Chapter Overview

• Test Drivers & Challenges
• Test & Yield Learning
• Test Cost
• Adaptive Test
• 3D device Test – New for 2012
• Test Technology Requirements
  – Test parallelism
  – SoC
  – Device types: Logic, Memory, RF/AMS, Specialty Devices
  – Device handling (Handlers, Probers)
  – Device Contacting (probing and package contacting)
# 2011 Test Contributors

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2011 Changes

• Updated Drivers, Difficult Challenges, and opportunities

• New Section on 3D Device Test Challenges

• Major Update to Adaptive Testing section

• Logic / DFT major rewrite
  – Added Fault Expectations using multiple fault models
  – Added test data volume given five compression assumptions

• Test Cost
  – Test cost survey update that quantifies current industry view

• Updates to Logic, SoC, RF, Analog, & Specialty devices
Drivers

• Device trends
  – Increasing device interface bandwidth (# of signals and data rates)
  – Increasing device integration (SoC, SiP, MCP, 3D packaging)
  – Integration of emerging and non-digital CMOS technologies
  – Complex package electrical and mechanical characteristics
  – Device characteristics beyond one sided stimulus/response model
  – 3 Dimensional silicon - multi-die and Multi-layer
  – Multiple I/O types and power supplies on same device
  – Fault Tolerant Architectures and Protocols
Drivers

- Increasing test process complexity
  - Device customization during the test process
  - Feedback data for tuning manufacturing
  - Dynamic test flows via “Adaptive Test”
  - Higher order dimensionality of test conditions
  - Concurrent Test
  - Maintaining Unit level Traceability
Drivers

• Economic Scaling of Test
  – Physical and economic limits of test parallelism
  – Managing (logic) test data and feedback data volume
  – Managing interface hardware and (test) socket costs
  – Balancing General Purpose Equipment vs. Multiple Insertions for System Test and BIST
Difficult Challenges

- **Cost of Test and Overall Equipment Efficiency**
  - CoT continues to be the primary driver for innovation
  - Traditional drivers for CoT are starting to be limited by OEE

- **Test Development gating volume production**
  - Increasing device complexity driving more complex test development

- **Detecting Systemic Defects**
  - Testing for local non-uniformities, not just hard defects
  - Detecting symptoms and effects of line width variations, finite dopant distributions, systemic process defects
Difficult Challenges

• Screening for reliability
  – Implementation challenges and effectiveness of screens
    • burn-in, IDDQ, and Vstress
  – Erratic, non deterministic, and intermittent device behavior
  – Mechanical damage during the testing process
  – Multi-die stacks/TSV
  – Power Management Issues
Future Opportunities

• Test Program Automation
  – Automatic generation of an entire test program
  – Tester independent test programming language
  – Resolve Mixed Signal test programming challenges

• Scan Diagnosis in the Presence of Compression

• Simulation and Modeling
  – Seamless integration of simulation & modeling into the testing process
  – Move to a higher level of abstraction with Protocol Aware test resources
  – Focused test generation based on layout, modeling, and adaptive feedback

• Convergence of Test and System Reliability Solution
  – Re-use of test collateral in different environments (ATE, Burn-in, System, Field)
Traditional Test Cost Components

- **NRE**
  - DFT design and validation
  - Test Development

- **Device**
  - Die Area Increase
  - Yield Loss

- **Work Cell**
  - Building
  - People
  - Consumables
  - DUT interface
  - Test Equipment
  - Handling Tools
  - Factory Automation

- **Untested Units** → **Good Units**
  - Production Test Cost
  - Reject Units

- **False Fail Units**
3D Test Cost Components

NRE
- DFT design and validation
- Test development

Device
- Die area increase
- Yield loss

False Pass Units

Smart Manufacturing

Probably Good Units

Untested Units

Test Cell

Reject Units

Analysis

Die Stacking

Test Cell

Pass/Fail

Good Units

Rejected Units

False Fail Units

Bad Die in a Good Stack
2011 Test Cost Survey Update

**Test Cost Metrics**
- Cost per unit
- % of total Product Cost
- Cost per second
- Cost per megabit

**Current Test Cost Drivers**
- ATE capital
- Interface hardware
  - **ATE utilization - NEW**
- Test program development
- Test Time and Coverage

**Future Cost Drivers**
- New Defects and Reliability problems
- Test Requirements of packaging
  - **Interfacing - NEW**
- Data (yield learning, traceability, test data) - **NEW**

**Current cost control Methods**
- Test Parallelism
- Structural Test & Scan
- Compression/DFT/BIST/BIST
- **Adaptive Test**
- Concurrent Test
- **Wafer-level at-speed testing**

**Future cost control Methods**
- Wafer-level At Speed testing
- Advanced embedded instruments
- Adaptive Test
- New contacting technologies
  - **In system testing - NEW**
- Built-in Fault Tolerance
Adaptive Test

• Modified testing based on analysis of real-time results

• Benefits
  – Higher Quality
  – Fast Test Time Reduction
  – Lower cost
  – Fast yield learning

• Requires data infrastructure
  – Database
  – Analysis tools
  – Confidence

• Implementation is evolving
3D Device Testing Challenges

• Die level test access to all die in the stack
  – Communication thru the top die in the stack
• Test Flow / Cost / Resources
  – Test partitioning, non-traditional test structure
• Die to Die Interactions
  – Signal routing thru another die
• Debug / Diagnosis
• DFT
• Test data management, distribution, & security
• Power management and implications
2012-2013 Plans

• 3D / “Cube” device test
  – Test step insertion / flow for TSV
  – Manage power & heat
  – Singulated die handling
  – Reliability wafer test requirements

• DFT / BISx via new methods – New Focus Team
  – 3D devices
  – Eliminate digital test data and test programs
  – RF / AMS parametric testing

• 3rd party review of test chapter by users and universities

• Cost & adaptive test section updates

• Logic table refinement

• Concurrent test table addition?
Summary

• 3D stacked devices will change test paradigms
  – The methods and approach seem available
  – Considerable work ahead to implement

• Adaptive testing is becoming a standard approach
  – Significant test data accumulation, distribution, and analysis challenges

• Managing cost is overall challenge
  – Industry is pulling in cost reduction methodology
Thank You!