

Dedicated to comprehensive
quality and customer support

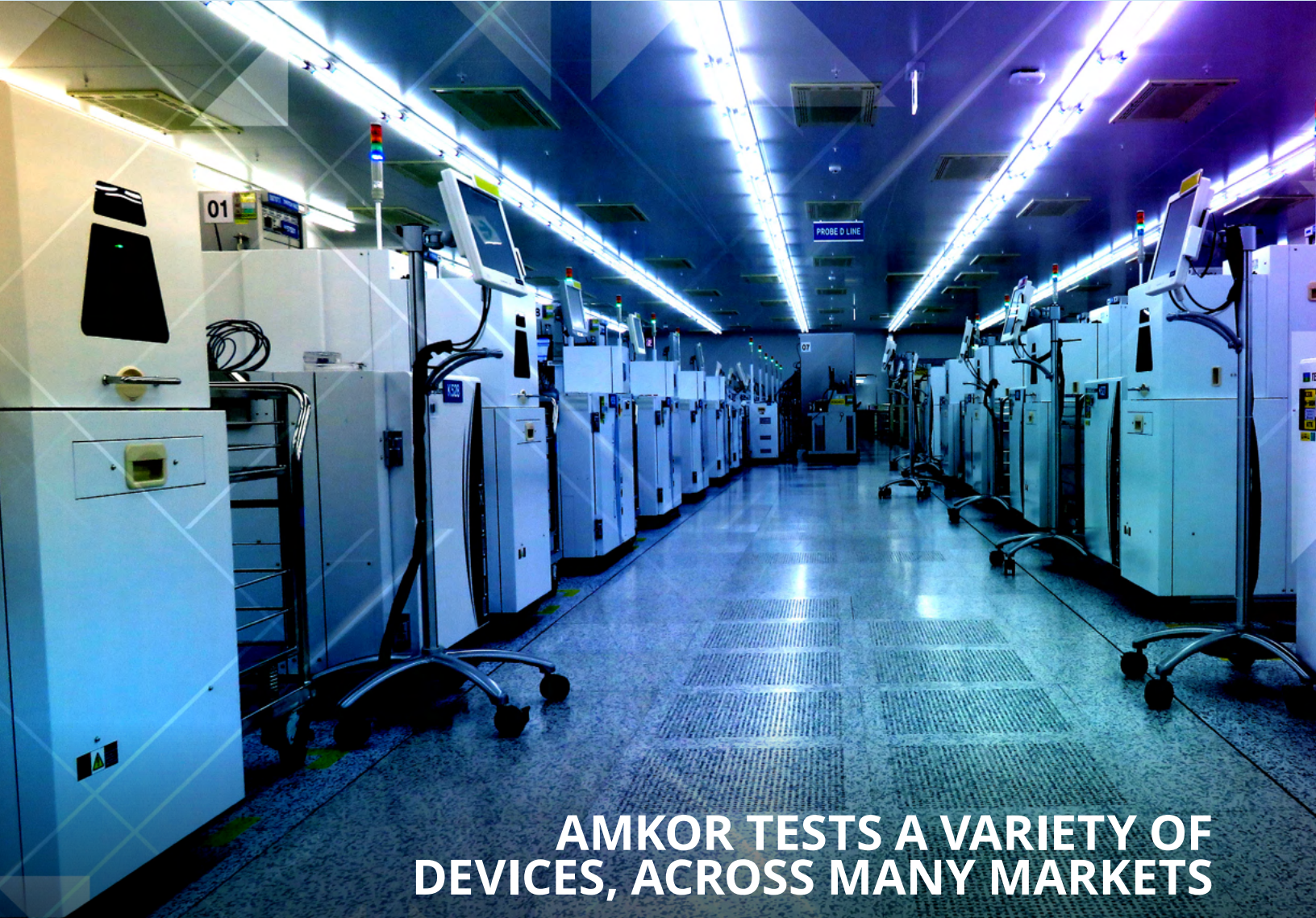


AMKOR TEST SERVICES



TABLE OF CONTENTS

- A HISTORY OF QUALITY 2
- LOCATIONS & SERVICES 3
- TEST SERVICES 4
- CAPABILITY HIGHLIGHTS 7
- LOWERING THE COST OF TEST 8
- DIFFERENTIATED TEST BY MARKET 9
- OTHER TEST SERVICES AND PROCESSES 14



