

GaAs IC SYMPOSIUM

IEEE GALLIUM ARSENIDE INTEGRATED CIRCUIT SYMPOSIUM

Co-Sponsored by The IEEE Electron Devices Society
and The IEEE Microwave Theory and Techniques Society

19th
Annual



TECHNICAL DIGEST 1997

ANAHEIM, CALIFORNIA

OCTOBER 12 – 15, 1997

97CH36098

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WELCOME TO THE 1997 IEEE GaAs IC SYMPOSIUM

On behalf of the Executive and Technical Program Committees of the 18th annual IEEE GaAs IC Symposium, it is with great pleasure that I welcome you to Anaheim, California.

Bill Stanchina and the Technical Program Committee have organized an excellent program that will provide a clear view of the present technology capabilities, and stimulate considerable debate about the future. Power Amplifiers for wireless applications, high speed digital communications, high speed computing, and device technology and reliability will be featured in the paper sessions, and panel sessions. We are especially thrilled with the quality of the sixteen Invited papers that form the framework of the twelve technical sessions.

Top industry experts will present the Short Course, "IC Technology for Wireless Communications beyond 2000" offered Sunday. Organized by Mark Wilson, the course leads off with an overview of technology requirements. The complete technology course covers ion implanted and epitaxial MESFET, HBT, PHEMT, and silicon RF MOS.

Our two Vendor Product Forums have become one of our most popular features because they provide technical coverage of the latest products hitting the streets. The four Panel sessions are the place to debate what makes the best linear power amplifier, how to simulate a circuit, what makes the most reliable PHEMT device, or how to build a 40GB/s communication system!

Another popular feature that has become a tradition at the Symposium is the Primer Course. This is the perfect introduction to the next three days for those new to GaAs, or just want to get a better grasp of the basics.

To complement the full technical program, we have provided some time for social interactions as well as an opportunity to interact with the exhibitors while catching up with the newest technology available on the market. The Sunday evening Opening Reception is the place to renew friendships and make new acquaintances. The GaAs Technology Exhibition opens Monday evening where exhibitors will introduce you to new products on display. The Tuesday night Theme party will be conveniently held at the hotel; be prepared for lots of great food and entertainment.

For the first time this year we have guaranteed the Exhibition Luncheon, held Tuesday. This interaction between the exhibitors and the attendees greatly enhances the Technology Exhibition. To make this possible we have begun a program for corporate benefactors to help support the Symposium. This year I would especially like to thank Anadigics, and RF Micro Devices for their support.

I would like to take this opportunity to acknowledge and thank the many individuals whose hard work and dedication has made this year's Symposium a success. The volunteers, working on the Executive and the Technical Program Committees, have put in many hours and have gone "beyond the call of duty" to bring you a well organized and high quality Symposium. I would also like to thank the 1997 International Advisors for promoting the Symposium in Europe and Japan. Special thanks go to all the past chairmen, IEEE Conference Services, and VIP Meetings and Conventions who helped make our jobs easier.

Thank you for attending this year's Symposium and for your continued support. Welcome to Anaheim, California.

**Phil Wallace
Chairman
1997 IEEE GaAs Symposium**

1997 IEEE GaAs IC Symposium

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SYMPOSIUM HEADQUARTERS

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Anaheim, California

SYMPOSIUM AT A GLANCE

SATURDAY, OCTOBER 11, 1997

REGISTRATION (Short Course & Primer Course Only)

6:00 p.m.-8:00 p.m.

Ballroom Foyer

SUNDAY, OCTOBER 12, 1997

REGISTRATION (Short Course & Primer Course Only)

7:00 a.m.-8:00 a.m.

Ballroom Foyer

Continental Breakfast for Short Course

7:00 a.m.-7:45 a.m.

Ballroom Foyer

SHORT COURSE: "IC Technologies for Wireless Applications Beyond 2000"

GaAs Reliability Workshop

8:00 a.m.-4:30 p.m.

Marriott Hall NE

Short Course Lunch

8:00 a.m.-5:00 p.m.

Orange County Ballroom 4 & 5

REGISTRATION for Symposium (and Primer Course until 5:30)

12:00 p.m.-1:30 p.m.

Marriott Hall NW

PRIMER COURSE: "Basics of GaAs Ics"

5:00 p.m.-8:00 p.m.

Ballroom Foyer

Symposium Opening Reception

5:30 p.m.-8:30 p.m.

