

# Test and Dependability of Microsystems

Serge Bernard, Philippe Cauvet

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**Tutorial DTC 2010**

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Test and Dependability of Microsystems

LIRMM  
Serge BERNARD

2010, June 22<sup>nd</sup>

ophthalmia  
Philippe CAUVET

**Outline**

- Introduction
- Implications for Integrated Systems
- Test Challenges
- Some Test Solutions
- From Test to Dependability
- Conclusion

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**Introduction**

**TOETS Project:** Towards One European Test Solution application, chip and transistor levels  
NXP, ST, INFINEON, PHILIPS, Q-STAR, D4T, TEMETO, ATMEL, E2V, JTAG, CEA, TIMA, UT...

- **LIRMM (Laboratoire d'Informatique Robotique Microélectronique de Montpellier)**: cross-faculty research entity CNRS-UM2. 350 people, including 160 researchers, 150 PhD students.
- **Ophthalmia**: SME, development, fabrication, and sales of innovative electronic solutions dedicated to diagnostics and treatment of eye pathologies, and to measuring *intra-body* physiological parameters

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**Introduction**

**Context**

- More functionalities
- Shorter time to market
- Higher quality

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**Outline**

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**Implications for Integrated Systems**

**Complexity: "More Moore"**

SoC (System on Chip): combinations of IPs into an integrated circuit

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### Implications for Integrated Systems

**Complexity and Heterogeneous: "More than Moore"**

**Bare dies**

**SiP**

**SiP (System in Package):** any combination of semiconductors, passives, and interconnects into a single package

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### Implications for Integrated Systems

**Complex and Heterogeneous: Several MS/RF blocks**

**Set-top box (PNX8327)**  
2 ADC, 6 DAC, TX/Rx

- Video decoder: 12 ADC, 2 DAC, ...
- Cell phone: GSM +TVoM+ WiFi+ Bluetooth+ GPS= 5 transceivers or Rx

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### Implications for Integrated Systems

**Complex and Heterogeneous: Packaging and 3D**

**Integration Trend**

- Discretes Solutions
- MCM Solutions
- Laminate + SMDs Solutions
- Laminate + SMDs + Passive die
- Double Flip Chip assembly
- Wafer Level Packaging
- 3D WLP SiPs

Legend:  
 Active Die  
 Passive/Interconnect die  
 SMDs / Components

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### Implications for Integrated Systems

**High Performances: Software Radio Example**

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### Implications for Integrated Systems

**Low Yield**

High Performances + Short Time to Market

**Tight Design Margin**

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### Implications for Integrated Systems

**Low Yield**

High Performances + Short Time to Market  
+ **high Quality**

**Tight Design Margin**

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## ATRENE Outline

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## ATRENE Test Challenges

### Test vs. Manufacturing Costs

Price of the Chip

100%  
50%  
0%

2010 2020

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## ATRENE Test Challenges

### Complexity, Heterogeneous, Performances

- Expensive Test equipment
  - ATE: 1M\$
  - MS/RF option: 300k\$
- Long testing time

2005 2010 2015 2020

Test Challenges

- Test equipment
- Test time

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## ATRENE Test Challenges

### Complexity, Heterogeneous, Performances

- Access
  - Few primary I/O
  - Complex system
  - Signal Integrity

2005 2010 2015 2020

Test Challenges

- Test equipment
- Test time
- Test access

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## ATRENE Test Challenges

[NXP Semiconductors]

SIP wafer

SIP

- Acceptable Yield
  - Known Good Die
- Recursive test
  - Missing dies
  - Scrubbing effect

Test Challenges

- Test equipment
- Test time
- Test access
- KGD
- Recursive test

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## ATRENE Outline

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### Test solutions

#### Access + Recursive Test → Sip-TAP

Solution for end-user: SIP-TAP  
*Fide Jang, A. Biewenga / ITC 2006*

Star Configuration (Intermediate Test)      Ring Configuration (End-user test)

