



**1997 IEEE
Radio Frequency
Integrated Circuits
(RFIC) Symposium**

Denver, CO - June 8-11, 1997

Digest of Technical Papers

Digest Editor - James Schellenberg



**Denver Convention Center
June 8-11, 1997**

Sponsored by
THE IEEE MICROWAVE THEORY AND TECHNIQUES SOCIETY
and
THE IEEE ELECTRON DEVICE SOCIETY



IEEE CATALOG NO. 97CH36095

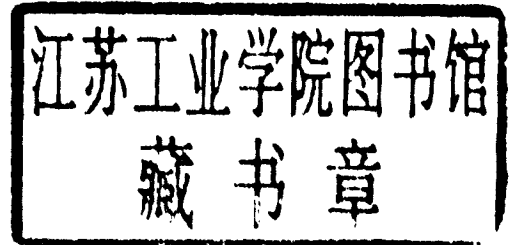


ISSN 0-7803-4603-9

1997 IEEE
RADIO FREQUENCY
INTEGRATED CIRCUITS
(RFIC) SYMPOSIUM

DIGEST OF TECHNICAL PAPERS

Editor: James M. Schellenberg



Sponsored by
THE IEEE MICROWAVE THEORY AND TECHNIQUES SOCIETY
and
THE IEEE ELECTRON DEVICE SOCIETY

97CH36095

Copies available from:
IEEE Service Center

IEEE Catalog Number 97CH36095
ISBN 0-7803-4063-9 (softbound)
ISBN 0-7803-4064-7 (casebound)
ISBN 0-7803-4065-5 (microfiche)
ISBN 0-7803-4066-3 (CD-Rom)
Library of Congress: 97-72646

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries are permitted to photocopy beyond the limits of U.S. copyright law for private use of patrons those articles in this volume that carry a code at the bottom of the first page, provided the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 29 Congress St., Salem, MA 01970. Instructors are permitted to photocopy isolated articles for noncommercial classroom use without fee. For other copying, reprint or republication permission, write to Director, Publishing Service, IEEE, 345 E. 47th St., New York, NY 10017. All rights reserved. Copyright © 1997 by The Institute of Electrical and Electronics Engineers, Inc.

1997 IEEE Radio Frequency Integrated Circuits Symposium Schedule

The 1997 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium will be held on Sunday, Monday, Tuesday and Wednesday, June 8–11, 1997, in conjunction with the International Microwave Symposium (IMS), at the Denver Convention Center (DCC). Sessions open to attendees of both symposia include the workshop on Sunday, three joint sessions on Tuesday, and the Open Forum on Wednesday where several RFIC papers will be presented.

Sunday, June 8, 1997

7:00 am–9:00 pm	Workshop Registration—CC Lobby A
5:00 pm–9:00 pm	IMS/RFIC Registration—CC Lobby A
7:00 pm–10:00 pm	RFIC Reception—Marriott Colo. Ballroom

Monday, June 9, 1997

7:00 am–5:00 pm	IMS/RFIC Registration—CC Lobby A
7:00 am–8:00 am	Speaker's Breakfast—CC Exh. Hall B2
7:00 am–8:00 am	Continental Breakfast—CC Exh. Hall B2
7:00 am–5:00 pm	Speaker's Prep Room—CC A210/A208
8:30 am–5:00 pm	Technical Sessions—CC C201/205, C207, C209
12:00 noon–1:15 pm	Panel Session—CC C201/205
6:00 pm–10:00 pm	Microwave Journal Reception—Natural History Museum

Tuesday, June 10, 1997

7:00 am–5:00 pm	IMS/RFIC Registration—CC Lobby A
7:00 am–8:00 am	Speaker's Breakfast—CC Ballroom 1
8:00 am–5:10 pm	Technical Sessions (Joint with IMS)—CC A201

Wednesday, June 11, 1997

7:00 am–5:00 pm	IMS/RFIC Registration—CC Lobby A
2:00 pm–5:00 pm	Open Forum—CC Ballroom 4

