Computing and Consumer

### 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

- 2.5D & 3D Chiplet, Cavity MEMS, 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

Full end-of-line processing: bake, scan, pack, ship and finished good services

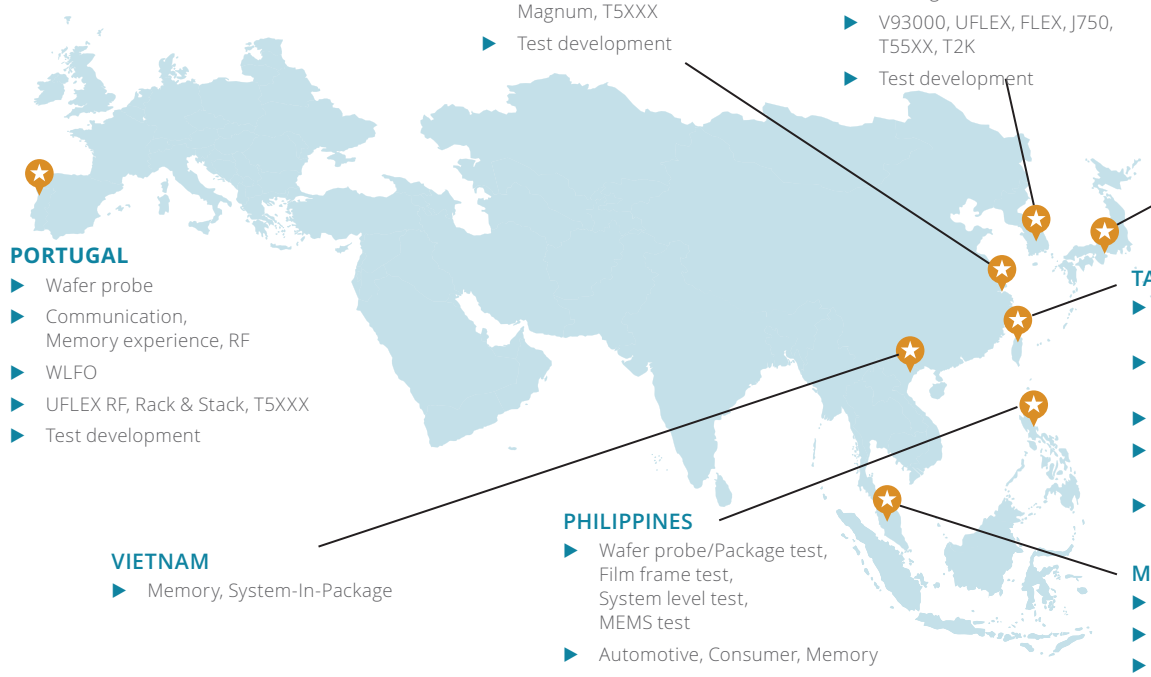
**TESTED ANNUALLY**
**>6.9** Billion units
**>1.0** Million wafers

**TEST DEVELOPMENT**
Software & hardware for probe, strip, burn in, final test 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

# LOCATIONS & SERVICES



### SHANGHAI
- Wafer probe/Package test, Film frame test, System level test
- Communication, Memory
- Bumping, FC, CSP, MLF®, PBGA
- V93000, 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, 2.5D & 3D Chiplet Packages
- V93000, UFLEX, FLEX, J750, T55XX, T2K
- Test development

### JAPAN
- Wafer probe/Package test
- Automotive, Consumer, Memory
- FC, PBGA, QFN
- V93000, UFLEX, FLEX, J750, T2K, Magnum, T65XX
- Test development

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

### TAIWAN
- Wafer probe/Package test, Film frame test
- Communication, Consumer, Networking
- Bumping, FC, WLCSP
- V93000, UFLEX, FLEX, J750, T2K, ETS, LTX, T6XXX, STS
- Test development

### VIETNAM
- Memory, System-In-Package

### PHILIPPINES
- Wafer probe/Package test, Film frame test, System level test, MEMS test
- Automotive, Consumer, Memory
- MLF®, Leadframe, QFP, Burn-in
- V93000, FLEX, J750, T2K, Magnum, ETS, LTX, D10, ASLX, Microtest
- Test development

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

# TEST SERVICES

Amkor has an extensive equipment fleet and continues to invest in new capabilities required to test the latest devices.

