Advanced Packaging & Test: Turning Innovative Ideas Into Reality

Rebeca Jimenez I CVP, Advanced SiP BU
QMW June 2022

Agenda

1 Macro Trends & Catalysts for Semiconductor Growth
2 Advanced Packaging & Test Enabling Growth
3 Evolving Test Requirements & Capabilities
4 Future of Advanced Packaging & Test

Supply Chain: Globalization to Localization?

Global

- Global production networks
- Global supply chain networks
- Minimized stock strategies

- Global delivery footprint
- Customer-specific variant
- Limited risk management

Local

- Localized production networks
- Local supply chain networks
- Local warehouse and reserve strategies

- Build where you sell
- Variant reduction
- Expect the unexpected

Source: “COVID-19 impact – A Yole Perspective”. Yole Développement. www.yole.fr.

Semiconductor Growth Catalysts

Communications

- AP/Modem & peripheral functions integration
- RF & sensors

Computing

- Processing power
- High speed connectivity
- Optical interface

Automotive

- ADAS & sensors
- Infotainment & connectivity
- Electrification

IoT

- Wearable products
- System integration
- Security/Authentication

5G Connectivity Accelerator

Agenda

1 Macro Trends & Catalysts for Semiconductor Growth

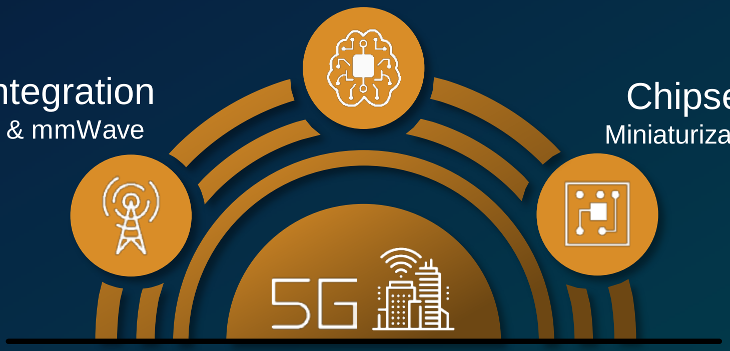
2 **Advanced Packaging & Test Enabling Growth**

3 Evolving Test Requirements & Capabilities

4 Future of Advanced Packaging & Test

Communications – 5G a Key Megatrend

Mega Trends



Sensors
ID Authentication & Bio Health

RF Integration
Sub-6 & mmWave

Chipset
Miniaturization

5G

Memory

Peripherals

RF Front End

Transceiver

Touch Screen Controller

Sensors

Application Processor

SCSP

WLCSP

MLF®

SiP

fcCSP/WLFO

MEMS

fcPoP

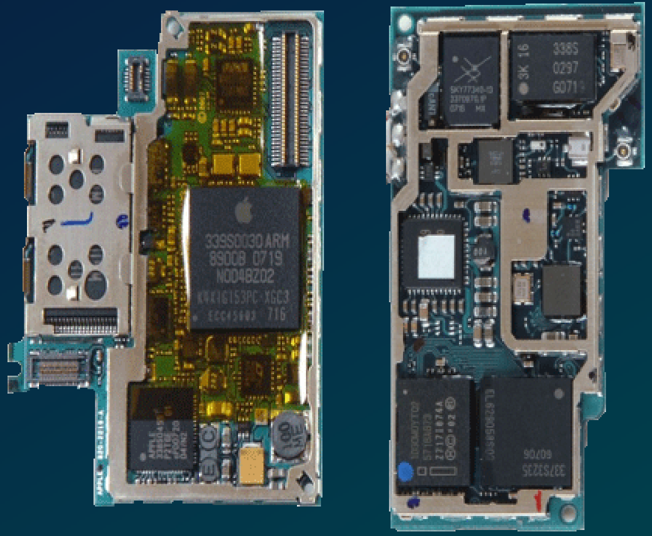
Package Drivers

- 5G RF integration
- Miniaturization of AP and modem
- Sensor fusion and optical sensors
- Integration of peripheral devices in SiP

