

*Center for Wireless and Microwave Information Systems*

# Center for Wireless and Microwave Information Systems

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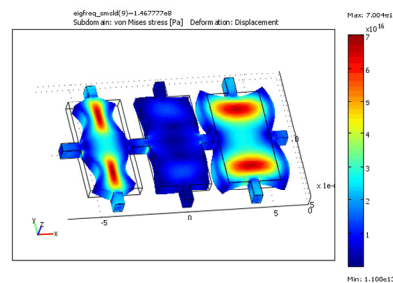
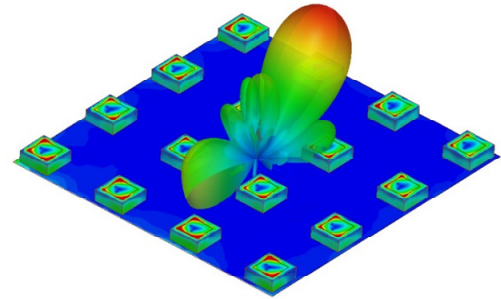
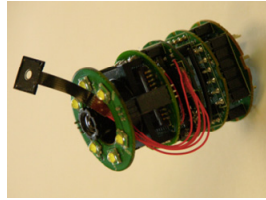
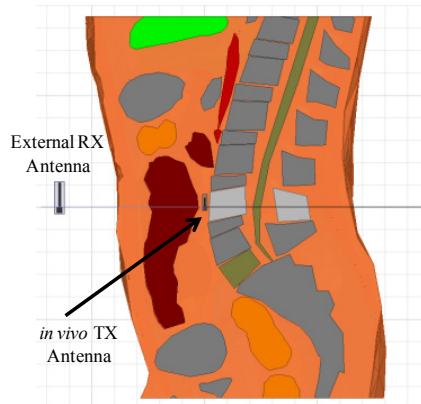
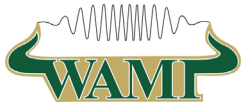
Department of Electrical Engineering  
University of South Florida

## *Annual Report 2014*

**Members: Dr. Huseyin Arslan, Dr. Lawrence Dunleavy, Dr. Richard Gitlin, Dr. Gokhan Mumcu, Dr. Ismail Uysal, Dr. Jing Wang (Co-Director), Dr. Tom Weller (Co-Director)**

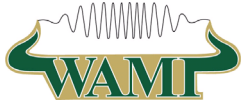
### **Contents:**

- **Center Updates**
- **Student Recognition**
- **Research Highlights**
- **Selected Curriculum Activities**
- **Professional Activities**



The Center for Wireless and Microwave Information Systems conducts research across a broad range of technical areas that include device modeling and characterization, RF micro electromechanical systems, advanced materials and nanoscale devices, active antennas, cognitive radio, next generation wireless architectures and RF identification (RFID). Research projects focus on basic scientific development as well as applications such as biomedical sensing, communications, robotics and transportation. Active collaborations are pursued with multiple industry and university partners as well as several centers at the University of South Florida.

In 2013/14 the Center supported 47 MS and PhD students, 2 post-doctoral fellows and 6 undergraduate students. Center faculty submitted over 44 research proposals in the past year; of these 24 proposals were funded. The WAMI faculty had more than 89 publications in journals, conferences and book chapters, 15 patents and gave 10 invited talks. The students and faculty received 15 awards and distinctions including best paper/poster awards and recognition for professional achievement.



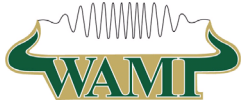
## Newsorthy Notes

- The **2014 Rudolf E. Henning Distinguished Mentoring Award** was presented to Dr. John Cressler at WAMICON 2014. Dr. Cressler grew up in Georgia, and received the B.S. degree in physics from Georgia Tech in 1984. From 1984 until 1992 he was on the research staff at the IBM Thomas J. Watson Research Center in Yorktown Heights, NY, working on high-speed Silicon and Silicon-Germanium (SiGe) microelectronic devices and technology. While continuing his full-time research position at IBM, he went back to pursue his graduate studies at Columbia University in 1985, receiving his M.S. and Ph.D. degrees in applied physics in 1987 and 1990, respectively. In 1992 he left IBM Research to pursue his dream of becoming a professor, and joined the faculty at Auburn University, where he served until 2002, when he left to join Georgia Tech. He is presently the Schlumberger Chair in Electronics at Georgia Tech. Dr. Cressler is interested in the understanding, development, and application of new types of silicon-based bandgap-engineered microelectronic devices and circuits for high-speed electronics in emerging 21st century communications systems. He and his team have published over 500 technical papers in this field, and he has written five non-fiction books (two for general audiences). He has recently become enamored with writing historical fiction, and his debut novel, *Emeralds of the Alhambra*, a love story set in medieval Muslim Spain, was released in June of 2013. His hobbies include wine collecting, cooking, gardening, and hiking.