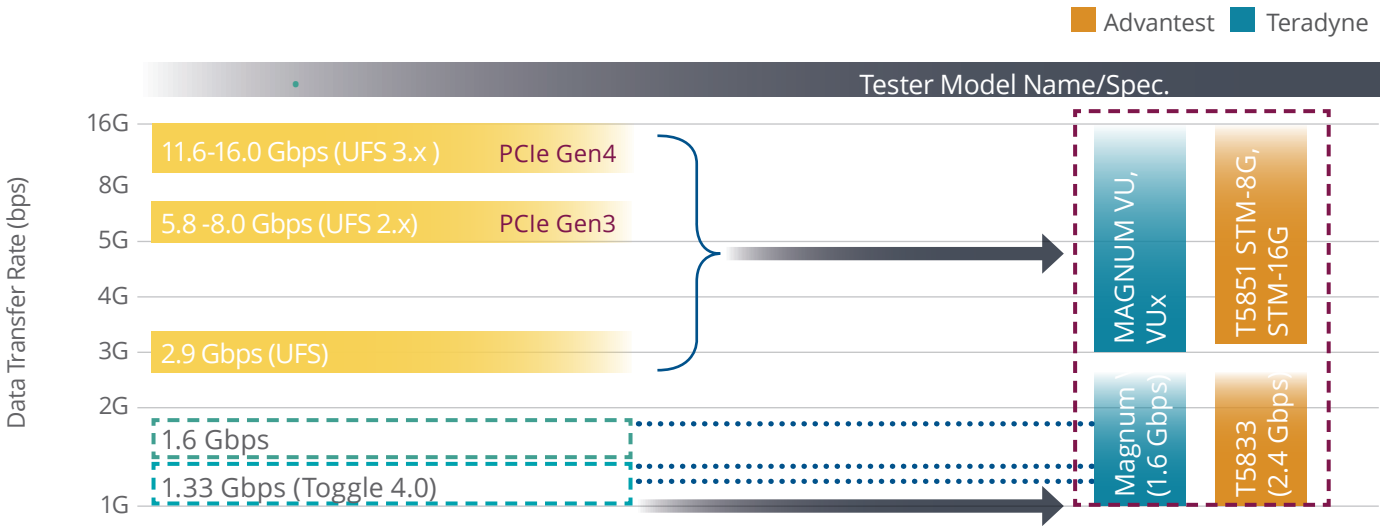
Primary testers, probers and handlers include:


## TESTERS

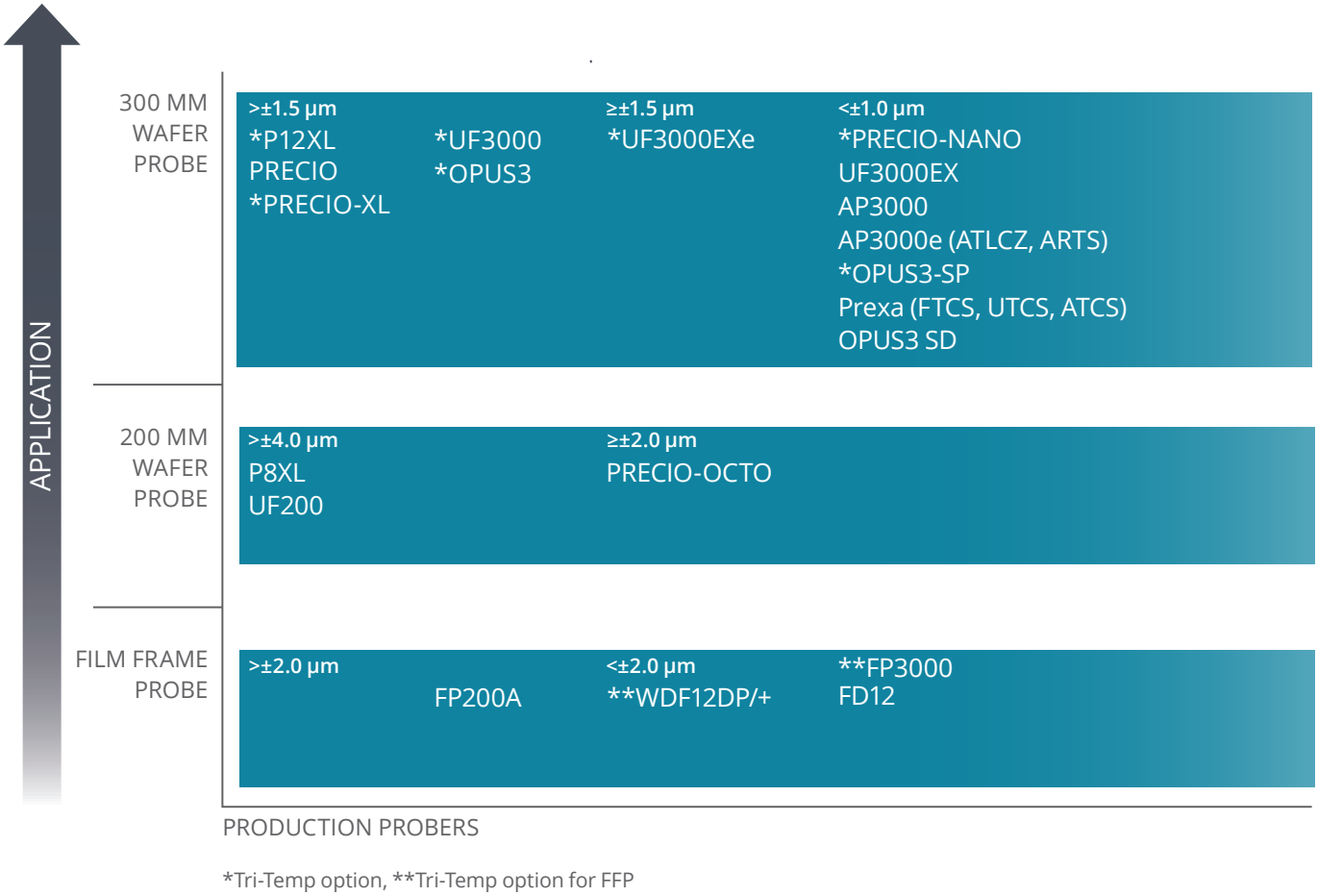
APPLICATION

| | PRODUCTION TESTERS | | |
|---|---|---|---|
| MIXED SIGNAL | V93000 (PS400/800), T657X, I-FLEX, J750, SX-37XX | V93000 SmartScale (PS1600), T2000, UFLEX, Diamond | Chroma 3650<br>DMDx (VI100)<br>V93000 EXAScale (PS5000, XPS256), UltraFLEXplus (UP2200, UltraVS256) |
| POWER ANALOG | J750, EVA100 | V93000 SmartScale (PS1600), ETS88/364, T2000 IPS, UFLEX, J750EX/HD | DMDx (VI100)<br>ETS800 |
| RF | I-FLEX RF, PAX, NI-STS | V93000 SmartScale (PS1600, PS-RF), UFLEX, (UW-12G/24G), V93000 (PS1600, WS-RF), PAx & DMDx (DragonRF) | V93000 (WS-RF MX53 mmWave), UFlex-RF (MX20, MX44, MX53), PAx (RedDragon-RF mmWave), NI-STS (PXIe-5831 mmWave) |
| MEMORY | **T537X, T558X, Magnum 1, Magnum 2, Magnum 2x** | **Magnum V, VU, VUx<br>T5832 (Scalable to 2.8 Gbps)<br>T5851** | **Magnum VUy, Magnum HSN, Litepoint IQXel Integrated in SLT handlers, T5832, T5835 (Scalable to 3.2 Gbps)** |
| CIS | | IP750, T2000ISS | |

