Advantest IR Technical Briefing

Future SoC Semiconductor Test Needs & Solutions

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Koichi Tsukui
Director, Managing Executive Officer, Leader, ATE Business Group

Tsutomu Sugii
Department Manager, SoC Marketing Department, SoC Marketing and Business Development Division, Sales Group
NOTE

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Agenda

✓ SoC Test: A Business in Transition

✓ The SoC Semiconductor Market Environment

✓ Future Test Needs & Solutions

✓ Summary
SoC Test: A Business in Transition
Operating Segment and Main Products / Solutions

Semiconductor & Component Test System

SoC Testers
- V93000: SoC Devices
- T2000: SoC Devices
- T6391: LCD/OLED Driver ICs

Memory Testers
- T5833: DRAM and NAND
- T5503HS2: High-Speed DRAM Test

Mechatronics Systems

Test Handlers
- M4972: High-End SoC / Automotive ICs
- M6242: Memory ICs

Device Interfaces
- Change Kit
- HIFIX

Nanotechnology
- E3650: CD-SEM for Photomasks / EUV Masks

Services, Support & Others

Maintenance / Service
- EM360 Service solution

System Level Test
- MPT3000HVM: SSD System Level tester
- ATS503x: High-end SoC System Level tester

Other new initiatives
- High-end SoC socket
- Thermal control unit

Leasing / Second Hands Resale

SoC: System on Chip. Used here to mean "non-memory devices."
R&D Synergy from M&A in Advantest’s SoC Test Business

- Advantest continues to provide outstanding solutions to the industry by expanding our portfolio.
Advantest has doubled our customer base in the past 10 years by providing solutions that anticipate customer needs, and sales have increased.

- Smartphone Market Expansion
- 4G Expansion Starts
- HPC/Al-related Demand Growth
- Accelerating Competition Among 5G Smartphone Makers
- Automotive-related Demand Expansion
- Accelerating Smartphone Performance Gains

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- Expanded customer base with sales resources enhanced by M&A
- Expanded solutions with R&D resources enhanced by M&A
- Acquired analog and power customers and accelerated design wins with new solutions
- Launched high-performance DDIC* products & dominated subsequent demand

*DDIC: Display driver IC
SoC Testers That Support Test of Diverse IP

Basically, SoC semiconductor test checks that each function is operating correctly while passing a clean electric current through devices. Test is performed by connecting a specialized module for each part of the SoC device: logic, analog, RF, etc.

Higher integration → greater test complexity
Adding Value to SoC Test: Module Architecture

- Various module configurations covering a wide range of SoCs, from simple low-end devices to the most complex high-end products on a single scalable and flexible platform.

More gates (cores) used in high-end logic ICs means longer test times.

Advancing performance and complexity of large size SoCs (e.g. AI functionality) increases test times.
Advantest’s SoC Tester Application Coverage

Module functions are optimized for each application
A wide range of applications can be measured by switching out modules

Computing & Communications
- Application processors (AP)
- High-performance logic ICs (MPU/GPU/Al/FPGA)
- RF devices (WiFi, Bluetooth, mmWave…)

Automotive / Industrial / Consumer
- Standard logic ICs (MCU, Smart Card…)
- CMOS image sensors (CIS)
- Power management ICs (PMIC)
- Display driver ICs (DDIC)
- Analog / mixed signal ICs
- CMOS image sensors (CIS)
- Power management ICs (PMIC)
- Display driver ICs (DDIC)

V93000
T2000
T6391 (dedicated DDIC tester)
Where Testers are Used: From Customer Lab to Fab

- Testing is essential for all semiconductors
- Through highly precise electronic signal analysis, Advantest’s semiconductor test systems contribute to product quality improvement and control, performance measurement and improvement, time-to-market reduction, and production yield increases, throughout customer workflows from R&D to volume production