Message from the General Chairman



On behalf of the Steering Committee, I would like to welcome you to the 1997 IEEE Radio Frequency Integrated Circuits (RFIC) Symposium. This new and exciting Symposium expands from our previous Microwave & Millimeter-wave Monolithic Circuits (MMWMC) Symposium. The MMWMC Symposium was created in 1982 to provide a focused forum for emerging MMIC technology. For the past 15 years, this Symposium encouraged the rapid advancement of the technology and facilitated its application in DoD and commercial systems. Today, approximately half of all papers presented during Microwave Week are related to the monolithic technology. We are very pleased that the MMWMC Symposium has served our society and membership well and has made a significant impact on our technology development.

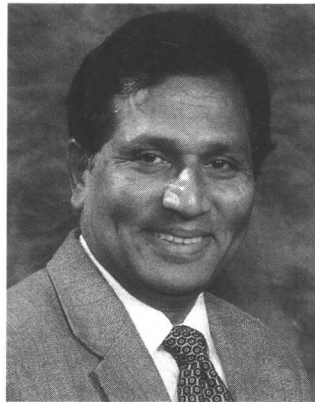
After observing the technology and business changes in the wireless industry and the high-volume production community, the Steering Committee began to implement the re-focus of the Symposium two years ago. The feedback we received from previous attendees and our membership is that there is a need for more emphasis on Si and GaAs RFICs for commercial applications. With all of this input taken into account, we decided to expand the MMWMC Symposium in several ways: to cover both Si and GaAs technology instead of GaAs only, to provide the high volume and low-cost technique emphasis, and to include both R&D and production development.

To reflect this expansion of the Symposium's scope, we changed the symposium name to Radio Frequency Integrated Circuits (RFIC) Symposium. We expect to bring you the newest developments in highly integrated ICs; ICs for wireless communications, GPS and automotive radars; Si bipolar, CMOS, BiCMOS and GaAs design techniques; design for manufacturability; and RFIC packaging.

This is the first year of the RFIC Symposium. I hope that you will hear the presentations of many interesting papers and learn new technology from the technical sessions, Sunday Workshop and Monday Panel Session. I also hope that you will meet many new friends. To ensure the continued success of this symposium, I would like to receive your feedback on areas that we can improve. If you like this Symposium, please tell your colleagues and invite them to attend and submit a paper. I look forward to seeing you in Denver.

Louis C.T. Liu, General Chairman

Message from the Technical Program Chairman



On behalf of the Technical Program Committee, it is my pleasure to welcome you to the 1997 IEEE Radio Frequency Circuits (RFIC) Symposium. This new and exciting symposium focuses on highly integrated ICs or subsystems that include RF functions at any frequency.

This year we have put together an outstanding conference for you. Recent advancements in RFICs suitable for wireless and other communication applications are highlighted at this symposium. Original papers describing low cost silicon and GaAs MMICs and subsystems for commercial and military applications are also announced at this conference.

Five invited talks from senior technologists from Europe, Japan and USA will provide additional impetus to this new symposium. These talks cover trends and changes in the wireless communication industry, Radio Frequency Identifications (RFID), Si MMIC applications, RFIC transceivers, and highly integrated ICs for GSM and DECT.

We have also arranged a focused session consisting of six papers on silicon MMICs to bring you the latest in the silicon RFICs.

A total of 26 contributed papers were selected for oral presentations from 51 papers submitted to RFIC. An additional 4 papers were chosen for the Open Forum. International exposure of this conference is evident from the fact that about half of the papers submitted were from outside the continental US.

The technical papers have been arranged into three parallel sessions on Monday. On Tuesday we have joint sessions with IMS subcommittees on Monolithic Technology and Low Noise Amplifiers. Open forum papers will be presented on Wednesday afternoon. Due to the fixed time schedule we could not accommodate many good papers. I thank all the authors who submitted the papers to this symposium and encourage them to continue to submit papers in the future as well.