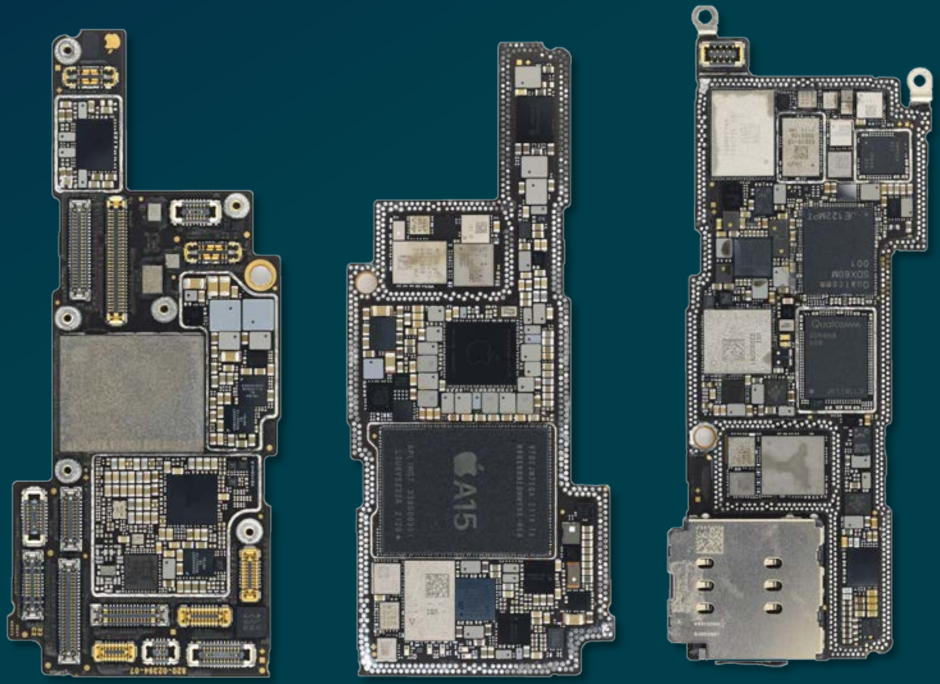
Test Drivers

- mmWave RF, OTA, AiP, chamber testing
- MEMS fusion and optical content
- Subsystem module – SLT complexity