## TESTERS FOR NAND

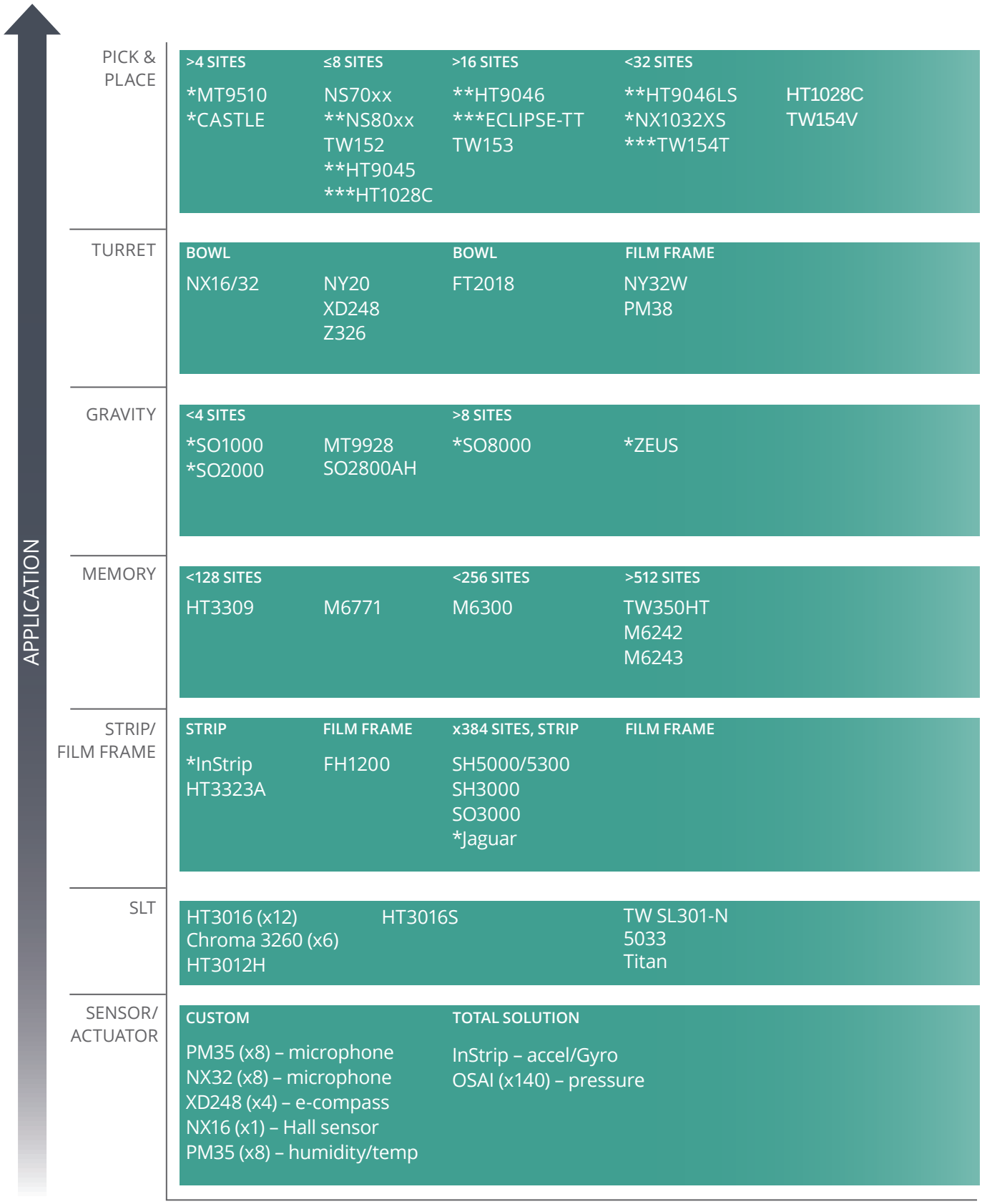



## PROBERS




*Tri-Temp option, **Tri-Temp option for FFP

## HANDLERS




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

# CAPABILITY HIGHLIGHTS

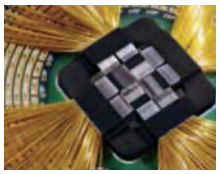
There are many benefits to partnering with Amkor for full turnkey solutions, including wafer processing, advanced bump, wafer probe, assembly, final test, system level test, burn-in and end-of-line services.