This year we are co-sponsoring three workshops, two on Sunday and one on Friday. The Sunday workshops are on 'Low Voltage Low Power Consumption RFICs for Wireless Communication Products' and 'Measurements for Silicon and GaAs Telecommunications ICs.' Friday workshop addresses 'Epitaxial Material Manufacturing for HEMT and HBTs.' The panel session on Monday discusses device technology choices for commercial portable power amplifiers.

The TPC members contributed significantly to bring you a top quality program for this symposium. I extend my sincere thanks and appreciation to each member of the TPC. Last but not least, I want to thank the authors, the invited speakers, and the panelist for enabling us to present you an exciting symposium.

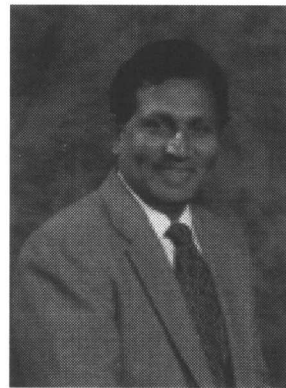
I look forward to seeing you in Denver, Colorado.

Vijay Nair
Technical Program Committee Chairman
1997 IEEE RFIC Symposium

1997 RFIC Committees



Louis Liu
Chairman



Vijay Nair
Co-Chairman

Steering Committee



back row: I. Bahl, J. Schellenberg, E. Cohen, M. Calcaterra, E. Strid, H.-C. Huang, D. Williams
front row: R. Kagiwada, F. Ali, V. Nair, L. Liu, C. Kermarrec, M. Kumar, T. Tokumitsu

Technical Program Committee



back row: J. Moniz, S. Heinen, D. Lovelace, J. Schellenberg, E. Strid
front row: M. Kumar, R. Kagiwada, V. Wair, H.-C. Huang, I. Bahl



back row: L. Liu, J. Mandal, M. Calcaterra, E. Cohen, S. Kiaei
front row: T. Tokumitsu, F. Ali, M. Madhian, A. Adar, C. Kermarrec

Table of Contents

Technical Program

MONDAY, JUNE 9, 1997

8:30 am–10:00 am
C201/205

Session I: ADVANCEMENT OF WIRELESS TECHNOLOGY AND ITS APPLICATIONS (Invited Session)

Chair: V. Nair, *Motorola*

Co-chair: L. Liu, *TRW*

Welcome and Introduction

I-1	(Invited) Wireless Portable Communications Trends and Challenges, J.S. Escher, <i>Motorola, Inc., Tempe, AZ</i>	1
I-2	(Invited) Traditional and Emerging Technologies and Applications in the Radio Frequency Identification (RFID) Industry, J.R. Tuttle, <i>Micron Communications, Inc., Boise, ID</i>	5
I-3	(Invited) On-Chip Matching Si-MMIC for Mobile Communication Terminal Application, N. Suematsu, <i>Mitsubishi Electric Corp., Kanagawa, Japan</i>	9

MONDAY, JUNE 9, 1997

10:30 am–11:50 noon
C201/205

Session II: SILICON RF TECHNOLOGY

Chair: C. Kermarrec, *Analog Devices*

Co-chair: J.M. Moniz, *IBM*

II-1	High Gain, High Efficiency, Low Voltage, Medium Power Si-Bipolar Transistor Suitable for Integration, F. van Rijs, R. Dekker, P.H.C. Magnée, R. Vanoppen, E. v.d. Heijden, B.N. Balm*, and L.C. Colussi*, <i>Philips Research Laboratories, Eindhoven, The Netherlands; *Philips Semiconductors, Nijmegen, The Netherlands</i>	15
II-3	A 5.8-GHz 1-V Low-Noise Amplifier in SiGe Bipolar Technology, M. Soyuer, J-O. Plouchart, H. Ainspan and J. Burghartz, <i>IBM T.J. Watson Research Center, Yorktown Heights, N.Y.</i>	19
II-4	A Silicon MOS MMIC Upconverter for CATV Applications, J. Birkeland and R. Sherman, <i>Motorola SPS, Tempe, AZ</i>	23

