IEEE WAMICON—A Regional Conference with a Global Impact

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The 18th IEEE Microwave Theory and Techniques Society (MTT-S) Wireless and Microwave Technology Conference (WAMICON) was held 24–25 April 2017 in Cocoa Beach, Florida, United States. Each year, WAMICON continues to provide an outstanding program of academic and industry papers with research updates, enhanced by high-level invited papers and future-oriented plenary talks.

This year the conference’s central theme was “Emerging Technologies for 5G Systems.” One highlight of this event is the student-focused poster session and networking reception followed by the awards banquet, featuring the presentation of the Rudolph Henning Distinguishing Mentoring Award to a professional who has had a uniquely strong impact on encouraging the next generation of engineers.

WAMICON’s Background and Goals
WAMICON began as part of an industry-academic–government exchange between the Center for Wireless and Microwave Information Systems (WAMI Center) in the Department of Electrical Engineering at the University of South Florida (USF) and invited advisory leaders from organizations involved in microwave and wireless engineering. The first conference was held as a local IEEE MTT-S/IEEE Antennas and Propagation Society/IEEE Electron Devices Chapter Symposium in February 1999 at the Embassy Suites adjacent to the USF campus in Tampa.

That small conference, with its 50 or so attendees, has blossomed over the years into an MTT-S-sponsored annual international conference earning generous support from academia and industry. The core of the WAMICON Organizing Committee and repeat attendees began as “a close collection of friends of the USF WAMI Center” and has grown to become a worldwide network with a warm affection for the unique atmosphere of this event, which we like to call “WAMI magic.”

The goal of this annual event is to create a stimulating professional environment for the exchange of information about the status and direction of wireless and microwave technology, the education and research challenges this changing technology presents, and actions being taken by educators to address these challenges. This is achieved through peer-reviewed presented and poster papers, tutorials, panel sessions, and inspiring keynote speakers.

One positive aspect of WAMICON is the strong involvement of student and early-career engineers as organizers, participants, and volunteers (Figure 1). At the 2017 banquet, awards were presented for best student poster, best student paper, and best overall oral presentation. New this year was the involvement of the IEEE Young Professionals, with a lively interactive workshop on Tuesday evening.

WAMICON is held regionally in Florida, usually taking advantage of one of the state’s outstanding and relaxing beach venues. The conference features strong participation from Florida universities including USF and the University of Central Florida, as well as the Florida Institute of Technology, Florida Atlantic University, Florida State University, and the University of Florida. RF and microwave companies from around the United States have generously supported WAMICON through sponsorship.
funds, by exhibiting regularly, and by serving as key members of the Steering Committee. Attendees travel from around the world to participate in this international IEEE event.

Technical Program
The WAMICON 2017 technical program featured quality research papers by advanced-degree students, professors, and engineers from industry. This year’s best paper award went to post-doctoral researcher Gregor Lasser of the University of Colorado, Boulder, United States, who was lead author and presenter of “Gate Control of a Two-Stage GaN MMIC Amplifier for Amplitude and Phase Linearization.” This year’s program was diverse, covering circuit and system design, test and measurement techniques, manufacturing issues, and specific technologies of current interest. As expected, a significant number of papers described work related to fifth-generation (5G) wireless development at both the circuit and system levels.

The program also included ten invited papers, providing high-level overviews of key microwave technologies. Among the topics covered were 5G millimeter-wave (mmW) communications, 60-GHz design and manufacturing, microwave sensors, design of tunable devices, and other subjects of current interest in research and system development.

An interactive poster session featured two types of papers: formal technical research papers and informal student research updates (Figure 2). The student research updates are a WAMICON tradition, providing insight into works-in-progress that always generate plenty of interest among those attending.

5G Panel Session
“The Push and Pull of Technology Solutions for 5G” was the topic of a five-member panel session (Figure 3). While 5G promises unprecedentedly high-speed mobile and wireless data rates, it will require utilization of frequencies into the mmW spectrum. 5G represents a strong, yet still not completely defined, market pull for new and cost-effective technology solutions. This pull is driving advances in semiconductors, circuit design, test and simulation, heterogeneous integration, and packaging.

Of course, various commercial interests have incentives to push their specific technology solutions for adoption by this new market. This panel allowed speakers from different industry segments to present their particular visions for 5G technology evolution and discuss their perspectives on the push and pull of the solutions required.

Figure 1. WAMICON gives students many opportunities to participate in the operation of the conference.