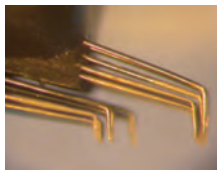
## WAFER PROBE

- Wafer testing sizes include 8” and 12” with 7, 5, 3, 2nm 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
- Multiple topologies: Al pad, fine pitch Cu pillar WLCSP, bump and film frame
- 40 µm pitch and 25 x 25 µm$^2$ pads/bumps, including sacrificial pads
- Prober capabilities: alignment to <±1 µm and -55°C to +200°C temperature range

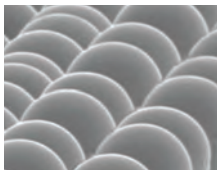
## PROBE TECHNOLOGY

Cantilever

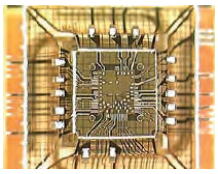




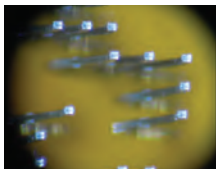
Cu Pillar Bump

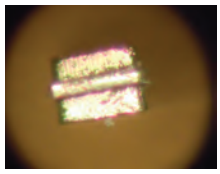


Membrane



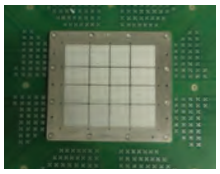
MEMS





CSP


Pogo Pin



## 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
- HPC (MCC)
- Automotive (MCC)
- 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.

| ASSEMBLY FORMAT | PACKAGES |
|---|---|
| **Std Leadframe** | ▶ TQFP up to 64 lead, 10 x 10 $mm^2$<br>▶ SOIC (mil): N (150), W (300), Std (208)<br>▶ TSSOP up to 28 lead (3.0 and 4.4 mm body sizes)<br>▶ PDIP up to 8 lead<br>▶ LGA 12 x 12 $mm^2$ |
| **Film Frame** | ▶ Saw MLF® up to 7 x 7 $mm^2$ |
| **InCarrier** | ▶ Saw MLF® (including various sensors/actuators (MEMS)) |

## TEST DEVELOPMENT ENGINEERING

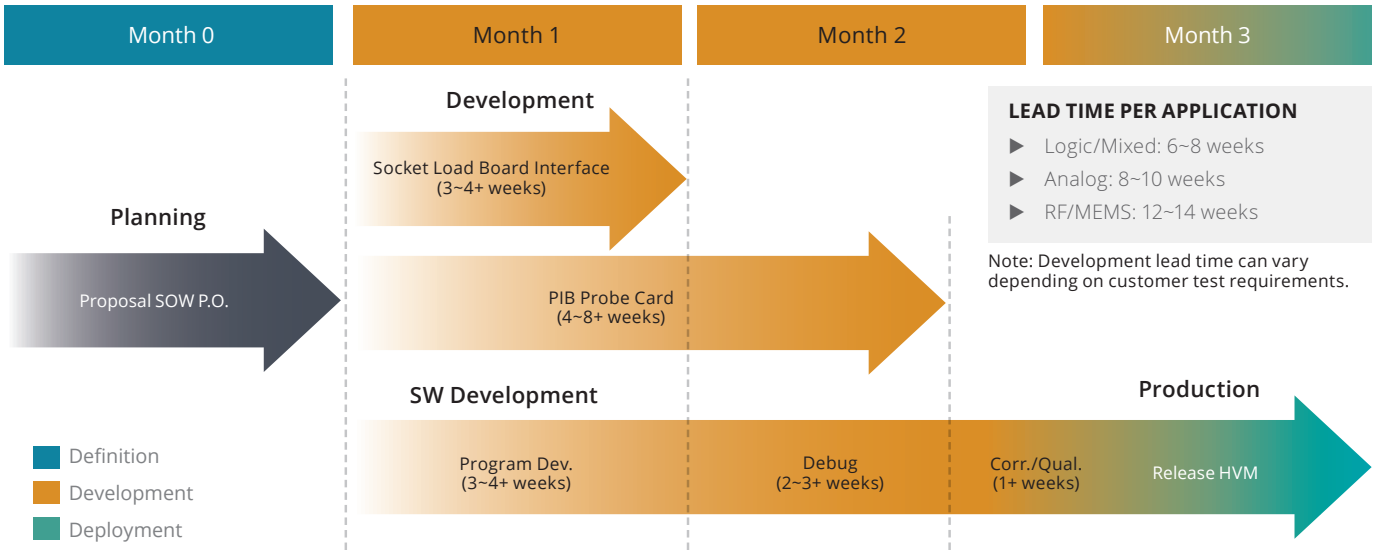
Some customers develop their own complete test solutions and offload to Amkor for production. Amkor can enable co-development, or full development, of complete test software and hardware solutions. Engage with us early in the product design for maximum impact, or come to us later in the product lifecycle 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