MONDAY, JUNE 9, 1997

10:30 am–11:50 noon
C207

Session III: GaAs TECHNOLOGY

Chair: M. Kumar, *Lockheed Martin*

Co-chair: T. Tokumitsu, *NTT*

III-1 10:30 am	A GaAs MMIC MMDS Downconverter, J. Birkeland, R. Sherman, R. Potyka, M. Zou, and J. Carbacio, <i>Motorola SPS, Tempe, AZ</i>	29
III-2 10:50 am	A Low-Cost Packaged MMIC Chip Set for 5.8 GHz ISM Band Applications, M.D. Pollman, C. Trantanella, M. Shifrin, V. Aparin and D. Upton, <i>Hittite Microwave Corporation, Woburn, MA</i>	33
III-3 11:10 am	Single 2.2 V Operation MMIC Power Amplifier Utilizing SrTiO ₃ Capacitors for 2.4GHz Wireless Communication Systems, T.B. Nishimura, K. Yamaguchi, N. Iwata, M. Tomita, K. Takemura, M. Kuzuhara and Y. Miyasaka, <i>NEC Corporation, Shiga, Japan</i>	37
III-4 11:30 am	Embedded Transmission Line (ETL) MMIC for Low-Cost, High-Density Wireless Communication Applications, H.-Q. Tserng, P. Saunier, A. Ketterson, L. Witkowski and T. Jones, <i>Texas Instruments, Dallas, TX</i>	41

MONDAY, JUNE 9, 1997

10:30 am–11:50 am
C209

Session IV: RF CIRCUIT TECHNIQUES

Chair: I. Bahl, *ITT GTC*

Co-chair: H.C. Huang, *AMCOM Communications, Inc.*

IV-1 10:30 am	Monolithic GaAs, Multi-Throw Switches with Integrated Low-Power Decoder/Driver Logic, J. Smuk and M. Shifrin, <i>Hittite Microwave Corporation, Woburn, MA</i>	47
IV-2 10:50 am	Low Power, Monolithic Tunable Recursive Filters Having Variable and Uniform Gain, J.-S. Ko* and K. Lee, <i>KAIST, Taejon, Korea; *Samsung Electronics Co., Kyungki-Do, Korea</i>	51
IV-3 11:10 am	AlGaAs/GaAs HBT Limiting Amplifier for 10Gbp/s Optical Transmission System, B. Kwark and M.S. Park, <i>Electronics and Telecommunications Research Institute, Daejeon, Korea</i>	55
IV-4 11:30 am	Analog RF-Optoelectronic Integrated Circuit Receivers, D. Yap, R.H. Walden, Y.-M. Xie, Y.K. Brown, J. Vivilecchia* and A.C. Yee*, <i>Hughes Research Laboratories, Malibu, CA; *MIT Lincoln Laboratory, Lexington, MA</i>	59

MONDAY, JUNE 9, 1997

1:30 pm–2:30 pm
C201/205

Session V: RFIC TRANSCEIVERS
(Invited Session)

Chair: F. Ali, *Nokia Mobil Phones*

Co-chair: D. Lovelace, *Motorola, SPS*

- V-1** (Invited) **The Future of RFIC Transceiver Technology**, C. Kermarrec, G. Dawe,
1:30 pm T. Tewksbury and T. Brown, *Analog Devices Inc., Wilmington, MA* 65
- V-2** (Invited) **Highly Integrated RF-ICs for GSM and DECT**, J. Fenk, *SIEMENS AG*,
2:00 pm *Munich, Germany* 69