Smartphone Semi Content Growth



iPhone Gen 1
<50 Components

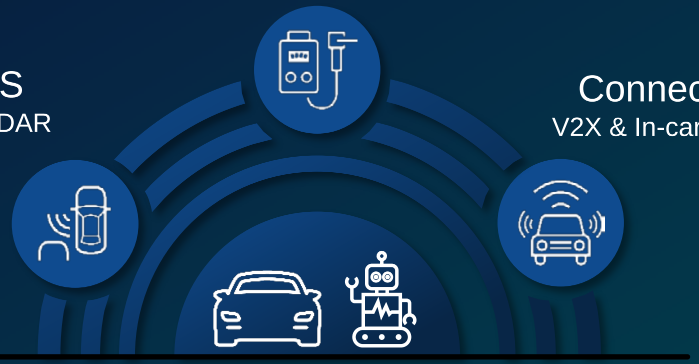


iPhone 13
>120 Components

Source: iFixit Images

Auto – Driven By Content & Features

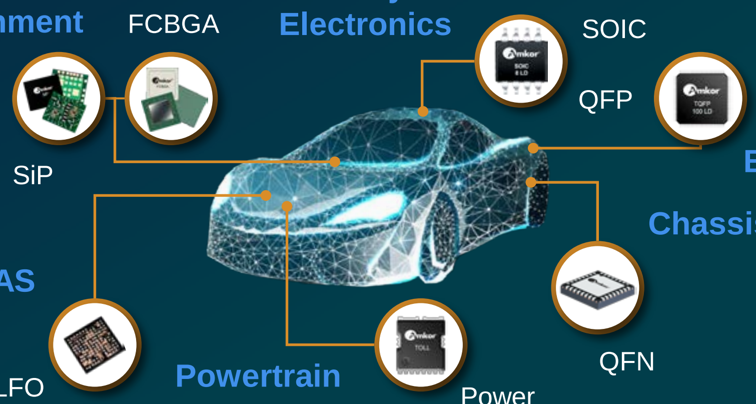
Mega Trends



Electrification
Inverters & Chargers

ADAS
Radar/LIDAR

Connectivity
V2X & In-car Network



Infotainment

FCBGA

Body Electronics

SOIC

QFP

SiP

EV/HEV

Chassis

ADAS

WLFO

Powertrain

Power

QFN

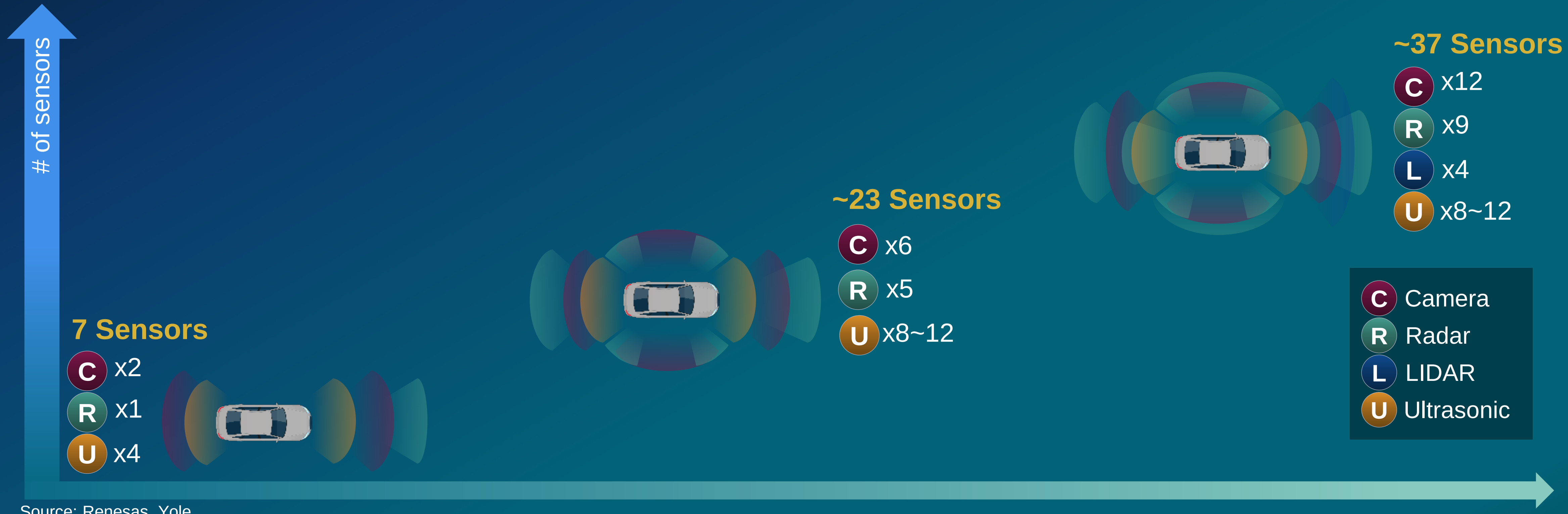
Package Drivers

- Radar, LIDAR, camera
- Sensors, processors, power solutions
- Wideband gap materials: SiC, GaN
- Digital cockpit & V2X, gateways, E/E architectures

Test Drivers

- 0 DPPM/DPAT, board level testing, burn-in
- System module – SLT complexity, tri-temp test
- Emergence of dynamic/system tests, SOA for xEV

The Evolution of Autonomous Driving



7 Sensors
C x2
R x1
U x4

~23 Sensors
C x6
R x5
U x8~12

~37 Sensors
C x12
R x9
L x4
U x8~12

C Camera
R Radar
L LIDAR
U Ultrasonic

Source: Renesas, Yole

L0	L1	L2	L3	L4	L5
No Automation	Feet Off	Hands Off	Eyes Off	Mind Off	Full Automation