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<th>Semiconductor Design / Development Phase</th>
<th>Semiconductor Volume Production Phase</th>
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<tr>
<td>Circuitry Design</td>
<td>Wafer Test · Package Test</td>
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<td>Sample Evaluation</td>
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- Chip development improvement via debugging of design failures
- Yield management support via fault tendency detection
- Open / short check
- Electrical characteristics check
- Burn-In test
- Structural test
- Function test
- At-speed test

Executed by hardware and test programs customized for the specific device under test

IDM
- Fabless
- Foundry
- OSAT

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Engineering Consultations Support Semiconductor Market Growth

- More than 600 test engineers support our customers' business worldwide

- As the evolution of semiconductors increases the difficulty of test, we provide consultations on appropriate test methods and environments for the latest semiconductors.
  - Seamless technical support from design / evaluation to volume production fabs
  - Integrated solutions that include peripherals, leading the industry in measurement reliability and efficiency

- Test trend data is fed back to the R&D teams developing next-generation testers to benefit customers

Close partnerships with a broad range of customers drive mutual growth
Advantest’s Core Competences Support SoC Evolution

➢ **Industry’s No.1 technological capabilities & leadership**
  ✓ SoC semiconductor test equipment market share > 50% (2018-2019) (Advantest estimate)
  ✓ Dominant position in the high-end market where test technology requirements are most demanding
  ✓ Industry-leading MTBF (Mean Time Between Failure)

➢ **Industry’s No.1 customer base and largest installed base**
  ✓ Advantest has built up a strong customer base including IDMs, fabless, foundries, and OSATs
  ✓ Number of volume production systems in operation worldwide is industry’s greatest

➢ **Total solutions including test peripherals and a global support network**
  ✓ Ranked No. 1 in VLSIresearch customer satisfaction survey, and ranked in "Best 10" for 32 consecutive years
  ✓ One-stop global support for test systems, test handlers, and device interfaces operating as a comprehensive test environment
Evolving Electronics, Evolving Test Technology

- Basic technology such as measurement instruments with DC test functions
- Automatic test equipment
- Function test technology
- Design for ease of test
- Scan test technology
- Improvement of existing test technology + Complementary system level test

✓ In the 2020s, not only 5G but also AI will be widely adopted, and data center / data server processing capacity will improve
✓ Technology leaders will accelerate innovation
✓ Synergy from diverse IP and advanced package adoption are two trends requiring more powerful test capabilities and measurement environments

Advantest aims to predict transitions from one technology era to the next ("Waves") and add customer value in an evolving semiconductor value chain
The SoC Semiconductor Market Environment
Semiconductors Support Changing Lifestyles

- Autonomous Smart Transportation
- Data Centers
- Smart Factory
- AI / Machine Learning
- AR/VR
- Infrastructure
- Smart Home

3 Benefits of 5G
- Ultra-High Speed
- Multiple Simultaneous Connections
- Ultra-Low Latency

Contributing to the safety, security, and comfort of the general public through measurement technology
Applications Driving the Next-Generation SoC Market

High performance and high functionality are required of SoCs in all arenas

- Smartphones
  - APU/BB
  - CIS
  - DDIC/TDDI
  - RF

- Ultra HD TV / Organic EL
  - DDIC

- Data Centers
  - AI
  - MPU
  - GPU

- ADAS / Self-Driving Cars
  - Automotive APU
  - LiDAR/RADAR
  - CIS
  - DDI/TDDI

- Entertainment
  - APU
  - GPU
  - CIS
  - DDIC
High-End Processors That Support Smart Lifestyles

**Smartphones**
- Computing performance that supports 5G
- Utilization of state-of-the-art process nodes
- Faster interfaces
- Balance of performance and power consumption

**Big Data Processing**
- Packaging that achieves high performance
- Next-generation architecture that achieves ultra-high-speed processing
- Adoption of state-of-the-art packaging techniques (Chiplets, 2.5D / 3D)
- High power and thermal control
- Million-core architectures
- Parallel processing and scalability
- Power domain control
It is necessary to expand the application range of semiconductors that support CASE*, and further improve functionality, performance, and reliability.