Marriott Hall NE

6:00 p.m.-9:00 p.m.

Marriott Hall NW

MONDAY, OCTOBER 13, 1997

REGISTRATION

7:00 a.m.-5:00 p.m.

Ballroom Foyer

Continental Breakfast

7:00 a.m.-8:00 a.m.

Ballroom Foyer

SYMPOSIUM OPENING

8:10 a.m.-8:30 a.m.

Marriott Hall N

SESSION A: Plenary Session

8:30 a.m.-11:30 a.m.

Marriott Hall N

PANEL SESSION 1: Will PHEMTs and InP HEMTs survive in your ICs

12:35 p.m.-2:05 p.m.

Marriott Hall NW

VENDOR PRODUCT FORUM 1

12:35 p.m.-2:05 p.m.

Marriott Hall NE

SESSION B: Wireless Power Amplifiers and System Linearity

2:20 p.m.-5:00 p.m.

Marriott Hall NW

SESSION C: High Performance FET Technology

2:20 p.m.-5:00 p.m.

Marriott Hall NE

GaAs IC Technology Exhibition Opening Reception

5:00 p.m.-7:00 p.m.

Marriott Hall Center

SEMI Compound Semiconductor Standards Committee Meeting

8:00 p.m.-10:00 p.m.

TBA

TUESDAY, OCTOBER 14, 1997

REGISTRATION

7:00 a.m.-5:00 p.m.

Ballroom Foyer

Continental Breakfast

7:00 a.m.-8:00 a.m.

Marriott Hall Center

GaAs IC TECHNOLOGY EXHIBITION

7:00 a.m.-4:00 p.m.

Marriott Hall Center

SESSION D: High Performance A/D Converters

8:30 a.m.-10:00 a.m.

Marriott Hall NW

SESSION E: High Speed Data Switching ICs

10:30 a.m.-12:00 noon

Marriott Hall NW

SESSION F: Advanced Devices & HBT Technology

8:10 a.m.-12:00 noon

Marriott Hall NE

Exhibition Luncheon

12:00 noon-1:30 p.m.

Marriott Hall Center

PANEL SESSION 2: Linear, Efficient, Portable PCS Power Amps

1:40 p.m.-3:10 p.m.

Marriott Hall NE

PANEL SESSION 3: Active Device Modeling: User Perspectives

3:30 p.m.-5:00 p.m.

Marriott Hall NE

SESSION G: Reliability & Transient Phenomena

1:50 p.m.-3:10 p.m.

Marriott Hall NW

SESSION H: High Speed Digital Applications & Late News

3:30 p.m.-4:50 p.m.

Marriott Hall NW

Symposium Theme Party

7:00 p.m.-10:00 p.m.

Marriott Hall N

WEDNESDAY, OCTOBER 15, 1997

REGISTRATION

7:00 a.m.-12:00 noon

Ballroom Foyer

Continental Breakfast

7:00 a.m.-8:00 a.m.

Ballroom Foyer

SESSION I: Optical Interconnects and Receivers

8:10 a.m.-9:40 a.m.

Marriott Hall NE

SESSION J: 40Gb/s Optical Communication ICs

10:00 a.m.-11:30 a.m.

Marriott Hall NE

SESSION K: Device Technology & High Performance Circuits

8:10 a.m.-11:30 a.m.

Marriott Hall NW

PANEL SESSION 4: 40 Gb/s (and beyond) TDM for

Optical Fiber Communication Systems

12:30 p.m.-2:00 p.m.

Marriott Hall NE

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Chairpersons: James Komiak,
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Richard Brown,
University of Michigan

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PANEL SESSION 123

Monday, October 13, 1997 - 12:35 p.m. - 2:05 p.m.

WILL PHEMTs AND InP HEMTs SURVIVE IN YOUR CIRCUITS?

Organizer & Moderator:

Kenneth J. Russell, *The Aerospace Corp., Los Angeles, CA*

Katerina Hur, *Hewlett-Packard Co., Santa Rosa, CA*

This panel will discuss issues affecting the reliable application of PHEMT and InP HEMT technology in various systems. These technologies will be compared to the MESFET, from a reliability point of view, to forecast where unique failure mechanisms, or increased sensitivity to old failure mechanisms, may occur. Drift and degradation in performance, as well as catastrophic failure, will be addressed. Environmental sensitivity of these new technologies will be discussed. Industry experience with the PHEMT and InP HEMT technology will be examined to help answer the following questions:

What is required to make PHEMTs and InP HEMTs reliable?