# DIFFERENTIATED TEST BY MARKET

## 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
- 5G NR conductive test for both FR1 and FR2 frequency ranges
- 6G is expected to require FR3 range of operation
- 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 802.11bn (WiFi8), 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

## ARTIFICIAL INTELLIGENCE (AI), NETWORKING & HIGH PERFORMANCE COMPUTE

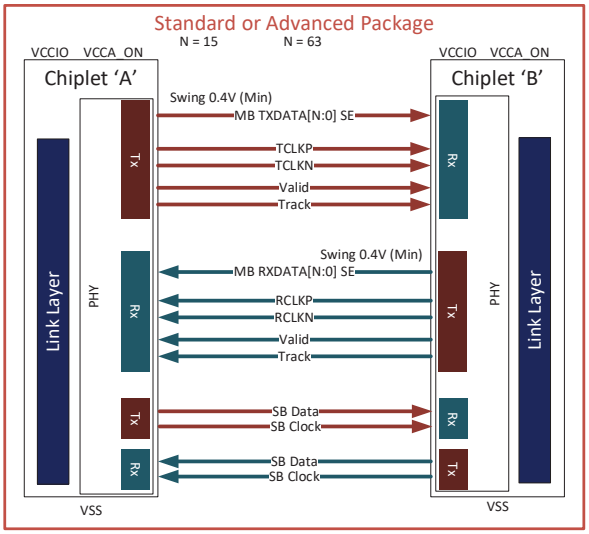
Amkor is a leading provider of high performance test solutions for the demanding networking and computing market – where five nines (99.999%) or higher uptime is expected. We have multiple customers supplying SiP(s), SoC(s) and components into these markets (servers, routers, switches, PCs, laptops and 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
- Silicon photonics ICs
- 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

### CURRENT SOLUTIONS

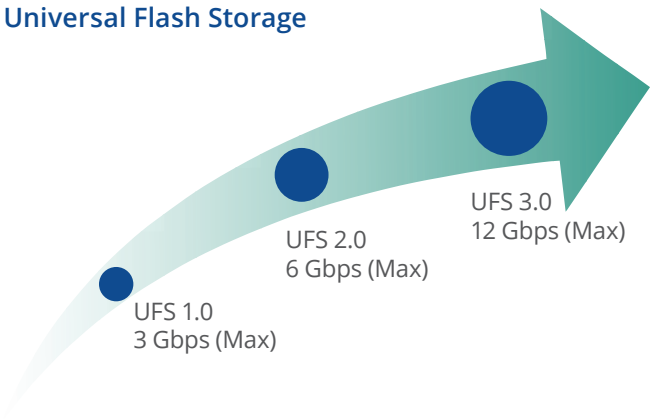
- >2 TB bandwidth in package
- High performance >3 GHz DDR4, DDR5, High bandwidth memory interfaces, including graphics
- Memory interface test through logic die
- UFS Protocol system level test
- PoP, MCP
- eMMC (NAND + Controller), MCP (SDRAM + NAND)
- MicroSD, SSD, UFS