Figure 2. The interactive poster session is a pre-banquet activity, combined with a late afternoon reception and held in the same area as the commercial exhibits. This arrangement encourages a high level of interaction among WAMICON participants.

Figure 3. The 5G panel of experts at WAMICON 2017: (from left) Paul Colestock, Vincent Pellicia, Bror Peterson, Takao Inoue Inoue, and Moray Rumney. (Photo by Michael Hallman.)
to realize the promise of 5G for practical applications.

The session moderators were Dr. Larry Dunleavy of Modelithics, Inc., and Michael P. Hallman of Microwave Journal. Panelists included Vincent Pelliccia, vice president of business development, Anokiwave; Paul Colestock, Ph.D., founding director and head of the Exploratory Design Group, GlobalFoundries; Moray Rumney, lead technologist, Keysight Technologies; Takao Inoue, Ph.D., wireless solutions architect, AWR Group, National Instruments; and Bror Peterson, principal systems engineer, Infrastructure and Defense Products Division, Qorvo.

The panel noted that many of the specific techniques required to implement 5G are still in development and that both system-based and physics-based technical issues remain to be solved. However, significant work has been accomplished that identifies pathways to an eventual 5G standard.

Several areas of technology were noted repeatedly during the discussion.

- **mmW spectrum.** To support the bandwidth required for all visions of 5G performance, radios must use higher frequencies, whether 28 GHz, 60 GHz, or some other part of the spectrum. mmW systems have a number of performance characteristics that offer significant challenges, a few of which are
  - high path loss
  - complex propagation behaviors
  - narrow antenna beamwidth
  - small geometry semiconductors
  - high cost of manufacturing.
- **Antenna beamforming.** The propagation and path loss at mmW will require adaptable antenna arrays to maintain transmitted effective isotropic radiated power and reduce the effects of propagation (such as reflections and Doppler delay spread) when receiving. Design issues include multiple RF paths in the radios, types and location of antenna arrays, switching and steering circuits and their control algorithms, and, of course, the overall complexity of such a system.
- **System modeling and measurement.** The short wavelengths at mmW make it impossible to perform conventional measurements of equipment using interconnecting cables. The full system must be in operation and performance measured from end to end. This places higher demands on system models, which must include propagation (in three dimensions) as well as hardware—both of which are more complex at the frequencies involved.
- **Mobile or handheld operation.** At mmW, the effects of propagation while a user is in motion are multiplied over what occurs in present fourth-generation (4G) systems. As noted earlier, these effects can be mitigated with steerable, narrow-beamwidth antennas configured as adaptable arrays. However, in mobile or handheld devices, there is limited room to place multiple antennas, and the devices are subject to highly variable environments and placement with respect to the body (hands, head, etc.).

Overall, the panel's contribution to the ongoing discussion of 5G consisted of pointing out where progress has been made (such as semiconductor technology), where further work is needed (such as adaptable antenna arrays), and a few areas where major technical issues remain to be solved (such as modulation schemes and many aspects of mobile performance).

### Plenary Talks

The plenary session at WAMICON provided insights into technologies that will help enable the next generation of wireless technologies, supporting the higher frequencies of operation and the wide bandwidths required for high-capacity data transmission.

The first of the two plenary presentations (Figure 4) was by Paul Colestock of GlobalFoundries (also a 5G Panel participant). His talk, “The Impact of Silicon as an Emerging Technology for 5G Circuits and System Solutions,” focused on the improvements and impact of silicon technologies on the microwave and mmW designs required for 5G wireless systems.

GlobalFoundries is a technology service company that participates in the design of complex integrated circuits. The company supports customers by partnering with leading providers in electronic design automation software tools, design intellectual property, design services, mask services, and assembly solutions. The combination of in-house expertise, such as its techniques for mmW-capable transistors in complementary–metal-oxide-semiconductor technology, and the resources of its partners helps monolithic microwave integrated circuit (MMIC) companies achieve low fabrication costs while accomplishing performance objectives. Silicon germanium technology and silicon-on-insulator are additional parts of the overall technology solutions for economically feasible systems at even-higher frequencies.

The second plenary talk was an academic view of technology, “PA Design for Future Wireless Systems,” by Zoya Popovic, Distinguished Professor and Hudson Moore, Jr., endowed chair of the Department of Electrical, Computer, and Energy Engineering at the University of Colorado, Boulder. Her paper presented an overview of efficiency enhancement techniques for microwave power amplifiers (PAs) through supply modulation. Next-generation wireless systems are
predicted to operate at higher carrier frequencies, with significantly larger signal bandwidths and under conditions that require more functionality and flexibility. These next-generation systems include improved performance of 4G, micro- and picocell equipment, and interim system advances leading to an eventual 5G rollout. Efficiency, linearity, thermal performance, and system cost are all elements of future PA solutions.

