

**MURI on “The Effects of RF Pulses
on Electronic Circuits and Systems”
(Administered by AFOSR)**

**Introduction to Presentations by
University of Maryland, College Park (UMCP)
and Boise State University (BSU)**

“Overview of Research Progress”

**presented by Victor Granatstein
Second Annual Review 11/14/03**

MAIN TOPICS

- A. Using wave chaos concepts to analyze complicated RF enclosures.**
- B. EM noise mitigation in circuit boards and cavities**
- C. Microwave effects on semiconductor devices, ICs & digital systems**
- D. Testing chaos and nonlinear effects in high speed circuits**

A. Wave Chaos : Significant Progress

(S. Anlage, T. Antonsen, E. Ott, 2 grad Students, 2 UGs)

- **Model gives statistical ensemble of scattering matrices describing coupling into and out of irregular enclosures (Random Coupling Model)**
- **RCM requires only generic input parameters (e.g., cavity Q & impedance of ports)**
- **Predictions of RCM verified in 2-d wave chaotic microwave cavity (1/4 bow tie cavity)**
- **Revolutionary new way to predict properties of irregular enclosures.**

A. Wave Chaos: Interactions/Transitions

- **HPM community and related intelligence community informed of results (AFRL, ARL & NRL visits to UMCP)**
- **Participation in Ad-hoc DOD Working Group on Nonlinear & Chaotic Effects (UMCP hosted their meeting on 4/25/03 and presented wave chaos work there)**
- **X. Zheng, T. Antonsen, E. Ott, “Statistics of Chaotic Scattering Matrices: A Random Coupling Approach” (in draft)**

B. EM Noise Mitigation: Significant Progress

(Omar Ramahi, 4 grad students, 1 M.S. & 1 Ph.D. completed)

- **Developed new concept for noise mitigation in circuit boards using high impedance surfaces (electromagnetic band gap material)**
- **Developed new aperture coating technique that substantially reduces aperture induced resonance**

B. EM Noise Mitigation: Interactions/Transitions

- **Invited presentations at IBM (Res.Triangle Pk., NC), Sun Microsystems. (Burlington, MA), Hewlett Packard (Marlborough, MA), Inco Corp (Toronto, Can) & E-tenna (Laurel, MD)**
- **Keynote talk at annual Nokia meeting in Finland on aperture modeling**
- **Proposal to IBM for expanded study of noise mitigation in PCBs**
- **3 papers in refereed journals, 10 papers in conference proceedings**

C. Microwave Effects on Devices & Circuits

Significant Progress

(N. Goldsman, P. Guzdar, A. Iliadis, B. Jacob, O. Ramahi,
10 grad students, 2 MS & 1 Ph.D. completed, 2 UGs)

- **Developed suite of state-of-the-art simulation tools for simulating EM effects on ICs; showed oxide breakdown occurs for induced voltages 2x power supply voltage (1.3 volts)**
- **On-chip protection circuit under patent review**
- **Identified sources of vulnerability in digital ckts. & used Verilog model to explore architecture-level approaches to mitigation of RF effects**

C. Microwave Effects on Devices & Circuits Interactions/Transitions

- **Working with NSA to develop models for predicting interactions in ICs**
- **Working with ARL to simulate details of wide bandgap semiconductor device operation**
- **2 papers in refereed journals, 7 papers in conference proceedings, patent disclosure**
- **Organizing session on RF Effects & Metamaterials at 2003 Int. Semiconductor Device Research Symposium (ISDRS), Dec. 10-12, 2003**

D. Testing Chaos & Nonlinear Effects in Ckts. Significant Progress

**(S. Anlage, V. Granatstein, J. Melngailis, J. Rodgers,
3 grad students incl. 1 MS completed, 6 UGs)**

- **Deeper understanding of chaos in p/n junctions; e.g., importance of reverse recovery effects**
- **Demonstrated that distributed ckt. containing p/n junction displays chaos**

D. Testing Chaos & Nonlinear Effects in Ckts. Significant Progress (cont.)

- Identified major mechanism responsible for RF upset of ICs ; viz., ubiquitous ESD devices demodulate RF and induced voltages cause bias shift, bit errors, latch, oscillations, noise, etc.
- Showed that spurious resonances could amplify induced voltages by a factor of 6
- Improved on-chip microwave sensor; viz. Schottky diode compatible with CMOS operating at 15 GHz (previous range was < 3 GHz)

D. Testing Chaos & Nonlinear Effects in Ckts. Interactions/Transitions

- **Provided test results on a wide variety of devices to Titan/Jaycor to assist with their modeling of RF effects in DOD systems**
- **Phillips Logic Co. supplying device samples & proprietary design parameters. They have expressed interest in stronger collaboration**
- **Papers presented at 2003 Directed Energy Symposium, AMEREM 2002, 2001 ISDRS, and accepted for presentation at 2003 ISDRS**
- **2 papers in refereed journals**

Research at Boise State University

(R. J. Baker, W. B. Knowlton,

6 grad students incl. 1 MS completed, 6 UG students)

- **Collaboration with J. Melngailis on CMOS compatible Schottky diode**
- **Demonstrated significant degradation in MOSFET operation resulting from gate oxide pulsed stress**
- **Interest in using high frequency pulses with direct tunneling (present in thin oxide layers) to develop new flash memory technology**
- **Cooperation with Micron Technology & Cypress Semiconductor**
- **6 papers in conference proceedings**

Presentations

PART A. WAVE CHAOS

2. “Statistical Properties of Wave Chaotic Scattering Matrices” ----- Presenter: Tom Antonsen
3. “Properties of Complicated Enclosures (Wave Chaos Experiments)” --- Presenter: Steve Anlage

PART B. NOISE MITIGATION

4. “EM Noise Mitigation in Circuit Boards and Cavities” ----- Presenter: Omar Ramahi

Presentations

PART C.

MICROWAVE EFFECTS on DEVICES & CKTS.

5. “EM Effects on Semiconductor Devices, Gates & IC Interconnects” ----- Presenter: Neil Goldman

6. “Microwave Interference Vulnerabilities of Devices in ICs” ----- Presenter: Agis Iliadis

7. “Evaluating Vulnerabilities of Digital Systems’ ----- Presenter: Bruce Jacob

Presentations

PART D. TESTING CHAOS & NONLINEAR EFFECTS in CIRCUITS

8. “Inducing Chaos in the p/n Junction”
----- Presenter: Steve Anlage
9. “RF Transient & Nonlinear Effects in High Speed
Circuits” ----- Presenter: John Rodgers
10. “Schottky Diode RF Detector & Focused Ion
Beam Post-processing” - Presenter John Melngailis

Presentations

RESEARCH at BOISE STATE UNIVERSITY

11. “Degradation in 3.2 nm Gate Oxides:
Effects on Inverter Performance and
MOSFET Characteristics”

----- Presenter: Bill Knowlton