Proceedings

Seventh Asian Test Symposium
(ATS'98)
# Table of Contents

## Seventh Asian Test Symposium (ATS '98)

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Message from the General Co-Chairs</td>
<td>xii</td>
</tr>
<tr>
<td>Message from the Program Co-Chairs</td>
<td>xiv</td>
</tr>
<tr>
<td>Committees</td>
<td>xvi</td>
</tr>
<tr>
<td>Reviewers</td>
<td>xvii</td>
</tr>
</tbody>
</table>

## Plenary Session: Keynote Address

**Chair:** V. Agrawal, AT&T Bell Labs, USA  
The New Frontier for Testing: Nano Meter Technologies  
**Speaker:** T. Williams, Synopsys, USA

## Session 1A: BIST I

**Chair:** C. Landrault, LIRMM, France  
BIST Diagnostics, Part 1: Simulation Models  
**J. Sauir**

- Configuring Arithmetic Pattern Generators and Response Compactors from the RT-Modules of a Circuit  
  **F. Mayer and A.P. Stroele**  
- Test Cycle Count Reduction in a Parallel Scan BIST Environment  
  **B. Ayari and P. Varma**

- A BIST Scheme for Asynchronous Logic  
  **V.C. Alves, F.M.G. França, and E.P. Granja**

- A Methodology for Minimum Area Cellular Automata Generation  
  **P.S. Cardoso, M. Strum, J.R. de A. Amazonas, and J.C. Wang**

## Session 1B: High-Level Synthesis

**Chair:** B. Courtois, TIMA-INPG, France  
A High-Level Synthesis Method for Weakly Testable Data Paths  
**M. Inoue, T. Higashimura, K. Noda, T. Masuzawa, and H. Fujiwara**

- Alleviating DFT Cost Using Testability Driven HLS  
  **M.L. Flottes, R. Pires, and B. Rouzeyle**

- Optimizing HW/SW Codesign towards Reliability for Critical-Application Systems  
  **F. Vargas, E. Bezerra, L. Wulff, and D. Barros Jr.**

- An Efficient Procedure for Obtaining Implication Relations and Its Application to Redundancy Identification  
  **H. Ichiahora, S. Kajihara, and K. Kinoshita**

- Economical Importance of the Maximum Chip Area  
  **J. Hirase**
Session 1C: Delay Testing

Chair: E. Weis, Chip Eye Technology, Israel

A Probabilistic Model for Path Delay Faults .......................................................... 70
C.-W. Wu and C.-Y. Su

A New Low-Cost Method for Identifying Untestable Path Delay Faults ..................... 76
Z. Li, Y. Min, and R.K. Brayton

False-Path Removal Using Delay Fault Simulation .................................................. 82
M.A. Gharaybeh, V.D. Agrawal, and M.L. Bushnell

An Automatic Test Pattern Generator for At-Speed Robust Path Delay Testing .......... 88
Y.-C. Hsu and S.K. Gupta

Delay Testing with Double Observations ................................................................. 96
H. Li, Z. Li, and Y. Min

Session 2A.1: Fault Modeling & Simulation

Chair: C.-L. Lee, National Chiao Tung University, Taiwan

On a Logical Fault Model H1SGLF for Enhancing Defect Coverage ....................... 102
J. Sang, T. Shinogi, H. Takase, and T. Hayashi

Diagnosis of Single Gate Delay Faults in Combinational Circuits
Using Delay Fault Simulation ...................................................................................... 108
H. Takahashi, K.O. Boateng, and Y. Takamatsu

On the Determination of Threshold Voltages for CMOS Gates to Facilitate Test Pattern Generation and Fault Simulation .......................................................... 113
K.-J. Lee, J.-J. Tang, and W.-Y. Duh

Fault Characterization of Low Capacitance Full-Swing BiCMOS Logic Circuits ........ 119
S.M. Aziz and J. Kamruzzaman

Session 2A.2: Software Testing

Chair: C. Messom, Dubai Polytechnic, OAE

Rough-Hierarchical Testing for Safety Critical Software ............................................. 126
H. Tu, F. Wu, and X. Ren