**Awards Banquet**

A highlight of the WAMICON awards banquet is the presentation of the Rudolph Henning Distinguished Mentoring Award. Dr. Henning spent his entire career tirelessly promoting the engineering arts as a profession to students not only at the college level but also in primary and secondary schools. To honor his efforts, the WAMICON committee created a mentoring award to recognize an individual who has performed exemplary service encouraging students and/or mentoring young engineers to advance careers in the areas of RF/microwave and/or wireless engineering. Unlike many individual accomplishment awards, this award is all about the positive and lasting impact these individuals have had on other people's careers.

A list of past award recipients reads like a “who’s who” of exemplary educators in the microwave, wireless, and electromagnetics field. These past recipients are

- Dr. Thomas Brazil, University College Dublin, Ireland (2009)
- Dr. Peter Asbeck, University of California, San Diego, United States (2010)
- Dr. Linda Katehi, University of California, Davis, United States (2011)
- Dr. Bumman Kim, Pohang University of Science and Technology, South Korea (2012)
- Dr. John Volakis, The Ohio State University, Columbus, United States (2013)
- Dr. John Cressler, Georgia Institute of Technology, Atlanta, United States (2014)
- Dr. Zoya Popovic, University of Colorado, Boulder, United States (2015)
- Dr. Robert Trew, North Carolina State University, Raleigh, United States (2016).

The 2017 Henning Award recipient was Dr. Constantine Balanis, Regents’ Professor at Arizona State University (ASU), Tempe, United States, and a member of the ASU faculty since 1983 (Figure 5). Dr. Balanis is known to many microwave students and engineers as the author of reference books and textbooks on antennas and electromagnetic theory. Throughout his career, he has encouraged and supported the efforts of engineering students in their academic development. Those students, many of whom have become professionals in the microwave realm, nominated their former professor for this prestigious award, a recommendation resoundingly affirmed by the WAMICON Awards Committee.

The guest speaker for the after-dinner talk and discussion was Dr. Linda Katehi, Distinguished Professor at the University of California, Davis (Figure 6). Dr. Katehi’s presentation, “Sustainability and the Fourth Industrial
Revolution,” generated a spirited discussion with comments from several different perspectives.

Exhibition and Sponsorship
WAMICON 2017’s sponsors and exhibitors included platinum sponsor Mini-Circuits; gold sponsors Keysight and Wolfspeed; silver sponsors TTE, Harris, and Advanced Test Equipment; media sponsors Microwave Journal, High-Frequency Electronics, IEEE Microwave Magazine, Wireless Design and Development, Microwaves & RF, and the discovery platform everything RF; along with Maury Microwave, Reactel, Modelithics, CST, Gowanda, Copper Mountain, National Instruments, Sonnet, Noisecom, and Boonton.

These companies also demonstrated their support for the conference through their sponsorship fees. They are excellent representatives of the microwave industry, well known for supporting educational and professional activities at all levels: local, regional, national, and international.

Summary
WAMICON has a history of a strong technical program, including research papers, high-quality invited papers, timely plenary presentations, and thought-provoking after-dinner talks. Combined with its vibrant exhibition area and a collegial atmosphere, the intent of WAMICON is to provide a venue that encourages interaction among its participants, as well as with sponsors.

WAMICON also has a strong international component. The 2017 conference included presenters and coauthors from the United States, Canada, Mexico, Italy, Spain, India, Taiwan, Turkey, Ireland, Norway, the United Kingdom, and France. WAMICON organizers are pleased that many researchers consider the conference a desirable place for their work to be presented.

The 2018 (19th) WAMICON will return to the Gulf of Mexico side of the state and is being held 9–10 April at the Sheraton Sand Key, Sand Key, Florida. The call for papers can be found at www.wamicon.org. The deadline for proposed papers is 9 February 2018. The theme of the 2018 conference is mmW and Internet of Things (IoT) for commercial and defense applications. We welcome submissions on all aspects of mmW- and IoT-related technologies, including antennas, passive and active circuits, communication theory, and system concepts. The topics of interest include PAs, RF integrated circuits, microelectromechanical systems, and wireless sensing.

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- Systems engineering, educations standards, processes and methodologies for the systems-of-systems environment.
- Research opportunities and results relating to systems-of-systems.