- The **15<sup>th</sup> annual IEEE Wireless and Microwave Technology (WAMI) Conference** was held in Tampa, FL on June 6, 2014 in conjunction with the 2014 International Microwave Symposium. The theme for WAMICON 2014 was “Emerging RF and Microwave Technologies” where authors submitted papers on biomedical applications, wireless sensing, energy harvesting, wireless power transfer, terahertz technologies, nanodevices and circuits. A total of 8 invited papers from universities and industry together with 27 other presentations were given in two parallel sessions during Friday June 6th. Consistent with WAMICON tradition, there was also an interactive Student Poster Session held in conjunction with a joint WAMICON/ARFTG

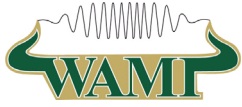




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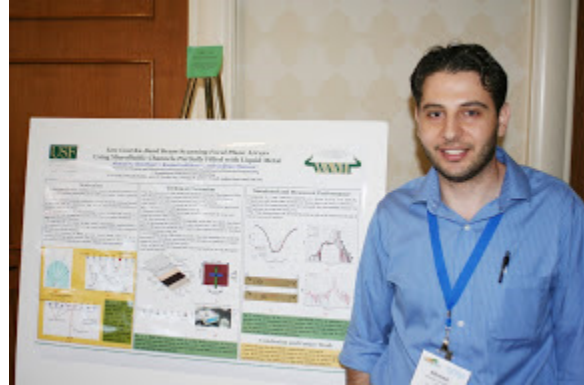
welcoming reception early Thursday evening on the 5th June. A separate interactive forum was held in the afternoon of the 6th June for other university and industry poster contributors

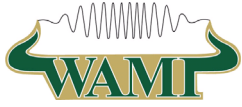
- Dr. Gokhan Mumcu, Assistant Professor in the WAMI Center, received the prestigious CAREER Award from the National Science Foundation for his work on microfluidic control of microwave circuits and antennas. Dr. Mumcu also received the 2014 Faculty Outstanding Research Achievement Award from the University of South Florida Office for Research and Innovation.
- Special thanks to Raytheon for their continued financial support, which is used to provide supplemental funds for our students, support conference travel, and allow the WAMI Center to maintain its equipment. Mini Circuits continues to be a strong supporter of the WAMI teaching laboratory by contributing microwave components. The Center also acknowledges the continuing strong support of Agilent Technologies, Applied Wave Research, Modelithics and Sonnet for providing our students with no-cost access to their exceptional software tools.
- The schedule for the 2015 **WAMI Advisory Board** meeting is *TBD* pending final arrangements for the WAMICON 2015 conference in Cocoa Beach in April.
- Dr. Arslan's paper has been selected as a winner of the 2013 Best Tutorial Paper Award for the paper "A survey of spectrum sensing algorithms for cognitive radio applications." IEEE Communications Surveys & Tutorials, Vol. 11, no. 1, January 2009, pp. 116-130.
- Ph.D. graduates from the WAMI Center in 2013/2014 are now working for Ansys, Intel, Skyworks, TDK and TriQuint/RFMD (now Qorvo).