MONDAY, JUNE 9, 1997

2:50 pm–5:00 pm
C201/205

Session VI: MM Wave RFICs

Chair: J. Mondal, *Northrop Grumman*

Co-chair: M. Madihian, *NEC Corp.*

- VI-1** **A Novel 12-24 GHz Broadband HBT Distributed Active Balanced Mixer**,
2:50 pm K.W. Kobayashi, L.T. Tran, M. Lammert, T.R. Block, A.K. Oki and D.C. Streit, *TRW, Redondo Beach, CA* 75
- VI-2** **A Monolithic 24-GHz Frequency Source Using InP-Based HEMT-HBT Integration**
3:10 pm **Technology**, H. Wang, E. Lin, D.C.W. Lo, R. Lai, L. Tran, J. Cowles, Y.C. Chen,
T. Block, P.H. Liu, H.C. Yen and K. Stamper*, *TRW, Redondo Beach, CA*;
**Wright-Patterson AFB, Ohio* 79
- VI-3** **A Novel Monolithic HEMT-HBT Ka-band VCO-Mixer Design**, K.W. Kobayashi,
3:30 pm A.K. Oki, D.K. Umemoto, T.R. Block, and D.C. Streit, *TRW, Redondo Beach, CA* 83
- VI-4** **Ultra-fast, Low-Power Integrated Circuits in a Scaled Submicron HBT IC**
3:50 pm **Technology**, M. Hafizi and J.F. Jensen, *Hughes Research Lab, Malibu, CA* 87
- VI-5** **Monolithic 77- and 94-GHz InP-Based HBT MMIC VCOs**, H. Wang, L. Tran,
4:10 pm J. Cowles, E. Lin, P. Huang, T. Block, D. Streit and A. Oki, *TRW, Redondo Beach, CA* 91
- VI-6** **50-100GHz Octave Band MMIC Mixers**, K. Kamozaki, N. Kurita, T. Tanimoto,
4:30 pm H. Ohta, T. Nakamura and H. Kondoh, *Hitachi, Ltd., Tokyo, Japan* 95

MONDAY, JUNE 9, 1997
2:50 pm–5:00 pm
C207

**Session VII: SILICON BASED TECHNOLOGIES FOR RF MONOLITHIC ICS
(Focused Session)**

Chair: L.B.P. Katehi, *The University of Michigan*

Co-chair: G. Ponchak, *NASA Lewis RC*

VII-1 2:50 pm	High Frequency Interconnects on Silicon Substrates , G.E. Ponchak, A.N. Downey, and L.P.B. Katehi*, <i>NASA Lewis Research Center, Cleveland, OH; *University of Michigan, Ann Arbor, MI</i>	101
VII-2 3:10 pm	SiGe SIMMWICs , J.-F. Luy and P. Russer*, <i>Daimler-Benz Research Center, Wilhelm-Runge Str., Germany; *Lehrstuhl für Hochfrequenztechnik, München, Germany</i>	105
VII-3 3:30 pm	A Fully Monolithic HMIC Low Noise Amplifier , T. Boles, <i>M/A-COM, Burlington, MA</i>	109
VII-4 3:50 pm	Three-Dimensional Masterslice MMIC on Si Substrate , I. Toyoda, K. Nishikawa, T. Tokumitsu, K. Kamogawa, C. Yamaguchi*, M. Hirano* and M. Aikawa, <i>NTT Wireless Systems Laboratories, Kanagawa, Japan; *NTT System Electronics Laboratories, Kanagawa, Japan</i>	113
VII-5 4:10 pm	SiGe MMICs and Flip-Chip MICs for Low-Cost Microwave Systems , M. Case, <i>Hughes Research Laboratories, Malibu, CA</i>	117
VII-6 4:30 pm	Silicon Low Noise Amplifier Chips for Multi-Chip Module Integration on a Silicon-Based Substrate , J. Lin, J.S. Weiner, H.-S. Tsai, G. Georgiou, Y.-K. Chen, K.L. Tai, M.Y. Lau and D.P. Kossives, <i>Bell Laboratories, Murray Hill, NJ</i>	121