### Universal Chiplet Interconnect Express UCIe™: 2.5D Chiplet Package Test



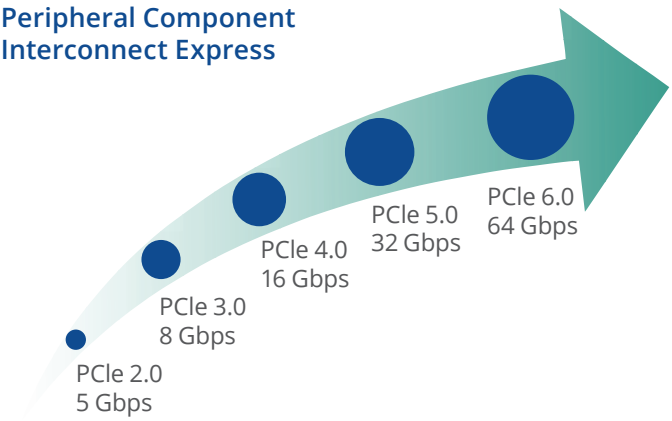

## HIGH DATA RATE TEST TECHNOLOGIES

### Universal Flash Storage




**Magnum (Scalable)**
**T5xxx (Scalable)**

### Peripheral Component Interconnect Express




**V93000 ExaScale, SmartScale, UltraFLEX$^{plus}$ UltraPin**

## POWER/DISCRETES

Amkor is a 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:

- SiC, GaN module test
- 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

| COMPANY | MODEL | TEST ITEM |
|---|---|---|
| Tesec | 881-TT, 351-TT, 341-TT | DC |
| ERD | CMS-100S8 Series<br>VS240AN, DTS-241 | Rg<br>DC |
| Hokuto | AT-999 Series<br>AM-083 | VDSX (SUS)/VCEX (SUS)/trr<br>trr/Vsurge |
| CATS | DV-240 Series | ΔVDS/ΔVBE |
| Minekoon | 615-SW | Switching test<br>(trr/I rr/t off/t on/I Latch) |
| ITC | ITC55100C | UIS |
| Shibasoku | WL-22, WL-25 | IC |
| Power Tech | QT-4100 Series<br>QT3101 Series | DC<br>UIS |
| POWorld | VC6700 | Transient test |

| HANDLERS | MANUFACTURER |
|---|---|
| Gravity | TESEC<br>Ueno Seiki |
| Turret | Sowa<br>KES<br>SRM |

## 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.

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

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

# OTHER TEST SERVICES AND PROCESSES

## FULL END-OF-LINE PROCESSING

- Bake
- Scan
- Pack
- Ship
- Finished good services

### OPERATIONAL EXPERIENCE

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

### TECHNICAL SUPPORT

- Advanced solution for advanced package (PoP/TSV/fcCSP/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

## 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
OBIRCH: Optical Beam Induced Resistance Change
PMIC: Power Management Integrated Circuit
SiP: System in Package
SLT: System Level Test
SoC: System on Chip
UFS: Universal Flash Storage

## 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

## EXTENSIVE FAILURE ANALYSIS

### Non-Destructive Analysis

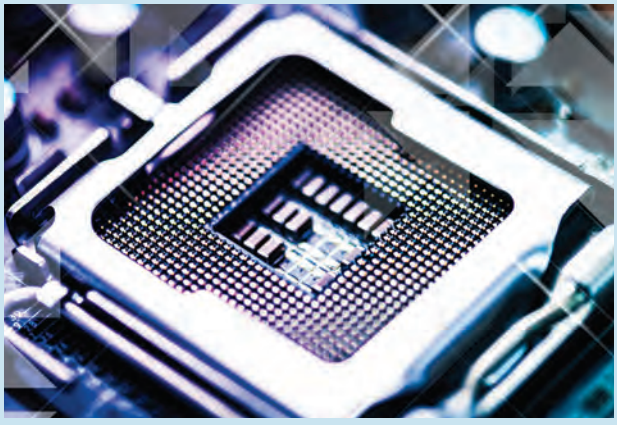
- E/L Bench test
- X-ray
- Scanning acoustic tomograph

### Destructive Analysis

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

### Die-Level Analysis

- Photo emission and OBIRCH
- Thermal emission



VISIT AMKOR TECHNOLOGY ONLINE FOR LOCATIONS AND TO VIEW CURRENT PRODUCT INFORMATION

Product info: **amkor.com** Questions? Contact us: **sales@amkor.com**



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