## Student Recognition

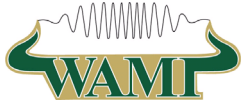
- **Maria Cordoba and Jon O'Brien**, WAMI Ph.D. students, received Outstanding Student Poster Awards at the 2014 International Microelectronics and Packaging Society Symposium.
- **Michael Grady**, a WAMI Ph.D. student received an IEEE Microwave Theory and Techniques Society Graduate Student Fellowship.
- **Eduardo Rojas, Ramiro Ramirez, Sean Murphy and William Mitchell**, WAMI Ph.D. and undergraduate students, were semi-finalists in the 2014 IEEE AP-S RFID Design Contest.
- **Vinicio Carias**, a WAMI Ph.D. student, was awarded a prestigious one-year Fulbright Research Grant (August 2013 to July 2014) to continue his dissertation research at the Institute for Microsystems Technology (IMTEK) of the University of Freiburg, Germany, which is one of the largest institution in the field of microsystems technology in Europe.
- **Juan Castro**, a WAMI Ph.D. student, took 1<sup>st</sup> Prize in the Student Paper Competition during the 26<sup>th</sup> Annual HENAAC Conference 2014.
- **Ahmad Gheethan** (pictured in photo), a WAMI Ph.D. student, received the IEEE Antennas and Propagation Society Doctoral Fellowship. This \$2,500 award is annually provided up to 10 students around the world based on the quality of their dissertation proposal on electromagnetic theory, antennas, and propagation. Ahmad also took first place in Texas Instruments Sensing Design Challenge that took place in EDN (<http://www.edn.com/contest/ti-challenge>). This national competition was open for all ideas regarding the innovative use of TI's newly introduced inductance to digital converter chip. The award included the design/idea to be featured in EDN along with a \$3,000 prize. In addition, Ahmad received an honorable mention in student paper competition of IEEE Antennas and Propagation Society Symposium 2014. Typically, the competition receives about 150 student papers, and the papers ranked between 15<sup>th</sup> and 30<sup>th</sup> receive this award which includes a \$1,500 stipend towards travel related expenses.
- **Abhishek Dey**, a WAMI Ph.D. student, was a finalist in student paper competition of IEEE Antennas and Propagation Society Symposium 2013. Typically, the competition receives about 150 student papers, and the papers ranked in top 15 receive this award that includes a \$1,500 stipend towards travel related expenses and a place in student paper poster competition held during the time of the conference.





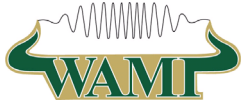
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- **Timothy Palomo** and **Abhishek Dey**, WAMI Ph.D. students, received best poster awards in USF research presentation days in Fall 2013. The award provides \$500 to be used towards conference travel.



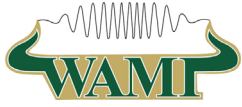
## Research Highlights – Current & Recent Projects

- **Collaborative Research: A Systems-Centric Foundation for Electrical and Computer Engineering Education**, P.I. S. Thomas, Co-P.I. T. Weller, Granting Agency: National Science Foundation. Development of systems-centric, hands-on learning modules for the introductory circuits course. This is a joint project with U. Hawaii, U. Minnesota, U. Vermont and Northern Arizona U.
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- **GOALI Collaborative Research: 3D RF Microsystems using Direct Digital Manufacturing Technology**, P.I. T. Weller, Co-P.I. C. Lusk (Mechanical Engineering) and K. Church (Sciperio), Granting Agency: The National Science Foundation. Investigate new 3D microwave systems using digital manufacturing techniques. This is a collaborative project with Georgia Tech (J. Papapolymerou).
  - **Affordable 3D Printed Phased Arrays**, P.I. P.I. T. Weller, Granting Agency: Office of Naval Research. Develop technology for active 3D digitally printed phased array modules.
  - **Rapid Design of Optimal Digitally-Manufactured 3D Electrically-Small Antennas**, P.I. T. Weller, Granting Agency: Central Intelligence Agency. Investigate design and optimization tools for digitally manufactured small antennas.
  - **3D Formable RF Materials**, P.I. T. Weller, Granting Agency: Army Research Office. Microwave characterization of materials used in 3D printed RF electronics.
  - **Additive Manufacturing Technologies – Phase 1**, PI T. Weller, Sponsor: Jabil. The purpose of this project is to investigate the application of direct digital manufacturing for high frequency consumer electronics fabrication.
  - **3D Fabricated Low Cost Phased Array Technology**, P.I. T. Weller, Granting Agency: Office of Naval Research. Develop a 2-18 GHz current sheet array unit cell using 3D direct digital manufacturing.
  - **Three-Dimensional (3D) Structural Radio Frequency (RF) Electronics**, P.I. T. Weller, Granting Agency: Air Force Research Lab. Investigate a 2.45 GHz phased array module using direct print additive manufacturing techniques.



