

2009

International Technology Roadmap for Semiconductors

Radio Frequency and Analog/Mixed-Signal Technologies for Wireless Communications Working Group

On behalf of the RF and AMS WG

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ITRS Summer Meeting



Outline

- Organization
- Scope
- Unique Feature of RF and AMS
 - More than Moore from the beginning
- Key Considerations
- Major Changes since 2008 ITRS Update
- Key Challenges
- Conclusions

2009 Membership

Name	Affiliation	Name	Affiliation
Pascal Ancy	STMicroelectronics	Yukihiro Kiyota	Sony Corporation,
Herbert S. Bennett	NIST	Sebastian Shyi-Ching Liao	Industrial Technology Research Institute
Volker Blaschke	Jazz Semiconductor	Ginkou Ma	Industrial Technology Research Institute
Bobby Brar	Teledyne Scientific and Imaging	Jan-Erik Mueller	Infineon Technologies
Wayne Burger	Freescale Semiconductor, Inc	Takashi Nakamura	Omron Corp
Pascal Chevalier	STMicroelectronics	Hansu OH	Samsung Electronics Co., Ltd.
David Chow	HRL	Jack Pekarik	IBM Corporation
Julio Costa	RFMD	Ed Preisler	Jazz Semiconductor
Stefaan Decoutere	IMEC	Marco Racanelli	Jazz Semiconductor
Jonathan Hammond	RFMD	Mark Rosker	DARPA
Erwin Hijzen	NXP Semiconductors,	Bernard Sautreuil	STMicroelectronics
Digh Hisamoto	Hitachi Ltd.,	Tony Stamper	IBM Corporation
Dave Howard	Jazz Semiconductor	Alberto Valdes-Garcia	IBM Corporation
W. Margaret Huang	Freescale Semiconductor, Inc	Sorin Voinigescu	University of Toronto
Matthias Illing	Bosch	Dawn Wang	IBM Corporation
Anthony A. Immorlica Jr.	BAE Systems,	Albert Wang	University of California
Jay John	Freescale Semiconductor, Inc	Dennis Williams	WinSemi
Alvin Joseph	IBM Corporation	Peter Zampardi	Skyworks Solutions, Inc
Mattan Kamon	Coventor, Inc.	Herbert Zirath	Chalmers University
Tom Kazior	Raytheon RF Components		