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



Operation of fully networked test floors



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

TESTED ANNUALLY



>9 Billion units



>1.8 Million wafers

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

LOCATIONS & SERVICES



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:

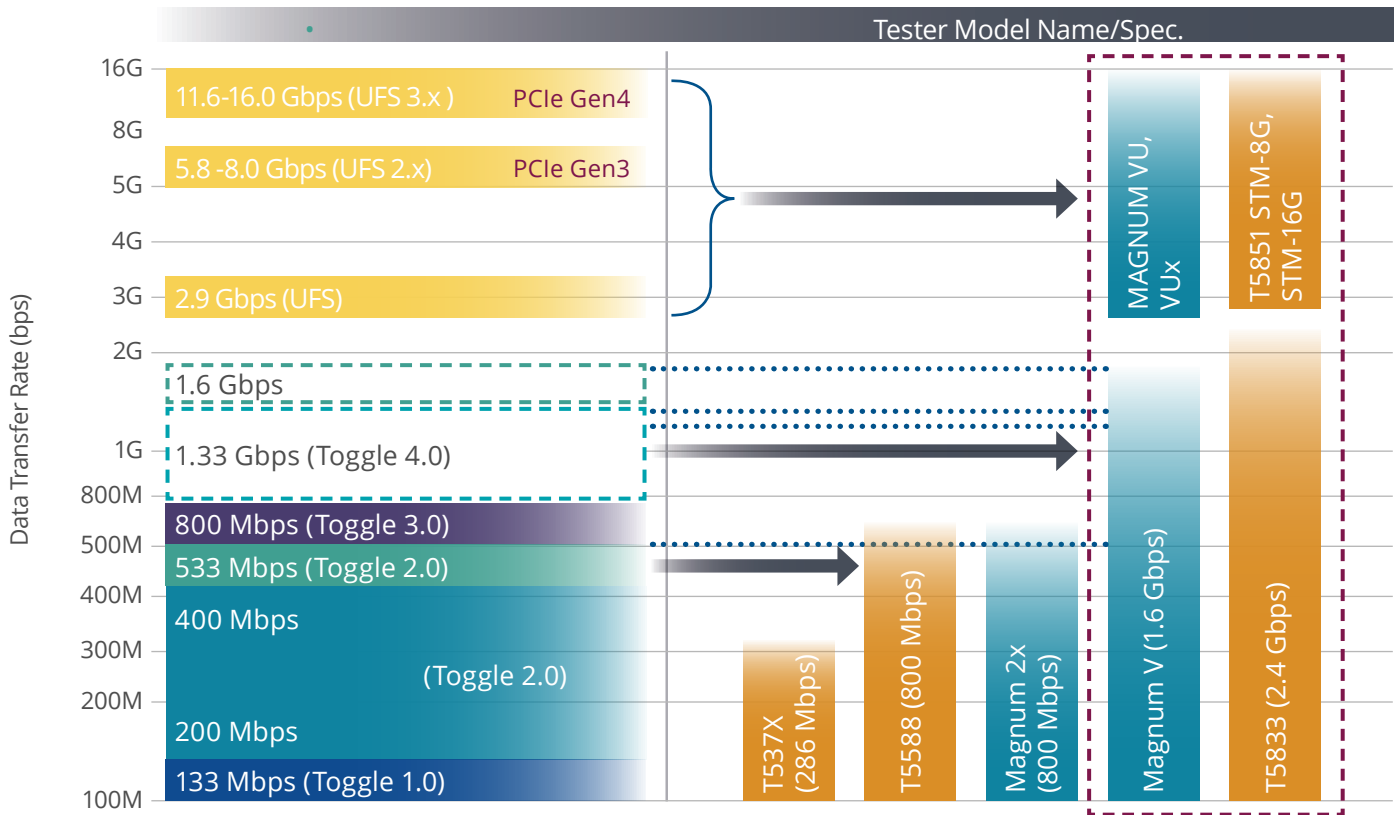


TESTERS

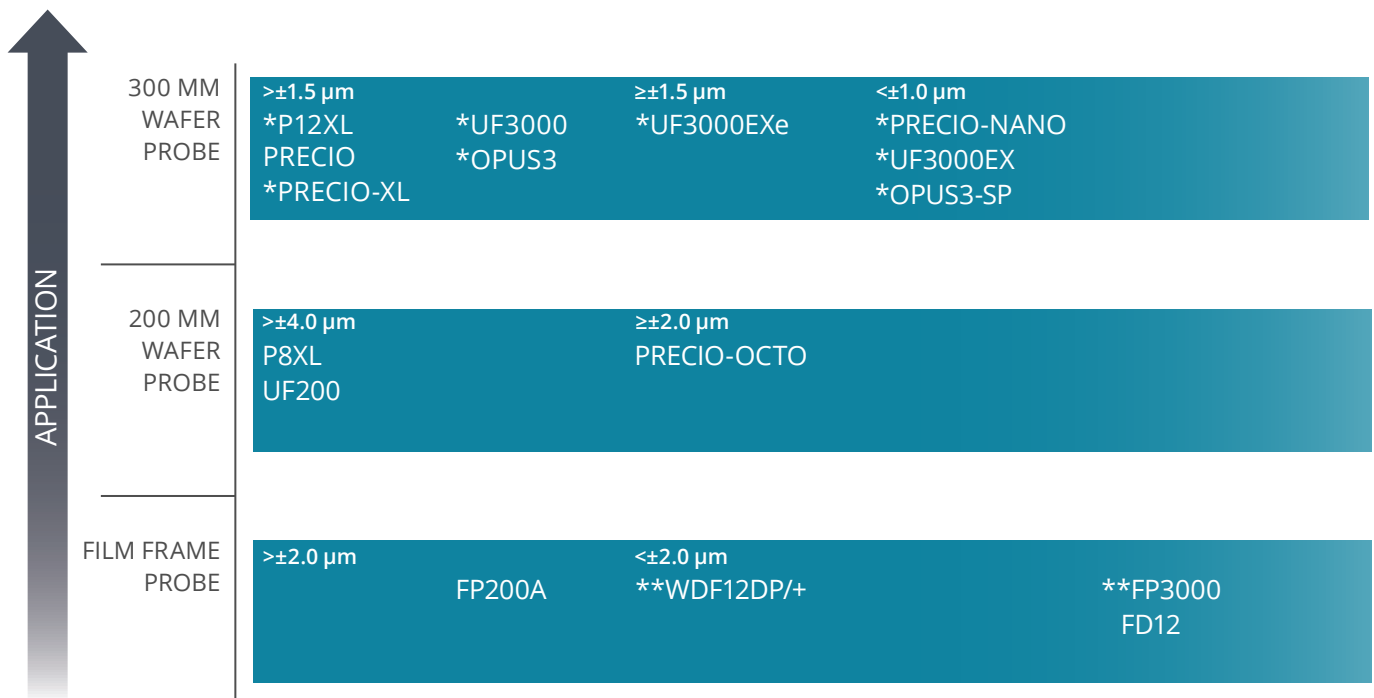
APPLICATION	MIXED SIGNAL	V93000 (PS400/800), T657X, I-FLEX, J750, SX-37XX	V93000 (PS1600), T2000, UFLEX, Diamond	Chroma 3650 V93000 (PS5000, XPS256), UltraFLEX ^{plus} (UP2200, UltraVS256)
	POWER ANALOG	J750, EVA100	V93000 (PS1600), ETS88/364, T2000 IPS, UFLEX, J750EX/HD	ETS800
	RF	I-FLEX RF, PAX, NI-ST5	V93000 (PS1600, PS-RF), UFLEX, (UW-12G/24G), V93000 (PS1600, WS-RF), PAX & DMDx (DragonRF)	V93000 (WS-RF mmWave), UFlex-RF (MX20, MX44), PAX (RedDragon-RF mmWave), NI-ST5 (PXIe-5831 mmWave)
	MEMORY	T537X, T558X, Magnum 1, Magnum 2, Magnum 2x	Magnum VU, Magnum VUx	Magnum VUy
	CIS	IP750, T2000ISS		
PRODUCTION TESTERS				