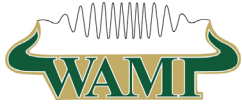
- **Improving the Communications Performance and Reliability of *In Vivo* Wireless Medical Devices** –Gitlin. Funded by the NSF. This STTR project has the goal of advancing novel wireless communications technologies that enable high performance, reliable communications, and the ability to overcome link and/or power failures among networked *in vivo* medical devices.
- **Channel Modeling and Optimized Radio Access Design for *In Vivo* Wireless Communication**---Arslan and Gitlin. Funded by QNRF. This project is directed towards developing reliable signal processing and wireless communications technologies and methodologies to address the major challenges of the *in vivo* communication channel that will be faced by emerging wireless body area networks.
- **Holistically Application-Aware Multi-dimensional Cognitive Radio (HAMCR)** ---Arslan and Gitlin [and Haas (Cornell). Funded by NSF. HAMCR is an application-aware cognitive radio with new technology that enables substantial growth in the capacity of wireless networks, with support for diverse applications, without additional spectrum. HAMCR maximizes spectrum utilization by trading off the spectral resource allocations of connections for the application-level QoS, while still maintaining acceptable levels of QoS for the users of the underlying applications, thus satisfying an increased number of users in times of shortage of spectral resources.
- **Vectorcardiogram (VCG) system.** Funded by Jabil Circuit. The Vectorcardiogram presents a three dimensional (3D) view of the depolarization (depolarization cycle) of the heart by calculating the magnitude and direction of the electrical signals emanated from the heart and provides the same information as the “gold standard” Electrocardiogram (ECG). From the 3-lead VCG the 12-lead ECG may be created via a 3x12 matrix transformation. The principal advantage of the VCG is that it provides the same information as the 12-lead ECG but with a smaller number of leads.. The project goal is to enable real-time 24x7 diagnostic-quality monitoring of the heart’s electrical with a small form factor VCG that can be worn on the body of the patient. This breakthrough capability can revolutionize the field of cardiac rhythm management.
- **Application of Photosynthetic Proteins in a Field-Effect Transistor for Low Light Intensity Detection**, P.I. A. Takshi, Co-P.I. J. Wang, Granting Agency: National Science Foundation. This project is about a new method of sensing low light intensities using photosynthetic proteins seamlessly integrated within a semiconductor device.
- **GOALI: COLLABORATIVE RESEARCH: Antenna-Coupled ALD-Enabled Metal-Insulator-Insulator-Metal Diodes for High Responsivity and High Resolution THz/Infrared Focal Plane Arrays**, P.I. J. Wang, Co-P.I. G. Mumcu, N. Kislov, Granting Agency: National Science Foundation. The objective



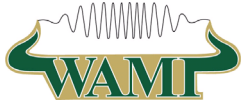


of this research is to develop a new class of room temperature metal-insulator-insulator-metal tunnel diode detectors and monolithically integrate them within novel miniature antenna focal plane array configurations for high resolution and high responsivity THz/infrared imaging as well as energy harvesting.

- **GOALI: Efficiency Enhancement of Solar Cells Through Electronic Structure Design**, P.I. R. Schlaf, Co-P.I. J. Wang, A. LaVoie (Novellus), Granting Agency: National Science Foundation. The proposed work aims at the characterization and subsequent tailoring of the electronic structure of nanolaminates and interfaces manufactured with atomic layer deposition (ALD).
- **Acoustic Emission Technology on a Chip**, PI J. Wang, Co-PI R. Guldiken, WavesinSolids, LLC through National Science Foundation (NSF) SBIR Phase I and Phase IB Program. The goal of this work is to thoroughly investigate the folded-beam MEMS resonator with interdigitated capacitive transducers to address the current limitations of MEMS acoustic emission sensors such as low sensitivity.
- **Development and evaluation at the laboratory level of biosensors for the diagnosis of all dengue virus serotypes based on the Non-Structural protein- 1 (NS-1)**, PI J. Wang, Granting Agency: the Administrative Department of Science, Technology and Innovation–COLCIENCIAS, Colombia. The aim of the proposed work is to develop lab-on-a-chip devices that can be used as immunoassays for all dengue virus serotypes based on the Non-Structural protein-1 (NS-1) for accurate and early diagnosis of dengue infection.
- **Simulation and Modeling of Ion Mobility Separative Capability**, P.I. J. Wang, Granting Agency: Draper Laboratory and Florida High Tech Corridor. The goal of the proposed work will be the optimization of resolution of the Differential Mobility Spectroscopy (DMS) which is currently limited to ~50. Furthermore, the experience gained from this task will be utilized later on in the understanding of ion transfer efficiencies from atmospheric pressure to vacuum.
- **Improved Device Fabrication Technology for High Frequency/High Q Resonator Filters**, P.I. J. Wang, Grant Agency: Plasma Therm LLC and Florida High Tech Corridor. The objective is to demonstrate and improve performance of USF developed high frequency MEMS filter device using advanced deep silicon etching technology. In particular, MEMS device structures with capacitive transducers with sub 250nm of narrow trench will be investigated to enhance of the performance.
- **Research and Training Internship for Enhanced Microwave and Millimeter-Wave Circuit Design, Characterization and Modeling**, PI: J. Wang, Granting Agency: Modelithics, Inc. and Florida High Tech Corridor. Research and training grant for development and verification of improved models as well as modeling and characterization techniques for high frequency transistors.