* CASE: Connected, Autonomous, Shared & Services, Electric
Further Expansion Expected in Image Sensor Market

- Market growth is expected as technological innovation continues, centered on smartphones
- Applications are expanding across various fields such as automotive, AR / VR, security, and drones

Smartphone Market

- Multiple cameras
  - By 2024, 80% of smartphones will be triple camera phones
- Higher speeds
  - Transition from MIPI* D-PHY to C-PHY

Emerging market

- Sony EV Prototype [VISION-S]

Application Expansion

- Core technology for autonomous car
- Application Expansion: AR/VR, Security, industrial drones etc.
- Intelligent Image sensor: Integration of Edge AI

[The merits of using C-PHY]

1) Data rate about 1.5 times that of D-PHY
2) High-capacity data communications and high speed allow reduction of data line wiring area
3) Lower power consumption during transmission and reception
4) More flexibility in circuit layouts

*MIPI=Mobile Industry Processor Interface Alliance
The Growing Display Market & DDIC Demand

- **Drivers of display demand**: The shift to 5G, the trend toward 4K / 8K TVs, the acceleration of DX due to greater WFH adoption

### Small Displays
- Viewfinders
- VR/AR
- Projectors
- Wearables
- Smartphones

### Large Displays
- Tablets
- Laptops
- Monitors
- TVs
- Digital billboards
- Public screens/Theaters

### Panel size (inch)
- 1
- 5
- 10
- 20
- 40
- 100

**Advanced technology driving the expansion of the display market**
- High-resolution display technology that achieves WQHD, 4K / 8K
- High-speed data transfer technology for better image quality: MIPI C/D-PHY for smartphones and dedicated high-speed I/F for TV
- Integration of DDIC, touch sensors, and fingerprint sensors
- Bezel-less displays for TVs and smartphones
Future Test Needs & Solutions
As SoC products evolve, makers need to achieve higher quality and performance assurance using ATE.
High-End SoC Device Test Challenges

New Scan Test Challenges

Scan test is the primary type of structured test applied to logic circuits. The scale of the logic circuits used in SoC devices is rapidly increasing, and so is the scale of test pattern, making it impossible to achieve a failure detection rate sufficient for quality assurance with manually created functional test data. Therefore, scan test has become a necessary prerequisite for SoC test.
High-End SoC Device Test Challenges ②

- Miniaturization of devices makes it important to acquire and analyze huge amounts of test data
- Higher integration also increases power consumption (>1000W: multiple types of power domains supported)

Advanced process node development times (ES~CS)

Volume of test result data required for yield improvement

Process shrinks have dramatically increased the volume of test result data required for yield improvement.

Electrical current consumption per power domain is increasing.

Process shrinks require higher power

Device voltage stress test ($I_{\text{max, core}}$)

Source: Qualcomm IPTC2018
Enabling Leading-Edge Technologies

Advanced packages powering the newest modules deliver innovative performance evolution

- 16 completely independent pins are mounted in a small space, with 256 pins—twice the pin count of previous products—mounted in one module
- Utilizes high-speed core to support high-speed serial scan test up to 5Gbps
- Multi-core processors such as MIPS processor core and DSP core are also installed to speed up calculation processing, achieving greater multifunctionality and higher-performance test functionality.

Adoption of a distributed computer network inside the tester improves the efficiency of parallel test

- Improve test throughput by means of decentralization of processing and communication, instead of only by the system controller
- Parallel setting and parallel processing increase the efficiency of multi-site test
- As the volume of test data such as scan increases, so does the volume of test result data. Data upload / download is now faster.
Advantest Debuts the V93000 EXA Scale™

➢ The new platform implements all the functions required to meet next-generation semiconductor test challenges

**Deepest vector memory**
- All pins have deep vector memory
- Integrated multi-pin memory enables even larger scan tests

**Industry-leading digital pins**
- Scan test speed of 5Gbps
- High speed scan test & existing functional test capabilities