TESTERS FOR NAND

Advantest Teradyne



PROBERS



PRODUCTION PROBERS

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

HANDLERS

APPLICATION ↑	PICK & PLACE	>4 SITES *MT9510 *CASTLE	≤8 SITES NS70xx **NS80xx TW152 **HT9045 ***HT1028C	>16 SITES **HT9046 ***ECLIPSE-TT ***M4871(GS1) TW153	<32 SITES **HT9046LS *NX1032XS ***TW154T	HT1028C TW154V	
	TURRET	BOWL NX16/32	XD248 Z326	BOWL NY20 FT2018	FILM FRAME NY32W PM38		
	GRAVITY	<4 SITES *SO1000 *SO2000	MT9928 SO2800AH	>8 SITES *SO8000	*ZEUS		
	MEMORY	<128 SITES HT3309	M6771	<256 SITES M6300	>512 SITES TW350HT M6242 M6243		
	STRIP/ FILM FRAME	STRIP *InStrip HT3323A	FILM FRAME FH1200	x384 SITES, STRIP SH5000/5300 SH3000 SO3000 *Jaguar	FILM FRAME		
	SLT	HT3016 (x12) Chroma 3260 (x6)			TW SL301-N 5033 Titan/MAGNUS		
	SENSOR/ ACTUATOR	CUSTOM PM35 (x8) – microphone NX32 (x8) – microphone XD248 (x4) – e-compass NX16 (x1) – Hall sensor PM35 (x8) – humidity/temp		TOTAL SOLUTION InStrip – accel/Gyro OSAI (x140) – pressure			

PRODUCTION HANDLERS

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

CAPABILITY HIGHLIGHTS

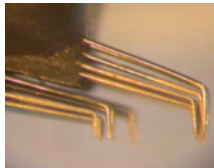
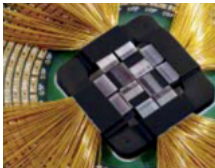
There are many benefits to partnering with Amkor for full turnkey solutions, including wafer processing, advanced bump, wafer probe, assembly, final test, system level test, burn-in and end-of-line services.

WAFER PROBE

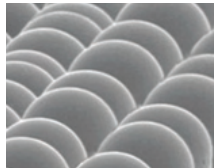
- ▶ Wafer testing sizes include 8" and 12" with 14, 10, 7 and 5 nm process technologies
- ▶ HS Logic, mixed signal, analog, high power (>100A) and RF including NB-IoT & 5G FR1 and FR2 standards
- ▶ Multiple probe card technologies: Cantilever (<1 GHz), vertical (up to 40,000 probes), pogo, membrane (>4 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 μm^2 pads/bumps
- ▶ Prober capabilities: alignment to $\pm 1 \mu\text{m}$ and -55°C to +200°C temperature range

PROBE TECHNOLOGY

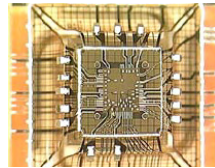
Cantilever



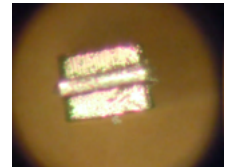
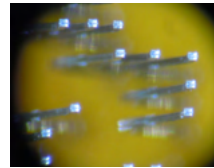
Cu Pillar Bump



Membrane



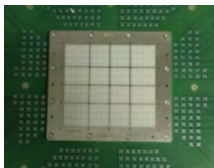
MEMS



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
- ▶ 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.