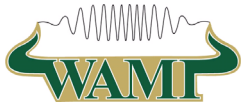
- **Structural Imaging of High Temperature Furnace Walls**, PI: G. Mumcu, Granting Agency: PaneraTech, Inc. through National Science Foundation (NSF) SBIR Phase II Program. Design an imaging array consisting of compact ultra-wideband antenna elements to work in contact with the high temperature glass furnace walls.
- **CAREER: Microfluidically Loaded Highly Reconfigurable Compact RF Devices**, PI: G. Mumcu, Granting Agency: National Science Foundation (NSF). This CAREER effort investigates the novel interdisciplinary concept of microfluidically loaded reconfigurability within the context of RF antennas, filters, and imaging systems. The project proposes unique RF device and imaging array implementations that provide unprecedented reconfigurability, high power handling capability, lower circuit complexity and cost-reductions as compared to the existing technologies.
- **EAGER: Reconfigurable Textile Antennas and RF Electronics Using Microfluidic Techniques**, PI: G. Mumcu, Granting Agency: National Science Foundation (NSF). This project focuses on a novel direction for efficient spectrum utilization of body worn RF front-ends by integration of highly functional textile antennas with microfluidics for reconfiguration.
- **Bulls Engineering Success Training (BEST): Orthogonal Interconnect Characterization**, PI: G. Mumcu, Granting Agency: Harris Corporation. This project engages a multidisciplinary undergraduate student team (from EE, CSE and ME departments) to carry out automated extensive performance/reliability characterizations of several compact orthogonal interconnects that are critical for large-scale and dense RF circuit integrations.
- **Remote Environmental Monitoring and Diagnostics in the Perishable Supply Chain** P.I. C. Nunes, Co-P.I. I. Uysal, Granting Agency: US Army Natick Soldier RD&E Center. Using RFID sensor technology to monitor freshness of army rations and develop smart distribution systems. This is a joint project with University of Florida.
- **Testing and Calibration of RF Temperature Sensors** P.I. I. Uysal, Granting Agency: RFID Innovative Solutions LLC. Testing and calibration of ISO18000-7 Temperature Sensors developed by RFID IS LLC.
- **Reducing Strawberry Waste and Losses in the Postharvest Supply Chain via Intelligent Distribution Management** P.I. I. Uysal, Co-P.I. C. Nunes, Granting Agency: Walmart Foundation. Temperature mapping of the cold chain with wireless sensors to enable smart distribution practices
- **Increasing Consumption of Specialty Crops by Enhancing their Quality and Safety** P.I. C. Nunes, Co-P.I. I. Uysal, Granting Agency: US Department of



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Agriculture. Algorithmic modeling of the effects of environmental variables like temperature and humidity on specialty crops.