Computing – Data, Speed, Storage

Mega Trends

Networking
Ultra-fast 800G TxRx

Data Center
Cloud Computing

Storage
Solid State
Modules

Package Drivers

- Flip chip interconnect
- 2.5D / memory, HDFO for chiplet integration
- MCM, multi-die stacking, solid state modules
- Silicon photonics & co-packaged optics

HDFO (SWIFT®)

Multi-die Memory Stack

Chiplet

SiP

2.5D TSV Interposer

FCBGA

Multi-chip Module

Test Drivers

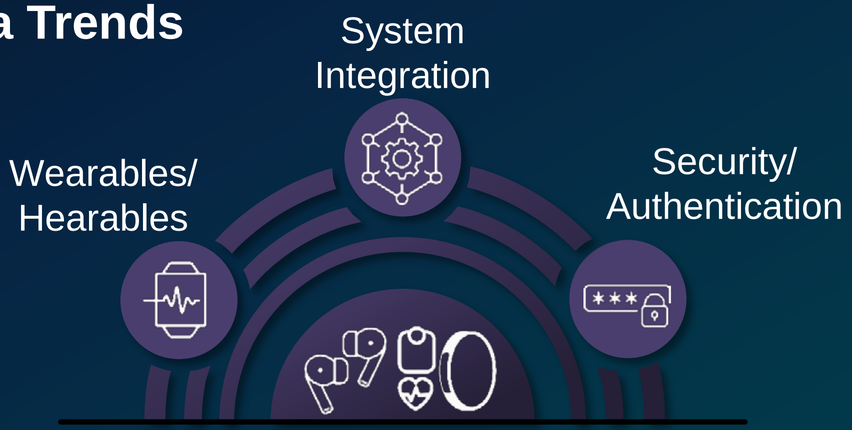
- Increasing bandwidth & I/O – smaller probe pitch
- Chiplets architecture – KGD & SLT complexity
- Optical probe, fiber attach & light source test

Google Datacenter in Iowa

Source:google.com

Consumer – Innovations in IoT

Mega Trends



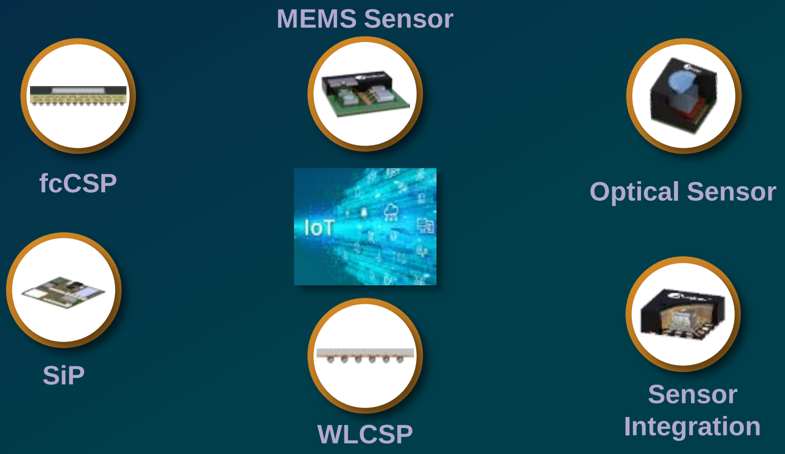
System Integration

Wearables/ Hearables

Security/ Authentication

Package Drivers

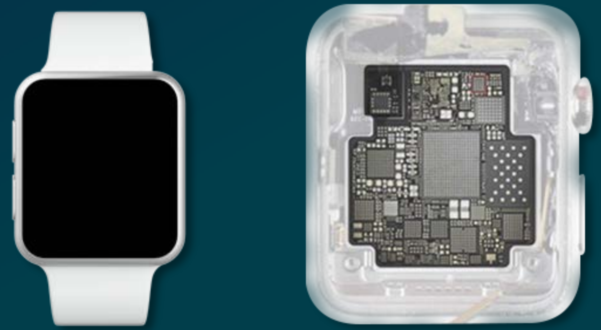
- SiP – full system integration
- Miniaturization and customization
- Always on sensing
- Health, ToF and proximity sensors