2009 Organization

Chair: Jack Pekarik, IBM 39 Members in 2009 / 43 Members in 2008

Co-chairs: Jan-Erik Mueller, Infineon 25 NA, 7 EU, 7 AP

Sebastian Liao, ITRI

Margaret Huang, Freescale

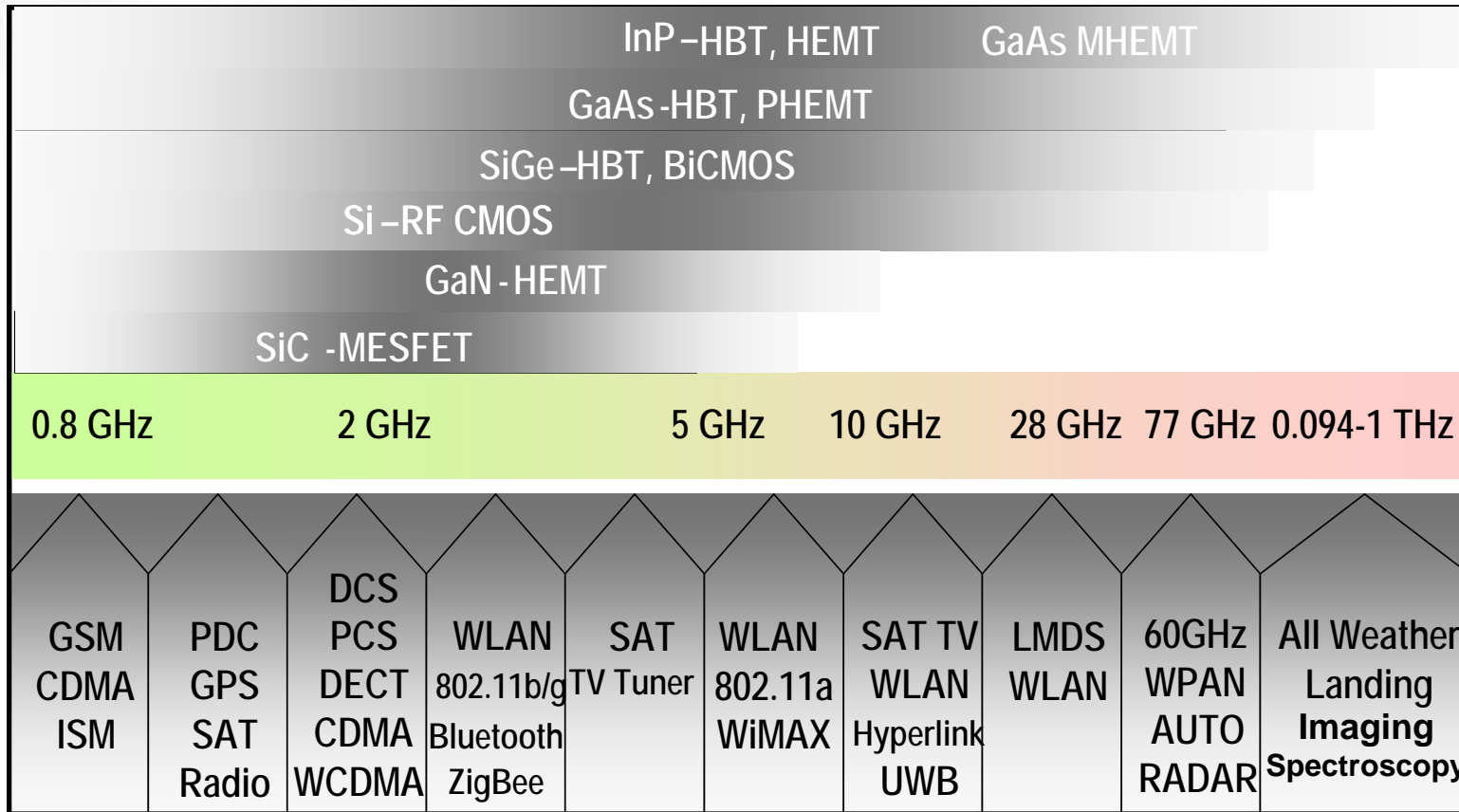
Editor: Herbert Bennett, NIST

- Subgroup CMOS Jack Pekarik, IBM
- Subgroup Bipolar Pascal Chevalier, ST
- Subgroup Passives Sebastian Liao, ITRI
- Subgroup PA Peter Zampardi, Skyworks
- Wayne Burger, Freescale
- Subgroup mm-Wave Tony Immorlica, BAE Systems
- Subgroup MEMS Dave Howard, Jazz

Wireless ITWG Background

- Scope of work remains the same; **wireless transceiver IC as technology driver**, with active contribution to ITRS-defined More than Moore thrust.
- Chapter subdivided into **<10GHz** applications and **mm-wave** applications.
- 5 technology subgroups cover <10GHz applications: **CMOS, bipolar, passives, power amplifier** and **MEMs**. A **mm-wave** subgroup focuses on higher frequency applications, considering power and low-noise using III-V and silicon-based devices.
- Some portions of the roadmap reflect **prototype capability more than volume production**. Production requires applications (especially emerging mm-wave connectivity and imaging) that currently lag technology capability.