A Structured Testing Approach for DSP Software .................................................... 131
E.M. La Fosse

Session 2B: Current Testing

Chair: C.V. Jagadish, DVS Technology, Singapore

• IDDQ Testing of Submicron CMOS by Cooling
V. Szekely, M. Renz, S. Torok, and B. Courtois

IDDQ Test Methodology and Tradeoffs for Scan/Non-Scan Designs ....................... 138
M.R. Patel, J. Fierro, and S. Pico

Design for Diagnosability of CMOS Circuits ......................................................... 144
X. Wen, T. Honzawa, H. Tamamoto, K.K. Suluja, and K. Kinoshita

IDDQ Defect Detection in Deep Submicron CMOS ICs ............................................ 150
S. Kundu

ATE Features for IDDQ Testing ............................................................................... 153
M.G. Faust
Session 2C: Test Engineering

Chair: W. Moorhead, Teradyne, Singapore

A New Technique to Ensure Quality of Test Patterns .............................................. 160
P.-C. Koo and S.-L. Pang
Testing CPU Based Boards for Functionality Using Bus Cycle Signature System .......... 165
S.R. Saepatthi
Non-Intrusive Testing of High-Speed CML Circuits .............................................. 172
V. Devdas and A. Ivanov
Fast Window Test Method of Hysteresis Test .................................................. 179
T. Corpuz
Development of a Multi-Channel PC-Based Hard Disk Drive Bode-Plot Generator ....... 184
K.W. Choo, G. Guo, and B.M. Chen

Session 3A: Sequential Circuit Testing

Chair: K. Hatayama, Hitachi, Japan

An Optimal Time Expansion Model Based on Combinational ATPG for RT Level Circuits ................................................................. 190
T. Inoue, T. Hosokawa, T. Mihara, and H. Fujiwara
Static Test Compaction for Scan-Based Designs to Reduce Test Application Time ........ 198
I. Pomeranz and S.M. Reddy
A Non-Scan DFT Method for Controllers to Achieve Complete Fault Efficiency .......... 204
S. Ohtake, T. Masuzawa, and H. Fujiwara
Complete Search in Test Generation for Industrial Circuits with Improved Bus-Conflict Detection ................................................................. 212
J.T. van der Linden, M.H. Konijnenburg, and A.J. van de Goor

Session 3B: Defect Analysis & Fault Diagnosis

Chair: M. Wong, Hong Kong Polytechnic University, Hong Kong

On Testing of Josephson Logic Circuits Consisting of RSFQ Dual-Rail Logic Gates .......... 222
T. Yamada, T. Hanashima, and Y. Suemori
Testing for Floating Gates Defects in CMOS Circuits ......................................... 228
S. Rafiq, A. Ivanov, S. Tabataboei, and M. Renovell
Electron Beam Tester Aided Fault Diagnosis for Logic Circuits Based on Sensitized Paths ................................................................. 237
N. Yanagida, H. Takahashi, and Y. Takamatsu

Session 3C: Boundary Scan & Interconnect Testing

Chair: S. Yano, Kochi University of Technology, Japan

BIST TPG for Combinational Cluster (Glue Logic) Interconnect Testing at Board Level ................................................................. 244
C.-H. Chiang and S.K. Gupta
Fault Detection in a Tristate System Environment .............................................. 253
W. Feng, W.K. Huang, F.J. Meyer, and F. Lombardi
Comprehensive Interconnect BIST Methodology for Virtual Socket Interface
C. Su and Y.-T. Chen

A DFT Methodology for High-Speed MCM Based on Boundary-Scan Techniques
Y. Sameshima and T. Fukazawa

Session 4A: FPGA Testing

Chair: M. Jacomet, Biel School of Engineering, Switzerland

SRAM-Based FPGA's: Testing the Interconnect/Logic Interface
M. Renovell, J.M. Portal, J. Figueras, and Y. Zorian