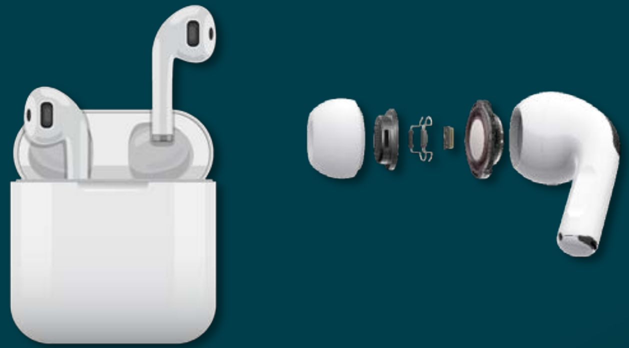
Test Drivers

- System module – increasing SLT complexity
- Secure test environments EAL5+
- Optical based health vitals monitoring

Consumer Semi Growth



Smart Watches 24-46 Components



Hearables 32-56 Components

Agenda

1 Macro Trends & Catalysts for Semiconductor Growth

2 Advanced Packaging & Test Enabling Growth

3 **Evolving Test Requirements & Capabilities**

4 Future of Advanced Packaging & Test

Amkor Test Services

24/7

Operation of fully
networked test floors

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

Full End-of-Line Processing

Bake, scan, pack, ship
and finished good services

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

>3,600 Testers in 7 Locations

3,000+ Amkor, 600+ consigned

Tested Annually

10 Billion units
7- 9 Million wafers

Test is an integral part of the overall Amkor business
Over 40 years of Automotive test experience

amkor.com/test-services

Amkor Test Locations

JAPAN
Automotive, Consumer, Memory

KOREA
Automotive, Communication, Memory

SHANGHAI
Communication, Memory

TAIWAN
Communication, Consumer, Networking

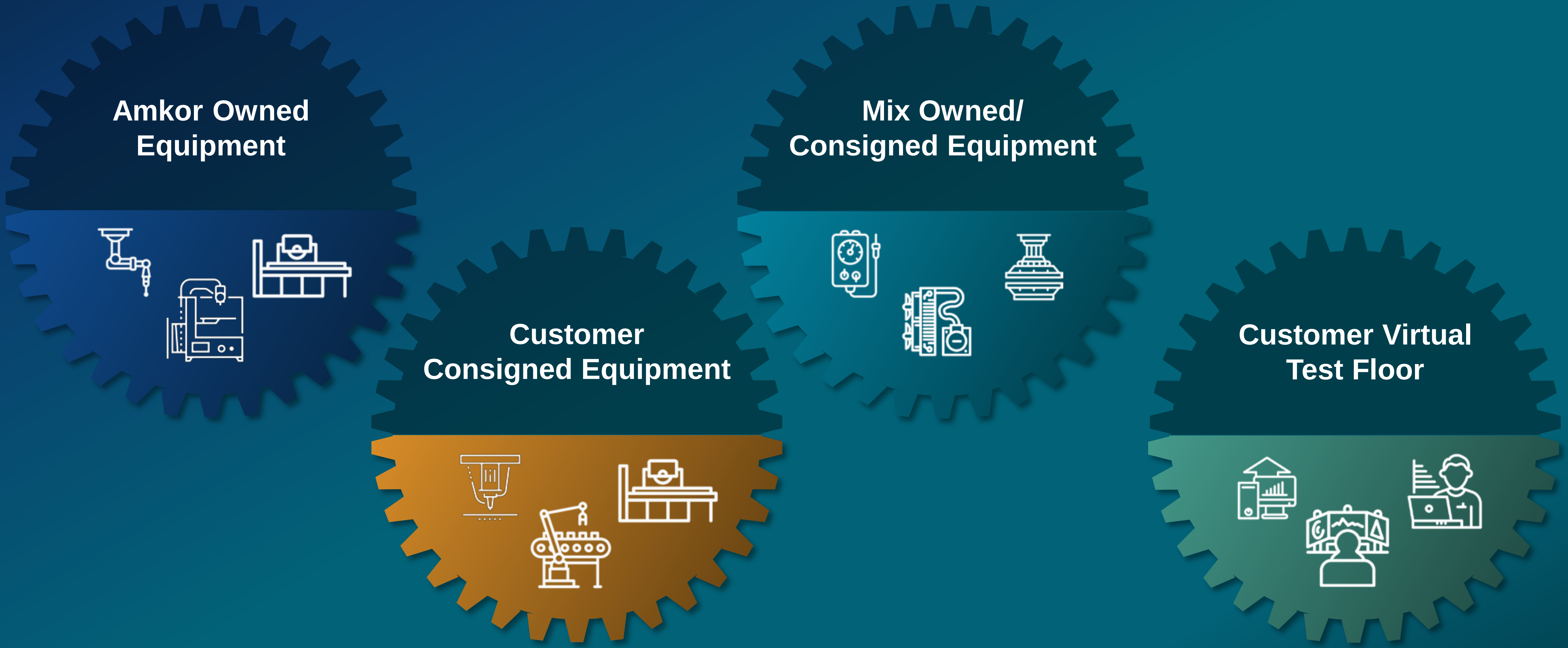
VIETNAM (planned)