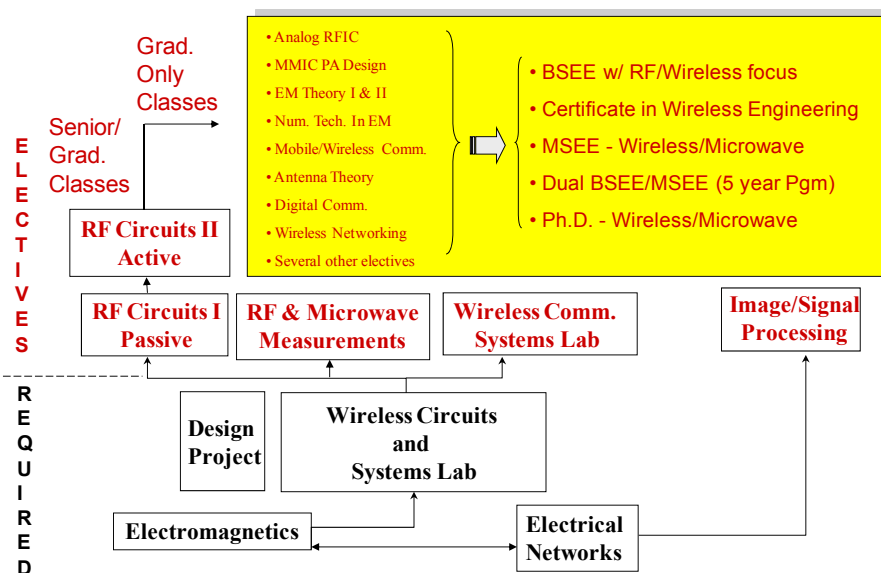
- **Calibration and Validation of DeltaTrak's Product Emulation Model**  
P.I. I. Uysal, Granting Agency: DeltaTrak Inc. Testing a product temperature emulation model developed by DeltaTrak to predict product temperatures by measuring ambient temperatures. This is a joint project with University of Florida.
- **Time-temperature Indicator Characterization** P.I. I. Uysal, Granting Agency: DeltaTrak Inc. Characterizing environmental behavior of TTI labels to construct a temperature-stage curve for response analysis and time prediction.

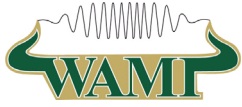


## Selected Curriculum Activities

The WAMI faculty was engaged in several on-going and new activities in 2012/2013 aimed at improving the RF/microwave/wireless curriculum. These activities include:

- A new, multi-university collaboration that will develop hands-on laboratories for the introductory circuits course, emphasizing systems-centric learning and the broad applications of electrical engineering. This project, called ENFUSE (Engaging Fundamentals & Systems Engineering) is sponsored by the National Science Foundation and involves the University of Hawaii, University of Vermont, University of Minnesota and Northern Arizona University.
- Dr. Gokhan Mumcu is developing innovative 3D visualization tools, first geared toward the undergraduate electromagnetics course, as part of his NSF CAREER Award. The aim of these tools is to help students grasp abstract concepts such as electromagnetic field propagation along transmission lines.
- WAMI faculty developed courses in RF/Microwave Theory and Antenna Theory as part of the USF EE Department's fully on-line master's program.
- New teaching methods, such as the 'inverted classroom' which involves significant hands-on problem solving in the classroom, are being implemented across the courses in the WAMI curriculum.
- Through a new partnership with TriQuint, the WAMI faculty has integrated the use of their GaAs process design kit into several of the RF/microwave courses. Students now have the opportunity to design, layout and test circuits fabricated by TriQuint. In January 2014, chosen student designs of ultra-wideband distributed amplifiers from the MMIC design course in Fall 2013 semester was submitted for fabrication to TriQuint as part of the university partnership program. These MMIC circuits have been evaluated recently by the student designers to be fully functional with the key specifications fulfilled.





## Professional Activities

- **USF WAMI Team Leads Successful IMS2014 Conference** – USF WAMI Faculty Drs. Larry Dunleavy and Tom Weller were honored to be asked to host, as General Chair and vice-Chair respectively, the IEEE IMS2014 Conference held for the first time in Tampa. The conference was a huge success by many measures.



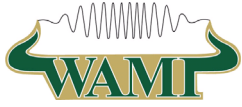
The IEEE MTT-S IMS is made up of many elements, each of which must be well executed and coordinated. The Steering Committee and student volunteer team included several USF WAMI faculty members and students along with several WAMI Center advisors and other colleagues who organize the USF WAMI spinout conference, IEEE WAMICON, each year.

The names of these individuals, as well as the names of all other volunteers who helped make IMS 2014 a success, are listed on the conference website ([www.ims2014.org](http://www.ims2014.org)).

A brief summary of some other relevant statistics from IMS2014: On the exhibition floor a total of 892 booths were occupied by a record 585 total companies; we had 72 first time exhibitors and 14 university pods, located outside of the trade show floor, which was completely sold out; overall attendance was estimated at near 7700; the event included an outstanding plenary session and outdoor kickoff event and closed with two inspiring talks in our closing ceremony – one of these talks was given by Dr. Quenton Bonds, a recent USF WAMI Center PhD graduate.