Built-In Self-Test for Multiple CLB Faults of a LUT Type FPGA
N. Itazaki, F. Matsuki, Y. Matsumoto, and K. Kinoshita

A Diagnosis Method for Interconnects in SRAM Based FPGAs
Y. Yu, J. Xu, W.K. Huang, and F. Lombardi

Testing and Diagnosis of Interconnect Structures in FPGAs
S.-J. Wang and C.-N. Huang

Session 4B: On-Line Testing & Fault Tolerance

Chair: S.M. Azis, Bangladesh University of Engineering & Technology, Bangladesh

An Approach to the On-Line Testing of Operational Amplifiers
J. Velasco-Medina, M. Nicolaidis, and M. Lubaszewski

Self-Dual Duplication for Error Detection
V. V. Saposhnikov, V. V. Saposhnikov, A. Dmitriev, and M. Goessel

On-Line Error Detection Schemes for a Systolic Finite-Field Inverter
Y. C. Chuang and C.-W. Wu

Fault Tolerance of a Tree-Connected Multiprocessor System and Its Arraylike Layout
S. Nakano, N. Kamiura, and Y. Hata

Session 4C: IDDQ Testing

Chair: H. Tamamoto, Akita University, Japan

Observation Time Reduction for IDDQ Testing of Bridging Faults in Sequential Circuits
Y. Higami, K.K. Saluja, and K. Kinoshita

An Off-Chip Current Sensor for IDDQ Testing of CMOS ICs
M. Altaf-Ul-Amin and Z.M. Darus

Integrated Current Sensing Device for Micro IDDQ Test
K. Nose and T. Sakurai

A High-Speed IDDQ Sensor for Low-Voltage ICs
M. Hashizume, Y. Miura, M. Ichimiya, T. Tamesada, and K. Kinoshita
Session 5A: Memory Testing

Chair: W. Tan, Texas Instruments, Singapore

Power Analysis of DRAMs ................................................................. 334
J. Vollrath, M. Huebl, and E. Stahl

Consequences of Port Restrictions on Testing Address Decoder Faults in Two-Port Memories ................................................. 340
S. Hamdioui and A.J. van de Goor

• March LA: A Test for All Linked Memory Faults
A.J. van de Goor, G.N. Gaydadjiev, V.N. Yarmolik, and V.G. Mikitjuk

Dynamic Power Supply Current Testing of CMOS SRAMs ............ 348
J. Liu, R.Z. Makki, and A. Kayssi

March PS(22N) Test for DRAM Pattern-Sensitive Faults ............... 354
V. Yarmolik, Y. Klimets, and S. Demidenko

Session 5B: Analog & Mixed Signal Test

Chair: B. Kaminska, OPMAXX, USA

Dynamic Test Set Generation for Analog Circuits and Systems ....... 360
S. Huynh, S. Kim, M. Soma, and J. Zhang

DC Nonlinear Circuit Fault Simulation with Large Change Sensitivity ................................................................. 366
M.W.T. Wong and M. Worsman

BISTing Switched-Current Circuits ................................................ 372
M. Renovell, F. Azais, J.-C. Bodin, and Y. Bertrand

Analog Module Metrology Using MNABST-1 P1149.4 Test Chip ...... 378
Y.-T. Chen and C. Su

A Methodology and Design for Effective Testing of Voltage-Controlled Oscillators (VCOs) .......................................................... 383
F. Azais, A. Ivanov, M. Renovell, and Y. Bertrand

Theory and Application of Multiple Attractor Cellular Automata for Fault Diagnosis .............................................................. 388

Session 5C: Design Verification

Chair: Y. Iguchi, Yukihiro, Meiji University, Japan

Formal Design Techniques — Theory and Engineering Reality .......... 394
C. Dislis, G. Musgrave, and R.B. Hughes

Verification of Asynchronous Circuits with Bounded Inertial Gate Delays ................................................................. 399
J. Gong and E.M.C. Wong

Verification Pattern Generation for Core-Based Design Using Port Order Fault Model .......................................................... 402
S.-W. Tung and J.-Y. Jou