**Covers all power requirements with a single DPS card**
- Broaden current supply capability (mA range to several KA)
- Excellent accuracy and responsiveness (instantly compensates for voltage fluctuations, improving yield)
- Innovative probe needle protection

**Throughput optimization**
- Dual sequencer enables highly efficient operation
- High-speed failure data capture

**Outstanding scalability**
- From small engineering configurations, to large configurations for volume production

**Broad application coverage**
- Also supports high-speed test and RF test

**Compatible with existing V93000 DUT boards**
DUT boards can be shared between EXA Scale and Smart Scale systems, eliminating migration barriers
Technical Requirements for Automotive Electronics

- The response to the shift to EVs and the introduction / evolution of autonomous driving technology
  Better mileage: Support for a wide range of voltages by further increasing the performance and capacity of Li-ion batteries
  More automotive ICs / electronic components: High efficiency and energy-saving performance required for each device

Electric Vehicle

12V Systems

- 12V to 12V
- 12V to HV/12V

48V Systems

- 48V to 48V
- 48V to HV/48V

BMS

HV (≥200V)

DC-DC HV

Traction Inverter

Battery Management System (BMS)

T2000 Automotive Test Solutions

Test Module Family

- SHV2KV
- MFHPE
- MMXHE

V93000 Automotive Solutions

Test Module Family

- HV800
- FVI16
- AVI64

A-Class

*BMS: Battery Management system
New Automotive Semiconductor Test Challenges

- Advantest’s handlers offer high precision, active thermal control and handling of various packages required by all automotive grades.
- The miniaturization of ADAS processors and the adoption of advanced packaging methods require reinforcement of the overall test process, including SLT.

Advanced Automotive Semiconductor Test Solutions

**Automotive Semiconductor PKG Proposals**

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<th>Current mainstream PKG</th>
<th>Future PKG</th>
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<td>QFP</td>
<td>QFN</td>
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<tr>
<td>QFN</td>
<td>FC CSP</td>
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<tr>
<td>BGA</td>
<td>FC BGA</td>
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<td>2.5D SiP</td>
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<td>SiP</td>
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**Automotive Semiconductor Thermal Requirements**

- **Grade 0**
  -40°C to +150°C
- **Grade 1**
  -40°C to +125°C
- **Grade 2**
  -40°C to +105°C
- **Grade 3**
  -40°C to +85°C

**AEC-Q100**

- Standards set by the Automotive Electronics Council, certified by industry standard test methods.

**Functionality**

- Less Power consumption More
- More Parts mounted Fewer

**SoC Handlers + Active Thermal Control**

- Individual heaters
- Individual temperature sensor
- High-speed, active, and highly accurate thermal control technology

**Automotive IC Test Solutions**

- V93000
- T2000

**SLT Solutions**

- Fully Automatic SLT System
Advantest provides a high-speed image processing engine that is optimal for CIS test, where image calculation volumes increase with the pixel counts of image sensors.

Advantest just announced the 4.8 GICAP module, the industry’s first to support C-PHY / D-PHY I/F. Multiple units are already in operation on customer volume production lines.
DDIC Test Challenges & Advantest’s Solutions

Display Technology Evolution Creates New DDIC Test Challenges

- High-precision multi-pin measurement capability for DDICs for high-resolution displays
- High-speed I/F measurement capability for smartphones and TVs
- Analog characteristic measurement capability for DDICs with integrated touch sensors and fingerprint sensors

All-In-One Solution for DDIC Test: the T6391

- Industry-leading 3,584 LCD pins achieved by applying multi-pin contact technology used in SoC testers
- Equipped with a high-speed I/F measurement option (6.5 Gbps) that supports test of all high-speed I/F standards for smartphone and TV displays
- Offers an analog measurement option for touch sensor and fingerprint sensor test
## Summary of Semiconductor & Tester Performance Innovations