MONDAY, JUNE 9, 1997
2:50 pm–5:00 pm
C209

Session VIII: HIGHLY INTEGRATED TRANSCEIVERS

Chair: S. Kiaei, *Oregon State University*

Co-chair: S. Heinen, *Siemens AG*

VIII-1 2:50 pm	An Integrated Bipolar Transmitter for DECT , S. Heinen, K. Hadjizada, U. Matter, W. Geppert, V. Thomas*, S. Weber*, S. Beyer* and J. Fenk*, <i>Siemens AG, Düsseldorf, Germany</i> , * <i>Siemens AG, München, Germany</i>	127
VIII-2 3:10 pm	A Highly Integrated Radio Transceiver Chipset for DECT , J. Strange and S. Atkinson, <i>Analog Devices, Kent, UK</i>	131
VIII-3 3:30 pm	The Measured and Predicted Noise Figure of a GaAs Heterojunction Bipolar Transistor Mixer , B.A. Xavier and C.S. Aitchison*, <i>Hughes Network Systems; Brunel University</i>	135
VIII-4 3:50 pm	An Integrated 2GHz 500mW Bipolar Amplifier , S. Weber and G. Donig, <i>Siemens AG, Munich, Germany</i>	139
VIII-5 4:10 pm	A New Paradigm for Base Station Receivers, High IF Sampling and Digital Filtering , T. Gratzek, B. Brannon, J. Camp, and F. Murden, <i>Analog Devices, Greensboro, NC</i>	143
VIII-6 4:30 pm	A Self Calibrating Quadrature Generator with Wide Frequency Range , D. Lovelace and J. Durec, <i>Motorola, Inc., Tempe, AZ</i>	147

TUESDAY, JUNE 10, 1997

8:00 am–10:00 am
A201

Session IX: AMPLIFIER TECHNOLOGY
(Joint RFIC and IMS Session)

Chair: J. Schellenburg, *Schellenburg Associates*
Co-chair: S. Weinreb, *University of Massachusetts*

IX-1 8:00 am	Silicon RF GCMOS Performance for Portable Communications Applications, E. Spears, D. Ngo, J. Ma, H.B. Liang, D. Spooner, F. Ford, S. Cheng, B. Courson, B. Yeung, J. Alvarez, J. Bhalla and D. Lamey, <i>Motorola, Tempe, AZ</i>	153
IX-2 8:20 am	High Dynamic Range Variable Gain Amplifier for CDMA Applications, M. Kasashima, S. Tachi and K. Tanaka, <i>Oki Electric Industry Co., Ltd., Tokyo, Japan</i>	157
IX-3 8:40 am	A Novel Integrated Microwave Bias Network for Low Cost Multistage Amplifiers, H. Morkner, M. Frank, K. Negus and T.-M. Kao, <i>Hewlett-Packard, Newark, CA</i>	161
IX-4 9:00 am	MMIC GaAs Transimpedance Amplifiers for Optoelectronic Application, Ph. Duême, M. Schaller, D. Mathoorasing*, S. Bouchoule*, C. Kazmierski*, S. Maricot [†] and Ch. Rumelhard [‡] , <i>Dassault Electronique, Saint-Cloud, France</i> , * <i>Centre National d'Etudes</i> <i>et Télécommunications, Bagnex</i> ; [†] <i>Institut d'Electronique, France</i> ; [‡] <i>Conservatoire des Arts</i> <i>et Métiers, Paris, France</i>	165
IX-5 9:20 am	Ka-Band Ultra Low Noise MMIC Amplifier Using Pseudomorphic HEMTs, S. Fujimoto, T. Katoh, T. Ishida, T. Oku, Y. Sasaki, T. Ishikawa and Y. Mitsui, <i>Mitsubishi Electric Corporation, Hyogo, Japan</i>	169

TUESDAY, JUNE 10, 1997

1:20 pm–3:00 pm

A201

Session X: MONOLITHIC WIRELESS TECHNOLOGY

(Joint RFIC and IMS Session)