Wireless Communication Application Spectrum



Wireless Working Group Key Considerations

Traditional Roadmap Drivers:

- Cost (scaling, die size, part count)
- Power consumption
- Chip functionality

Non-traditional Roadmap Drivers:

- Government regulations determining system spectrum and specifications
- Standards and protocols drive frequencies, power and performance
- Color coding “Manufacturing solutions exist” does not imply product volume shipment per ITRS definition
- RF module form factor (size and height requirements)

Cost / Performance Drives Integration:

- Multi-band & multi-mode system applications (embedded passives, filter, switch integration)
- Signal isolation and integrity
- Analog shrink (power supply, area, design innovations)



RF&AMS Chapter Change Overview

AMS CMOS

Many foundries focus RF&AMS technologies on major nodes skipping “half-nodes”
Power-management & analog are being supported by optional devices since 90nm

Bipolar

Major update to High-Speed HBT reflecting a higher f_{MAX}/f_T ratio
Drop High-Voltage HBT. Update Power-Amplifier HBT. Added High-Speed PNP.

Passives

No major update to On-Chip passives
Added Inorganic substrate to Off-Chip passives to reflect 3D and passive only integration

Power Amplifier

Handset - Low-cost market driving CMOS PA
Base station – Drop GaAs roadmap reflecting growing interest in GaN

mm-Wave

Growing in scope to sub-THz applications, still dynamic and focus on near term only
RF CMOS move into mm-Wave table and added MAG predictions at 24, 60 and 94 GHz

MEMS

Moved from MtM to new section in 2009 roadmap (total six sections)
Growing MEMS market beyond wireless scope of transceiver ICs (e.g. gyro/accelerometer, microphone, display), considering separate MEMS TWG

Summary of Key Challenges

- **AMS CMOS** - New materials (e.g., high-permittivity gate dielectrics, embedded structures to induce channel strain, and metal-gate electrodes) make predicting trends uncertain for transistor mismatch and for $1/f$ noise.
- **Bipolar HS-NPNs and HS-PNPs** - Increasing f_T by more aggressive vertical profiles and still maintaining FOMs, manufacturing control, and punch-through margins.
- **Bipolar PAs** - Improving the tradeoff between f_T/f_{MAX} and breakdown voltages to provide voltage handling and power densities at performance levels that can effectively compete with alternative technologies.
- **On-Chip Passives** - Integrating new materials in a cost-effective manner to realize compact high quality factor (Q) inductors and high-density metal-insulator-metal (MIM) capacitors demanded by the roadmap for increased RF performance.



RF & AMS

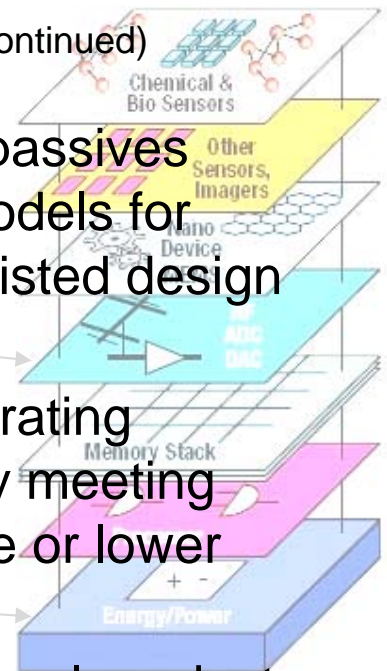


Summary of Key Challenges (continued)

- **Off-Chip Passives** - The large variation in embedded passives options increase complexity and cost. And accurate models for process tolerances, parasitic effects, and computer assisted design (CAD) tools.
- **Handset PAs** - Increasing functionality in terms of operating frequency and modulation schemes and simultaneously meeting increasingly stringent linearity requirements at the same or lower cost.
- **Basestation PAs** – Enhancing performance with continual product price pressure. And Improving amplifier efficiency.
- **mm-Wave** - Thermal management for high power density circuits, multi-level integration and E/D mode transistors. And reduction of leakage current and understanding of failure mechanisms, particularly for GaN materials which are piezoelectric in nature

RF & AMS

Power Management



Summary of Key Challenges (continued)

- **MEMS** - Incorporating the great process diversity of MEMS into specific ITRS processes. And developing design tools, packaging, performance drivers, and cost drivers for each MEMS device type.

Conclusions

Cost / Performance / Power Consumption/ Functionality

Signal Isolation and Integrity

Other Roadmap Drivers

THANK YOU