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.

ASSEMBLY FORMAT

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

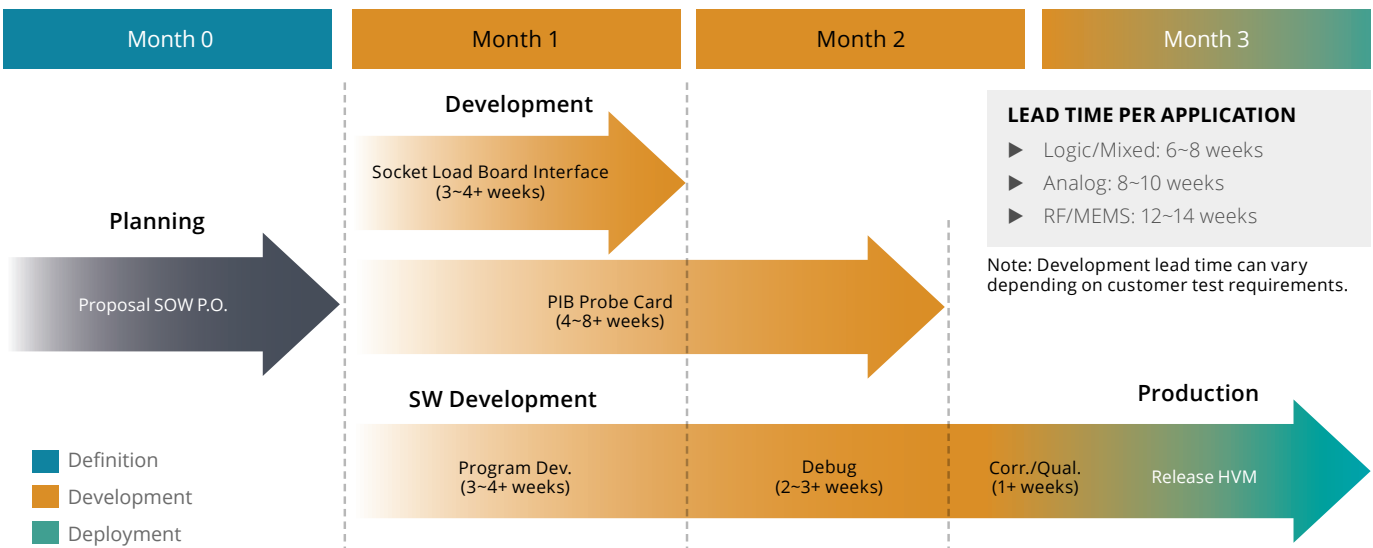
- ▶ Saw MLF[®] (including various sensors/actuators (MEMS))

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



AMKOR IS THE
NUMBER ONE
AUTOMOTIVE
OSAT SUPPLIER

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
- ▶ 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