Chair: N. Camilleri, *Advanced Micro Devices*

Co-chair: Z. Bardai, *Hughes Aircraft*

X-1 1:20 pm	Silicon RF-GCMOS IC Technology for RF Mixed-Mode Wireless Applications, J. Ma, H.-B. Liang, D. Ngo, E. Spears, B. Yeung, B. Courson, D. Spooner, D. Lamey, J. Alvarez, T. Teraji, J. Ford and S. Cheng, <i>Motorola, Tempe, AZ</i>	175
X-2 1:40 pm	Optimization of High Q CMOS-Compatible Microwave Inductors Using Silicon CMOS Technology, M. Park, S. Lee*, H.K. Yu and K.S. Nam, <i>Electronics and Telecommunications Research Institute, Taejon, Korea; *Hankuk University of Foreign Studies, Kyungki-do, Korea</i>	181
X-3 2:00 pm	Low-Frequency Noise Characteristics of Self-Aligned AlGaAs/GaAs HBT'S with a Noise Corner Frequency Below 3 KHZ, J.-H. Shin* [†] , J. Kim*, Y. Chung*, J. Lee [‡] , K.H. Ahn* and B. Kim*, <i>*POSTECH, Kyung-pook, Korea; [†]LG Cooperative Institute of Technology, Seoul, Korea; [‡]Hyundai Electronics Industries Co., Ltd., Kyoungki-do, Korea</i>	185
X-4 2:20 pm	28 V Low Thermal Impedance HBT with 20 W CW Output Power, D. Hill and T. Kim, <i>Texas instruments Inc., Dallas, TX</i>	189
X-5 2:40 pm	High-Reliability GaAs HBT Monolithic Microwave Amplifier, F.M. Yamada, A.K. Oki, D.C. Streit, D.K. Umemoto, L.T. Tran, T.R. Block, D.T. Okazaki, M.M. Hoppe and E.A. Rezek, <i>TRW Inc., Redondo Beach, CA</i>	193
X-6 2:50 pm	Systematic Investigations on MESFETs and Passive Components Transplanted by Expitaxial Lift Off Onto Host Materials with Various Resistivities, T. Morf, C. Biber* and W. Bächtold*, <i>Swiss Federal Institute of Technology; *Laboratory for Electromagnetic Fields and Microwave Electronics, Zürich, Switzerland</i>	197

TUESDAY, JUNE 10, 1997

3:30 pm–5:10 pm

A201

Session XI: MILLIMETER-WAVE MONOLITHIC CIRCUITS

(Joint RFIC and IMS Session)

Chair: H.A. Hung, *TRW*

Co-chair: S.S. Bharj, *Princeton Microwave Technology*

- XI-1** **A 6 Watt Ka-Band Power Module Using MMIC Power Amplifiers**, D.L. Ingram, D.I. Stone, T.W. Huang, H. Wang, M. Siddiqui, M. Nishimoto, B. Allen, D. Tamura, R. Lai, M. Biedenbender and H.C. Yen, *TRW, Inc., ESTD, Redondo Beach, CA*
(Paper not available at time of printing)
- XI-2** **Compact Integrated Coplanar T/R-Modules for Automotive Applications**, L. Verweyen, 3:50 pm
A. Bangert, H. Massler, T. Fink, M. Neumann, R. Osorio, T. Krems, T. Jakobus, W.H. Haydl and M. Schlechtweg, *Fraunhofer Institute, Freiburg, Germany* 203
- XI-3** **A V-Band GaAs MMIC Chip Set on a Highly Reliable WSi/Au Refractory Gate Process**, 4:10 pm
J. Mizoe, T. Matsumura, K. Unosawa, Y. Akiba, K. Nagai, H. Sato, T. Saryo and T. Inoue, *NEC Corporation, Kawasaki, Japan* 207
- XI-4** **A D-LDD (Double Lightly-Doped Drain) Structure H-MESFET for MMIC Applications**, 4:20 pm
Y. Yamane, K. Onodera, T. Nittono, K. Nishimura, K. Yamasaki and A. Kanda, *NTT System Laboratories, Kanagawa, Japan* 211
- XI-5** **Low Phase Noise Ka-Band VCOs using InGaP/GaAs HBTs and Coplanar Waveguide**, 4:40 pm
M.S. Heins, D.W. Barlage, M.T. Fresina, D.A. Ahmari, Q.J. Hartmann, G.E. Stillman, and M. Feng, *University of Illinois at Urbana, Urbana, IL* 215
- XI-6** **1 Watt, 65% PAE K-Band AlGaAs/GaAs Heterojunction Bipolar Transistors Using Emitter Air-Bridge Technology**, 5:00 pm
H.-F. Chau, D. Hill, R. Yarborough and T. Kim, *Texas Instruments Inc., Dallas, TX* 219