Is it more device development, or circuit or package modifications?

What reliability criteria should be applied for different applications (space, wireless, instruments, etc.)?

How do we demonstrate these criteria?

What future government/industry activity, if any, is needed to insert these technologies into systems successfully?

Panel Members:

Lisa Aucoin	<i>Raytheon</i>
Michael Delaney	<i>Hughes</i>
James Hwang	<i>Lehigh University</i>
Sammy Kayali	<i>Jet Propulsion Laboratory</i>
Kazuhiko Onda	<i>NEC</i>
Paul Saunier	<i>Texas Instruments</i>
Lawrence Studebaker	<i>Hewlett Packard</i>
Alan Swanson	<i>Sanders</i>
C. S. (Chan) Wu	<i>TRW</i>

VENDOR PRODUCT FORUM 1 25

Monday, October 13, 1997 - 12:30 p.m. - 2:00 p.m.

Chairman:

Tim Henderson,
Texas Instruments, Dallas, TX

The 1997 Vendor Product Forum will provide an opportunity for potential customers, business partners, or other interested parties to learn about some of the latest GaAs IC products available for wireless communication applications.

Because of the overwhelming interest in ICs for microwave communications markets, both of the sessions will focus on these types of products. Participants in this year's Vendor Product Forum are among the leaders in the industry. Monday's Forum participants will include:

Honeywell
Rockwell
Anadigics
Siemens
TRW

SESSION B

Monday, October 13, 1997 -- 2:15 p.m.

WIRELESS POWER AMPLIFIERS & SYSTEM LINEARITY

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Brad Nelson,
Pacific Monolithics
Mitchell Shifrin,
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HIGH PERFORMANCE FET TECHNOLOGY

Chairpersons: Katerina Hur,
Hewlett-Packard
Byung-jong Moon,
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SESSION D

Tuesday, October 14, 1997 -- 8:30 a.m.

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Chairpersons: Zachary Lemnios,
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Neng-Haung Sheng,
Rockwell.

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SESSION E

Tuesday, October 14, 1997 -- 10:30 a.m.

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SESSION F

Tuesday, October 14, 1997 -- 8:10 a.m.

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PANEL SESSION 2..... 151

Tuesday, October 14, 1997 -- 1:40 p.m. -- 3:10 p.m.

LINEAR, EFFICIENT, PORTABLE PCS POWER AMPLIFIERS: S/dBc GaAs TECHNOLOGY BATTLE

Organizers/Moderators: Hausila Singh,
ITT
Fazal Ali,
Nokia

Reliable, low cost and linear power amplifiers are needed for portable PCS applications. It is important that these amplifiers are very efficient to provide longer talk time. Several GaAs based technologies are being utilized to develop power amplifiers for PCS applications. It is not known at this moment which technology is favorite? A technology will be the winner if it provides reliable, linear power amplifier with lowest cost and highest performance. The panel members, who are actively involved in PCS power amplifier development, will address linearity, efficiency, reliability, and cost for their technology of choice.

Panel Members:

Jon Jorgenson	<i>RF Micro Devices</i>
Ken Weller	<i>Rockwell International</i>
Damian McCann	<i>Celeritek</i>
Joe DeMoura	<i>Anadigics</i>
Ray Pengelly	<i>Raytheon</i>

PANEL SESSION 3153

Tuesday, October 14, 1997 - 3:30 p.m. - 5:00 p.m.

ACTIVE DEVICE MODELING: USERS' PERSPECTIVES ON COMMERCIAL CIRCUIT SIMULATORS

Organizer/Moderator: Robert Anholt,
Gateway Modeling

One of the curses of bandgap engineering is that it has provided us with so many different types of transistor technologies that the active device models available in commercial circuit simulators must struggle to keep up. This panel explores users' experiences with commercial RF and SPICE simulators. Mike Golio (Rockwell) will speak on quantifying large-signal model performance, device characterization requirements and coping with process variations. Micheal Schlechtweg (Fraunhofer Inst.) will compare analytical and table-based models for HEMTs with respect to accuracy, simulation time and robustness. To deal with over four types of transistor technologies, Texas Instruments supports Libra models for foundry customers. Martin Jones (TI) will describe the frustrations and limitations of this approach. Paul White (Raytheon) will also discuss experiences with supporting active device models in RF simulators. Finally Dave Smith (TriQuint) will describe his experiences supporting the implementation of the TriQuint FET model (TOM) by commercial SPICE simulators.