ARTIFICIAL INTELLIGENCE (AI), NETWORKING & COMPUTING

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

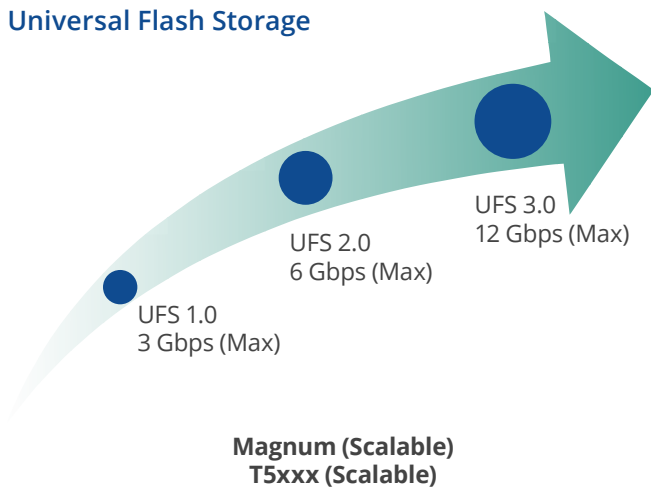


CURRENT SOLUTIONS

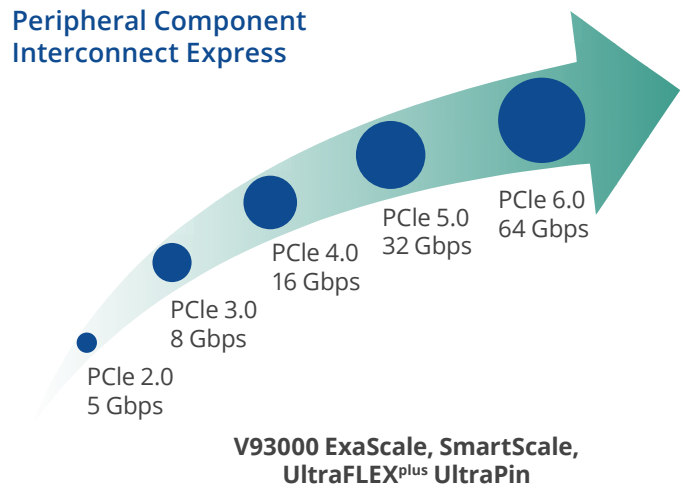
- ▶ >2 TB bandwidth in package
- ▶ High performance >3 GHz DDR4, DDR5, High bandwidth memory interfaces, including graphics
- ▶ Memory interface test through logic die
- ▶ UFS Protocol system level test
- ▶ PoP, MCP
- ▶ eMMC (NAND + Controller), MCP (SDRAM + NAND)
- ▶ MicroSD, SSD, UFS

HIGH DATA RATE TEST TECHNOLOGIES

Universal Flash Storage



Peripheral Component Interconnect Express



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 VS240AN, DTS-241	Rg DC
Hokuto	AT-999 Series AM-083	VDSX (SUS)/VCEX (SUS)/trr trr/Vsurge
CATS	DV-240 Series	Δ VDS/ Δ VBE
Minekoon	615-SW	Switching test (trr/I rr/t off/t on/I Latch)
ITC	ITC55100C	UIS
Shibasoku	WL-22, WL-25	IC
Power Tech	QT-4100 Series QT101 Series	DC UIS
POWorld	VC6700	Transient test

HANDLERS	MANUFACTURER
Gravity	TESEC Ueno Seiki
Turret	Sowa KES 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
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

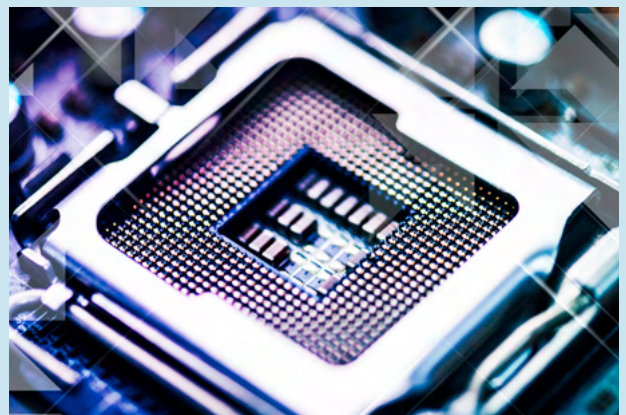
- ▶ E/L Bench test
- ▶ X-ray
- ▶ Scanning acoustic tomograph

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](https://www.amkor.com) Questions? Contact us: sales@amkor.com



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