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<th>Innovations in SoC Semiconductor Technology</th>
<th>Innovations in SoC Tester Performance</th>
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<td><strong>General</strong></td>
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<tr>
<td>• Increasing transistor counts due to miniaturization</td>
<td>• Power supply module flexibility supports larger-scale semiconductor circuits</td>
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<td>• Larger-scale semiconductor circuits mean larger current supply and multiple IPs on one chip</td>
<td>• Support for multiple domains for installation of multiple IPs</td>
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<tr>
<td>• Faster interfaces</td>
<td>• Enhanced dynamic response and accuracy for new failure mode detection and yield improvement</td>
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<td>• Higher frequencies, data processing speed improvements (high-speed data transfer)</td>
<td>• Enhanced lineup of measurement modules</td>
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<tr>
<td>• Enhanced reliability (demand for mission-critical applications is growing)</td>
<td>• Reinforced high-speed interface test to address increasing data volumes and test data speed</td>
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<tr>
<td>• Power supply module flexibility supports larger-scale semiconductor circuits</td>
<td>• Industry-leading platform flexibility and scalability</td>
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<td><strong>High-End Processors</strong></td>
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<tr>
<td>• Adoption of advanced processes, higher integration</td>
<td>• Better high-speed test result capture with superior throughput addresses the increased importance of failure analysis and yield improvement stemming from the adoption of advanced processes</td>
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<tr>
<td>• Adoption of advanced packaging (chiplets, memory I/F with higher speeds and lower power consumption)</td>
<td>• Support for large data capacity, high-speed scan test</td>
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<tr>
<td>• Better high-speed test result capture with superior throughput addresses the increased importance of failure analysis and yield improvement stemming from the adoption of advanced processes</td>
<td>• Broaden current supply capability (mA range to several KA)</td>
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<td>• Support for more demand for SLT test processes</td>
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<tr>
<td><strong>Automotive Semiconductors</strong></td>
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<tr>
<td>• Expanding semiconductor applications, automotive grade temperature control</td>
<td>• Achieve high-end processor equivalent test coverage in the autonomous driving processor market</td>
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<tr>
<td>• Autonomous driving</td>
<td>• In order to achieve zero DPPM, the quality required for vehicles, it is necessary to increase test times. Support for high precision, active thermal control technology during test. Strengthening of overall test flows including SLT</td>
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<tr>
<td>• BVE</td>
<td>• With the adoption of EVs, the measurement range for large currents and high voltages has grown</td>
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<td>• Connected car technology</td>
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<td>• Diverse package development</td>
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<td><strong>CMOS Image Sensors</strong></td>
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<tr>
<td>• Adoption of C-PHY (new data interface)</td>
<td>• Faster interfaces to handle larger data transfer volumes</td>
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<tr>
<td>• Higher pixel counts and higher resolution</td>
<td>• Better calculation processing throughput to keep up with increasing image data size</td>
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<tr>
<td>• Expanding applications for sensing technology</td>
<td>• Strengthening of logic functions for increasingly widespread AI-equipped CMOS image sensors</td>
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<tr>
<td><strong>Display driver ICs</strong></td>
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<tr>
<td>• High-speed data transfer technology that achieves high resolution and high image quality</td>
<td>• Support for all high-speed display interfaces</td>
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<tr>
<td>• Multiple functions on a single chip</td>
<td>• Improved analog measurement functions</td>
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<tr>
<td>• Support for all high-speed display interfaces</td>
<td>• Enhanced logic functions to support mounting of touch sensors, fingerprint sensors, etc. on chips</td>
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Smart Lifestyles
Semiconductor design and manufacturing technology is constantly evolving amidst the growing adoption of 5G and AI
Moves to enhance reliability are accelerating as semiconductor performance, integration, and capacity improve

Test Demand Expansion
Faster, larger-scale test and higher reliability ×
Growth in TTM demand
The added value of more advanced test equipment and know-how is growing

Safety Security Comfort
Contributing to customer success through measurement technology
Contributing to the safety, security, and comfort of the general public

Big-Picture Summary