Application of Real-Time Temporal Logic to Design Fault Detection in Responsive Communication Protocols ......................... 408
S. Nagano, H. Fujita, Y. Kakuda, and T. Kikuno
Design and Simulation of RISC-Based 32-Bit Embedded On-Board Computer ..........413
Z. Guo, H. Li, S. Guo, and D. Wang

• Improving Design Robustness with the Aid of Simulation and
  Statistical Techniques
  S. Mozar and P. Hodgson

Session 6A: BIST II

Chair: M. Lubaszewski, University of Porto Alegre, Brazil

A Ring Architecture Strategy for BIST Test Pattern Generation ..............418
C. Fagot, O. Gascuel, P. Girard, and C. Landrault

Exploiting BIST Approach for Two-Pattern Testing ................................424
X. Li and P.Y.S. Cheung

Evaluating BIST Architectures for Low Power ..................................430
C.P. Ravikumar and N.S. Prasad

A BIST Structure to Test Delay Faults in a Scan Environment .................435
P. Girard, C. Landrault, V. Moreda, S. Pravossoudovitch, and A. Virazel

An Examination of PRPG Selection Approaches for Large, Industrial Designs .....440
I. Bayraktaroglu, K. Udawatta, and A. Orailoglu

Session 6B: Sequential Circuit Testing

Chair: H. Fujiwara, Nara Institute of Science & Technology, Japan

Test Generation for Synchronous Sequential Circuits to Reduce Storage Requirements ..............................................446
I. Pomeranz and S.M. Reddy

Partitioning and Reordering Techniques for Static Test Sequence Compaction of Sequential Circuits .................452
M.S. Hsiao and S.T. Chakradhar

Vector Restoration Using Accelerated Validation and Refinement ............458
S.K. Bommu, S.T. Chakradhar, and K.B. Doreswamy

On Speeding-Up Vector Restoration Based Static Compaction of Test Sequences for Sequential Circuits .........................467
R. Guo, I. Pomeranz, and S.M. Reddy

Synthesis of Sequential Circuits with Clock Control to Improve Testability ........................................472

Session 6C: Test Program Generation

Chair: Q.-F. Chen, Beijing Institute of Automatic Test Technology, China

A Test Pattern Generation Algorithm Exploiting Behavioral Information ........480
S. Chiusano, F. Corno, and P. Prinetto

A Diagnostic Test Generation Procedure for Combinational Circuits Based on Test Elimination .................................486
I. Pomeranz and W.K. Fuchs

Special ATPG to Correlate Test Patterns for Low-Overhead Mixed-Mode BIST ......492
M. Karkala, N.A. Touba, and H.-J. Wunderlich
Test Pattern Generation for Column Compression Multiplier ........................................... 500
P. Zeng, Z. Mao, Y. Ye, and Y. Deng

An Efficient Random-like Testing .................................................................................. 504
S. Xu and J. Gao

Panel Discussion 1: Microsystem Testing: Challenge or Common Knowledge?
Organizer: H.G. Kerkhoff, MESA Research/UT, The Netherlands

Microsystem Testing: Challenge or Common Knowledge? ........................................... 510
H.G. Kerkhoff

Microsystems Testing: A Challenge................................................................. 512
M. Renovell

Bridging the Gap between Microelectronics and Micromechanics Testing .......... 513
M. Lubaszewski

Panel Discussion 2: Testing Embedded Memories: Is BIST the Ultimate Solution?
Organizer: C.W. Wu, National Tsing Hua University, Taiwan

Testing Embedded Memories: Is BIST the Ultimate Solution? .............................. 516
C.W. Wu

An ASIC Designer's Point of View ............................................................................. 518
M. Jacomet

Testing of Embedded Memories — The Aggregate ................................................. 519
R.Z. Maierki

Answers to the Key Issues ......................................................................................... 520
A.J. van de Goor

Author Index .............................................................................................................. 526

ATS'99 Call for Papers ............................................................................................. 529