PHILIPPINES
Automotive, Consumer, Memory

MALAYSIA
Power Discrete

PORTUGAL
Communication, RF

Test Models Are Changing



Amkor Owned Equipment

Customer Consigned Equipment

Mix Owned/ Consigned Equipment

Customer Virtual Test Floor

Partnerships are Critical

Customer Partnerships

- Operational excellence
- Joint roadmaps
- Test development engineering
- Value engineering
- Supply chain solutions
- Solving customer problems

Vendor Partnerships

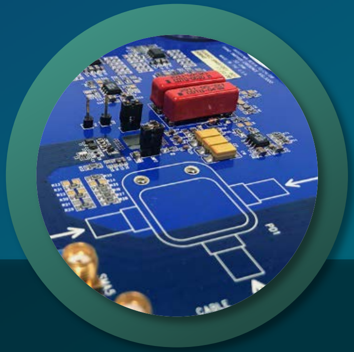
- Capability development
- Cost optimization
- Joint R&D
- Supply chain optimization

Joint Customer Partnership

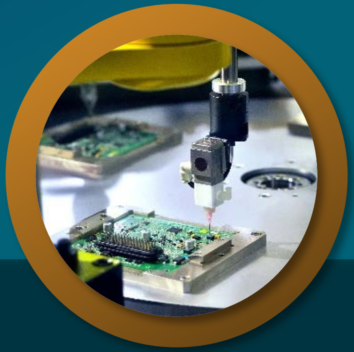
Test development

New Product Review

RF Module Design & Simulation



HW/SW Develop & Prototype Build



Pre-production Build & ATE Setup

Production Release & EFA

Joint Supplier Partnerships

Environment
HW/SW access
SW IP
HW IP
Applications
Turnkey solutions
HVM ramp
Configuration roadmap
Auto program gen
Equipment capability

- Partnership with industry leading test vendors
- Joint development of fully integrated solutions
- Tester, handler, board, contactor & pin
- Industry leading test solution development environment for engineers