WEDNESDAY, JUNE 11, 1997

2:00 pm–5:00 pm
CC - Ballroom 4

RFIC Open Forum 1: PAPERS
(Joint with IMS)

- WE3F-1** **A Monolithic GaAs PIN Switch Network For A 77 GHz Automotive Collision Warning Radar**, J. Putnam, M. Barter, K. Wood* and J. LeBlanc*, *M/A-COM, Burlington, MA*;
**Millitech Corporation, South Deerfield, MA* 225
- WE3F-2** **Temperature Analysis and On-Chip Compensation for an UHF VCO**, Y. Sun, H.G. van Veenendaal* and J.L. Tauritz, *Delft Institute of Microelectronics and Submicrontechnology, The Netherlands*; **Philips Semiconductors Systems Laboratory Eindhoven, The Netherlands* 229
- WE3F-3** **Multilayer Passive Components for Uniplanar Si/SiGe MMICs**, T. Gokdemir, U. Karacaoglu*, D. Budimir, S.B. Economides, A. Khalid, A.A. Rezazadeh and I.D. Robertson, *King's College London, London, UK*; **San Diego Tech. Centre, San Diego, CA* 233
- WE3F-4** **Analysis of Ground Bond Wire Arrays for RFICs**, H. Patterson, *Motorola Inc., Tempe, AZ* 237

(Invited)
**Wireless Portable Communications
Trends and Challenges**

John S. Escher, Senior Member IEEE
Motorola
Phoenix Corporate Research Laboratories
2100 E. Elliot Road, Tempe, Arizona 85284

ABSTRACT

The electronic wireless communications age has its earliest origins with Thomas Edison and Guglielmo Marconi about 100 years ago. Early R&D on portable communications systems was carried out over forty years ago at AT&T Bell Labs, who led much of the earliest development in communications in the United States. Motorola pursued mobile wireless communications research beginning in the 1960s resulting in the first mobile cellular telephone service in the early 1980s. Decades of continuous cost / performance improvements from the semiconductor and IC packaging industry have had a dramatic impact on reducing the costs, and hence affordability, of all forms of commercial electronics and communications systems. Furthermore, the recent decade has seen an increased desire for personal and business communications mobility, security and access to information at any time, anywhere. Many of these factors have launched numerous commercial wireless communications systems, such as paging and cellular phone systems from a relatively high-end niche market into the multi-billion dollar consumer electronics businesses of today.

I. THE MARKET

Currently there are about 145 million analog and digital cellular phone customers in the world. About one third of these customers are in the United States. They average about one hundred air time minutes per month. Growth rates of wireless communication products such as cellular phones are very significant. From now through the year 2000, CAGR forecasts for digital cellular phone service is at about 30%. Analog cellular phones will continue to be in demand for many years to come as the lowest - cost solution for emerging and lower volume markets. However only two percent of all phone calls in the US. are currently made using a cellular phone.

As the cost of ownership and usage of wireless communications has come down there has been a dramatic expansion of wireless communication products into the newly developing countries of the world as well. There is a significant demand for reliable phone service in the poorer countries around the world. Wired phone service can not meet this demand fast enough. A paging system, for example, can be installed and made operational in only a few weeks time, giving reliable communications to