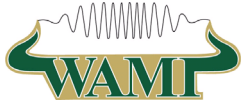


This was also the first time IEEE WAMICON was combined with ARFTG and IMS. Among the things IMS2014 did a little differently were emphasizing student involvement from the successful middle-school/high-school STEM program, the newly introduced Project Connect undergraduate student program, the PhD (student) initiative to all the various competitions, including a record number of graduate student competitions. Please join us in thanking and congratulating the Steering Committee, authors, reviewers, and all participants of IMS2014 for a job well done!



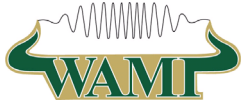
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- **The 15<sup>th</sup> annual IEEE Wireless and Microwave Technology Conference (WAMICON 2014)** – Dr. Wang served as the general co-chair for this conference, which was held in Tampa in June 2014.
  
- **2014 IEEE International Conference on RFID** – Dr. Uysal was a member of the Technical Program Committee and an invited speaker at the RFID Industry Panel for IEEE International Conference on RFID’s 2014 meeting which was held in Orlando in April.
  
- **International Journal of RF Technologies: Research and Applications** – Dr. Uysal was selected to the editorial board.
  
- **Dr. Gitlin** was appointed a faculty member of USF’s Institute for Advanced Discovery & Innovation.
  
- **IEEE Transactions on Cognitive Communications and Networking-** Dr. Arslan was selected to the editorial board
  
- **IEEE Communications Surveys and Tutorials (COMST)** - Dr. Arslan was selected to the editorial board



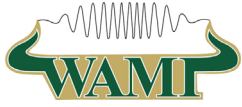
## Publications

1. Nassar, I.; Tsang, H.; Weller, T., "3D printed wideband harmonic transceiver for embedded passive wireless monitoring," *Electronics Letters*, vol.50, no.22, pp.1609,1611, 10 23 2014.
2. Cordoba-Erazo, M.F.; Weller, T.M., "Noncontact Electrical Characterization of Printed Resistors Using Microwave Microscopy," *Instrumentation and Measurement, IEEE Transactions on* , vol.PP, no.99, pp.1,1, 2014.
3. I. Nassar and T. Weller, "A Compact Dual-Channel Transceiver for Long-Range Passive Embedded Monitoring," accepted for publication in *IEEE Trans. MTT*, October 2014.
4. R. Davidova and T. Weller, "High-Sensitivity, AM-modulated harmonic transceiver for wireless sensing," *Electronics Letters*, 11<sup>th</sup> April 2013, Vol. 49, No. 8.
5. S. Melais, D. Cure and T. Weller, "A Quasi-Yagi Antenna Backed by a Jerusalem Cross Frequency Selective Surface," *International Journal of Microwave Science and Technology*, vol. 2013, Article ID 354789, 8 pages, 2013. doi:10.1155/2013/354789.
6. D. Cure, T. Weller, T. Price, F. Miranda and F. Van Keuls, "Low Profile Tunable Dipole Antenna Using Barium Strontium Titanate Varactors," *IEEE Trans. Antennas and Propagation*, Vol. 62, Issue 3, 2014.
7. Castro, J.; Cure, D.; Wang, J.; Weller, T., "Development and Characterization of High-Permittivity and Low-Loss Polymer-Ceramic Composite Substrates for RF and Microwave Applications", *Hispanic Engineer National Achievement Awards Corporation Conference (HENAAC), 2014 HENAAC 26th Annual, Great Minds in STEM, New Orleans, Louisiana, October 3, 2014.*
8. M. Córdoba-Erazo, E. Rojas-Nastrucci and T. Weller, "Measurement of Electrical Conductivity of Direct Digital Printed Conductive Traces Using Near-Field Microwave Microscopy," *2014 IMAPS Symposium, San Diego, Ca, October 2014.*
9. Dunleavy, Lawrence; Weller, Thomas, "Presentation of the 2014 IEEE WAMICON Rudolf E. Henning Distinguished Mentoring Award," *Microwave Symposium (IMS), 2014 IEEE MTT-S International* , vol., no., pp.1,1, 1-6 June 2014.
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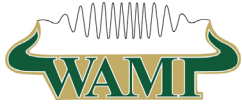


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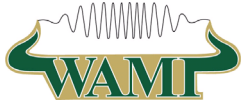




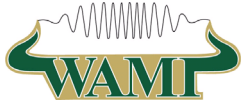
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