Comprehensive Value Add

Full turnkey end-to-end solutions

Fully integrated solutions

Early access and technology ahead of the need

Joint research and development

Joint customer engagements

Best in class test solution development environment

Early NPI capacity

Successful ramps

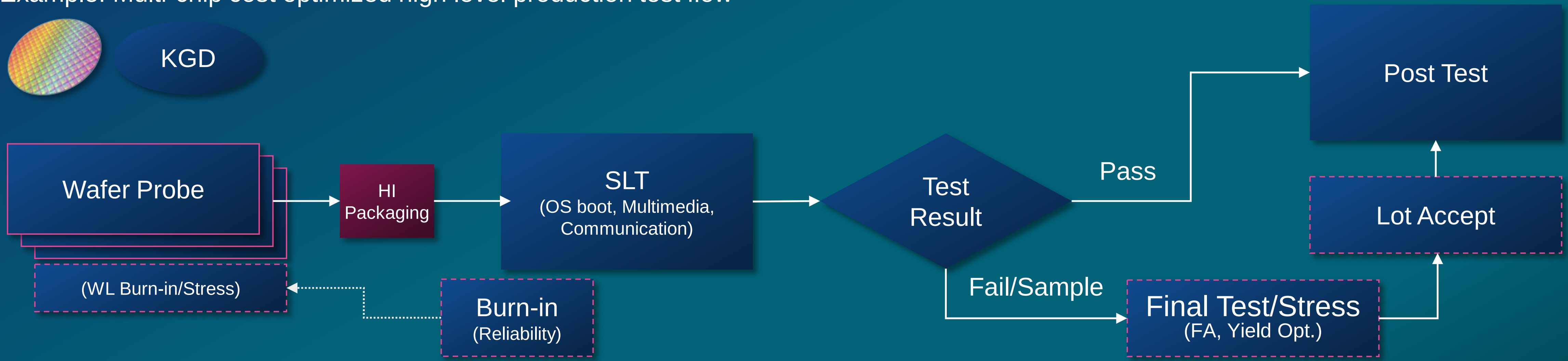
Flexible capacity

Production Test – Impact to Test Flow

Example: Single chip production test flow

Wafer Probe → Packaging → Final Test → Burn-in (Reliability) → Final Test/ QA → SLT → Post Test

Example: Multi-chip cost optimized high level production test flow



KGD

Wafer Probe

(WL Burn-in/Stress)

HI Packaging

SLT
(OS boot, Multimedia, Communication)

Burn-in
(Reliability)

Test Result

Pass

Post Test

Lot Accept

Fail/Sample

Final Test/Stress
(FA, Yield Opt.)

Altered Test Flow

Test Content Re-distributed

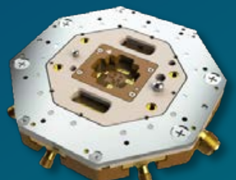
Platform Level Test Quality

Evolving Test Technologies

5G mmWave test

Source: bostonsemiequipment.com

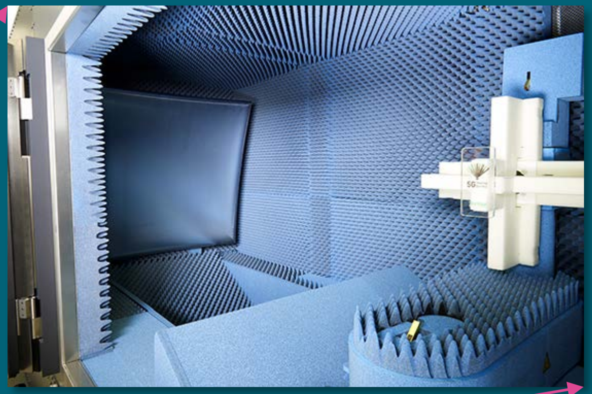
Conductive



Source: cohu.com

Source: ni.com

Radiative (OTA)



- **Antenna integrated**
- **5G mmWave FC**
- **>80GHz signal loss**

Progression Towards System Level Test (SLT)

Advantest A93K

ATE

Core Development Platform

Hontech

Application board based

Titan

System level test

Agenda

1 Macro Trends & Catalysts for Semiconductor Growth

2 Advanced Packaging & Test Enabling Growth

3 Evolving Test Requirements & Capabilities

4 **Future of Advanced Packaging & Test**

Future of Advanced Packaging & Test

Enabling semiconductor growth

Macro drivers & Semi growth catalysis: Re-thinking corporate strategies

Moore’s law slowdown: Accelerating Packaging & Test innovation

Business model evolution: Earlier product creation engagement

Partnerships: Turning innovative ideas into reality

Advanced packaging & test enabling growth

Amkor Technology®

Enabling the Future

amkor.com