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### Test solutions

#### Recursive Test → Wireless Test

ATE      Wafer under tested

- A tester with a radio interface
- Integrating a "wireless module" in each DUT

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### Test solutions

#### Equipment + Time + Access → Built-in-Self Test

Primary Input      Primary output      Test result

- Low-cost (no?) Test Equipment
- At Speed Test
- Up-to-date Technology

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### Test solutions

#### Equipment + Time + Access → Indirect Test

"Classical"      "Indirect"

Spec2      Spec1      Spec3      IP2      IP1

DUT#100      Spec1      Spec2      Spec3      IP1      IP2

Non-linear Regression Models

[azals06]

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### Test solutions

#### Equipment + Time + Access → Loopback Test 1/2

TX-FEM      Transceiver      Baseband      DSP

- Low-cost Test Equipment
- Test simulation
- Easier BIST implementation
- Close to the application conditions

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### Test solutions

#### Equipment + Time + Access → Loopback Test 2/2

DSP Part 1      DSP Part 2      DSP Part 3      DSP Part 4

Digital part 1      Digital part 2      Digital part 3      Digital part 4

Using DSP-based methods / algorithms, the contribution of the non-linearity of each converter is discriminated.  
 The converters may be re-used as embedded instruments in the loop!

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**ATRENE** **TOETS**

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**ATRENE** **TOETS**

## From Test to Dependability

### From production test to in situ repair

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**ATRENE** **TOETS**

## From Test to Dependability

### General concepts 1/2

- **Dependability:** "a measure of the degree to which an item is operable and capable of performing its required function throughout the lifespan of the contract"

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**ATRENE** **TOETS**

## From Test to Dependability

### General concepts 2/2

- **Correct service:** when the service implements the system function
- **Failure:** an event that occurs when the delivered service deviates from correct service
- **Error:** part of the system state that may cause a subsequent failure
- **Fault:** adjudged or hypothesized cause of an error

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**ATRENE** **TOETS**

## From Test to Dependability

### How to attain dependability?

By...

- Fault prevention: design and manufacturing
- Fault tolerance: **error detection** and recovery
- Fault removal: design (verification) and operational life time (**maintenance**)
- Fault forecasting: qualitative and quantitative evaluation

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**ATRENE** **TOETS**

## From Test to Dependability

### How to attain dependability for miniaturized systems?

By implementing / improving...

- **Error detection :**
  - BIST (built-in-self-test)
  - BISD (built-in-self-diagnosis)
- **Maintenance :**
  - BISR (built-in-self-repair)
  - BISC (built-in-self-calibration)

Easy to tell, but not easy in practice, especially for heterogeneous micro-systems!!!

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## From Test to Dependability

### Example 1: automotive

Source : Bosch

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## From Test to Dependability

### Example 2: Medical

System life time

Human beings !!

- Strategy for risk handling
- System level management to avoid any real failure

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## From Test to Dependability

### (Advanced) Examples

Phase 1 : acquisition & recording

Phase 2 : download

Intraocular pressure recording system (Class 2a)

- Dependability issues:
  - Too high RF power transmitted to the eye → control circuitry
  - Poor contact between sensor and cornea → reference

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## From Test to Dependability

### (Advanced) Examples

The temperature information is transmitted continuously to the reader (acquisition and recording)

Reader

Capsule (Class 2a)

- Autonomy of 10-15 days continuous after activation
- Size : 17.2x8.2mm

The reader is interfaced to a computer to store and analyze the data (download)

- Dependability issues:
  - Power drop down during transit → management circuitry
  - Temperature measurement error → calibration + in-situ checks

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## From Test to Dependability

### Two major items

In Class 2 electronic medical devices, dependability mainly focuses on:

- The safety and the security of the patient:
  - Hardware + software monitors / controllers are embedded, re-using functional and DFT resources
- The accuracy of the practitioner diagnosis:
  - Built-in functions are provided for in-situ test, diagnosis and repair

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## Conclusion

- Test Challenges (for production test)
  - Test equipment
  - Testing time
  - Test access
  - KGD
  - Recursive Testing
- Test solutions (at research level)
  - BIST
  - SiP-TAP
  - ANC
  - Wireless Test
  - Loopback
  - ...
- New Challenge = Dependability
  - BIST, BISD, BISR
  - At System level

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