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Test and Dependability of Microsystems

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Tutorial DTC 2010

Test and Dependability of Microsystems

LIRMM
Serge BERNARD

2010, June 22nd

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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Test Challenges

Test vs. Manufacturing Costs

Price of the Chip

100%
50%
0%

2010 2020

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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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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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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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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

Tolerance Limits on Indirect Parameters

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 core Digital part 1 Digital part 2 Digital part 3 Digital part 4 Analog part 1 Analog part 2 Σ DAC

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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From Test to Dependability

From production test to in situ repair

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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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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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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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From Test to Dependability

How to attain dependability for miniaturized systems?

By implementing / improving...

- **Error detection :**
 - BIST (built-in-self-test)
 - BISR (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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