Panel Members:

Mike Golio	<i>Rockwell</i>
Michael Schlechtweg	<i>Fraunhofer Inst.</i>
Martin Jones	<i>TI</i>
Paul White	<i>Raytheon</i>
Dave Smith	<i>TriQuint</i>

SESSION G

Tuesday, October 14, 1997 -- 1:50 p.m.

RELIABILITY AND TRANSIENT PHENOMENA

Chairpersons: Jan-Erik Mueller,
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Albert Baca,
Sandia National Lab

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Lehigh University, Bethlehem, PA

SESSION H
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Chairpersons: Gary McCormack,
TriQuint
Chung-Yi Su,
Hewlett-Packard

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SESSION I

Wednesday, October 15, 1997 -- 8:10 a.m.

OPTICAL INTERCONNECT AND RECEIVERS

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SESSION J

Wednesday, October 15, 1997 -- 10:00 a.m.

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Chairpersons: John Sitch,
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Mike Roberts,
M/A COM

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SESSION K

Wednesday, October 15, 1997 -- 2:00 p.m.

DEVICE TECHNOLOGY & HIGH PERFORMANCE CIRCUITS

Chairpersons: David Dening,
RF Micro Devices
John Heaton,
Sanders - A Lockheed-Martin Co.

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Tuesday, October 14, 1997 - 12:30 p.m. - 2:00 p.m.

40 Gb/s (AND BEYOND) TDM FOR OPTICAL FIBER COMMUNICATION SYSTEMS

Organizer & Moderator:

Mehran Mokhtari,
Royal Institute of Technology, Stockholm, Sweden

40 Gb/s systems seem to be well on their way to becoming a reality, as demonstrated by the number of papers at the symposium this year. The question still remains however, as to whether 40 Gb/s TDM systems can ever become a "practical" reality. If the answer is yes, then where is the limit? How fast can TDM ultimately go?

Building 40 Gb/s TDM systems poses a new set of problems that extend beyond the design methods used for lower rate systems. Every circuit element, including the interconnect between devices, becomes a complex circuit at 40 Gb/s. The weak link may not be the IC, but the signal path from one chip to the next. Even the test methods to verify performance are being stretched to their limits. Although the results to date look promising, can all the problems be solved?

The panelists will present their views on the achievements to date and the challenges that remain. Topic areas will include a debate over the best technologies (HEMT, HBT, etc.), the competition from Si, packaging and interconnect issues, and where the line between TDM and WDM will finally come to rest.

Panel members will include:

Dr. J. Godin, *CNET*
Dr. T. Otsuji, *NTT*
Prof. M. Rodwell, *UCSB*
Dr. K. Runge, *Rockwell*

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Wednesday, October 15 - 12:30 p.m. - 2:00 p.m.

Chairman: Tim Henderson,
Texas Instruments, Dallas, TX

The 1997 Vendor Product Forum will provide an opportunity for potential customers, business partners, or other interested parties to learn about some of the latest GaAs IC products available for wireless communication applications. Because of the overwhelming interest in ICs for microwave communications markets, both of the sessions will focus on these types of products. Participants in this year's Vendor Product Forum are among the leaders in the industry. Today's speakers include representatives from:

TriQuint
Raytheon
Hewlett-Packard
Texas Instruments
Celeretek

SESSION L

Wednesday, October 15, 1997 -- 2:10 p.m.

MILLIMETER WAVE INTEGRATED CIRCUITS

Chairpersons: Mohammad Madihian,
NEC
Sanjay Moghe,
Northrop Grumman

- L.1 **GaAs MMICs FOR CELLULAR BROADBAND WIRELESS INFRASTRUCTURE: A SYSTEM PERSPECTIVE** 267
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SESSION A

Monday, October 13, 1997 -- 8:30 a.m.

PLENARY SESSION

Chairpersons: James Komiak, *Sanders, a Lockheed-Martin Co.*,
Richard Brown, *University of Michigan*

- A.1 **W-CDMA: AN APPROACH TOWARD NEXT GENERATION MOBILE RADIO SYSTEM, IMT-2000** (Invited Paper), Y. Furuya, *NEC Corp., Tokyo, Japan*
- A.2 **GaAs IN THE BROADBAND INFRASTRUCTURE** (Invited Paper), J. Jakobson, *Tele Danmark, Tranbjerg, Denmark*
- A.3 **GaAs TECHNOLOGY RIDES THE WIRELESS WAVE** (Invited Paper), E. Lum; *Dataquest/Gartner Group, San Jose, CA.*
- A.4 **DESIGN OF THE TERA MTA COMPUTER SYSTEM** (Invited Paper), M. Howard, *Tera Computer Co., Seattle, WA.*
- A.5 **III-V COMPOUND SEMICONDUCTOR MOSFETs USING $\text{Ga}_2\text{O}_3(\text{Gd}_2\text{O}_3)$ AS GATE DIELECTRIC**, F. Ren, M. Hong, J. Kuo, W. Hobson, J. Lothian, H. Tsai, J. Lin, J. Mannaerts, J. Kwo, S. Chu, Y. Chen & A. Cho, *Bell Laboratories, Lucent Technologies, Murray Hill NJ.*

W-CDMA: An Approach Toward Next Generation Mobile Radio System, IMT-2000

Yukitsuna Furuya

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1. Introduction

Rapid growth of cellular industry made cellular phone as an indispensable equipment for human life. Within Japan, cellular phone is changing from a business tool to a personal tool. Demands for higher quality services, such as high capacity systems, wide area coverage (hopefully a world wide coverage), high speech quality, and various kinds of data services are becoming more and more serious. Within ITU-R, standardization efforts toward next generation cellular systems, which satisfy such various demands, have been extensively done. The system was originally called as FPLMTS (Future Public Land Mobile Telecommunication Systems) and is now called IMT-2000 (International Mobile Telecommunications 2000). Requirements for IMT-2000 air interface is summarized in Table 1[1]. Within Japan, study group toward IMT-2000 was formed to make a valuable contribution to ITU-R. After collecting various proposals, followed by two year's evaluation, Wide band CDMA based system is agreed to be a good candidate for IMT 2000[2]. This paper describes the activities within Japan and explains the candidate wide band CDMA systems.

2. Standardization within Japan

The air interface for IMT-2000 has been discussed within FPLMTS Radio Transmission Special Group (referred as " special group " hereafter) in Japan.

The activity of special group is shown in Fig. 1 together with ITU-R standardization schedule[2]. At the first meeting, 29 proposals were submitted from various organizations. They were classified to CDMA technology (20 proposals) and TDMA technology (9 proposals). The detailed technology and system evaluation were discussed within each Ad Hoc group. After the round 1 evaluation, (third meeting), CDMA Ad Hoc group decided that there were four major proposals, System A, System B, System C using CDMA/FDD

technology and single CDMA/TDD system. TDMA Ad Hoc group decided two major candidates; TDMA-A proposal based on equalizer approach and TDMA-B(BDMA) proposal based on OFDM technology.

At the end of the round 2 (fourth meeting), CDMA Ad Hoc group proposed to merge three CDMA/FDD proposals into a single proposal, primarily based on the system A proposal considering some additional features from core B,C proposals. CDMA/FDD proposal and CDMA/TDD proposal formed a unified CDMA proposal, so that system operators can select suitable technology depending on the allocated frequency band. Based on the reported technology and experimental results, the unified CDMA proposal, referred as W-CDMA hereafter, was agreed to be a promising candidate technology for IMT-2000 air interface. A new team was formed to determine more detailed interface specifications for CDMA technology. On the other hand, two core technologies in TDMA Ad Hoc group were regarded as not well proven yet. They were decided to continue evaluation within the Ad Hoc group.

3. W-CDMA System

The application of CDMA technology to mobile radio systems has been reported in various literature and a CDMA based cellular system, called IS-95, has been introduced in several countries[3],[4],[5]. CDMA systems with wider bandwidth and different features from IS-95 have been studied within the study group. Major parameters of CDMA/FDD System A proposal and CDMA/TDD proposals are shown in Table 2,3[1]. Although there are several bandwidth options depending on the frequency allocation, the 5 MHz system is considered as a primary system at this moment.

Compared with IS-95, W-CDMA(5MHz system) has following features[6]:

1) It is easy to provide high bit rate services, such as 144kbps or 384kbps because system bandwidth is wider.