

*Center for Wireless and Microwave Information Systems*

# Center for Wireless and Microwave Information Systems

<http://wami.eng.usf.edu/>

**Department of Electrical Engineering  
University of South Florida**

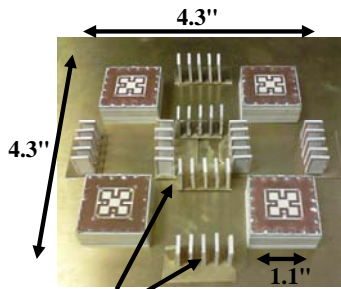
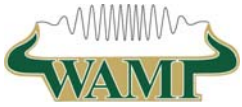
## *Annual Report 2012*

**Center Director – Dr. Thomas Weller**

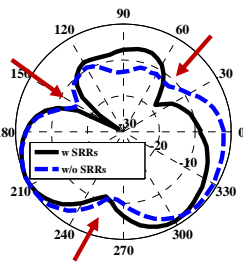
**Members: Dr. Huseyin Arslan, Dr. Lawrence Dunleavy, Dr. Richard Gitlin, Dr. Gokhan Mumcu, Dr. Ismail Uysal, Dr. Jing Wang**

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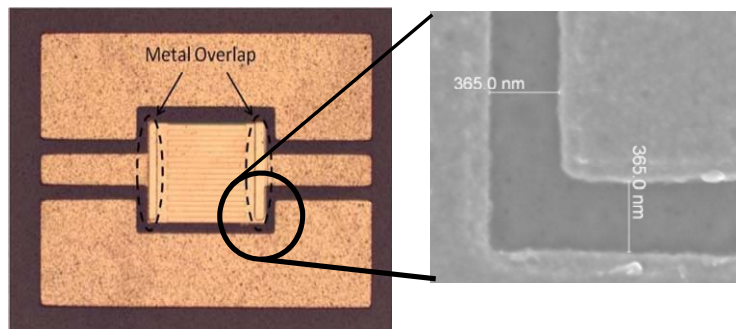
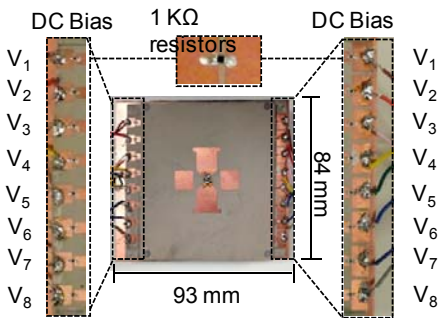
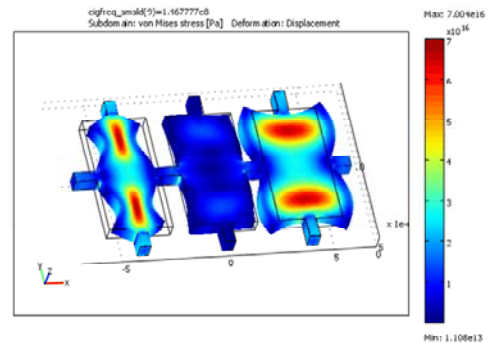
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**BC-SRR Stacks for reduced coupling**

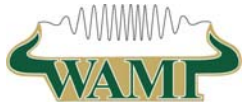


**Significant improvement in nulling depth (>10dB) and accuracy**



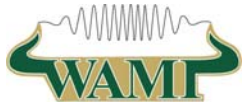
The Center for Wireless and Microwave Information Systems conducts research across a broad range of technical areas that include device modeling and characterization, RF micro electromechanical systems, advanced materials and nanoscale devices, active antennas, cognitive radio, next generation wireless 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 2011/12 the Center supported 40 MS and PhD students, 8 post-doctoral fellows and 8 undergraduate students. Center faculty submitted over 41 research proposals in the past year; of these 17 proposals were funded. The WAMI faculty had more than 75 publications in journals, conferences and book chapters, 14 patents and gave 15 invited talks. The students and faculty received 17 awards and distinctions including best paper/poster awards and recognition for professional achievement.

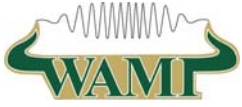


## Newsorthy Notes

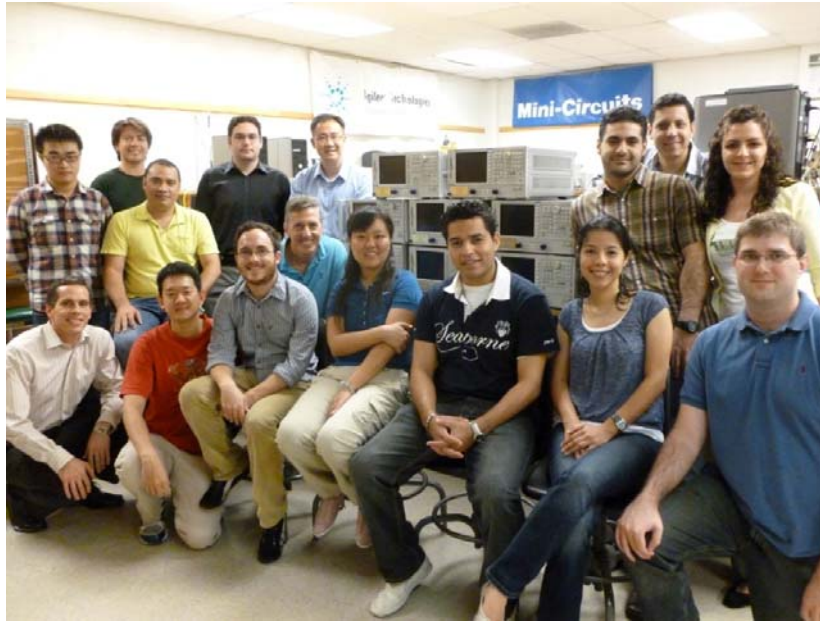
- The **2012 Rudolf E. Henning Distinguished Mentoring Award** was presented to Dr. Bumman Kim at WAMICON 2012. Dr. Kim is the Chong Yul Lee Professor for the Department of Electrical Engineering and is Director of the Microwave Application Research Center at Pohang University of Science and Technology. He has a Ph.D. in Electrical Engineering from Carnegie-Mellon University, an M.S. in Electrical Engineering from the University of Texas and a B.S. in Electronics Engineering from Seoul National University. His work has been concentrated on the field of microwave and millimeter-wave circuits and devices. He has developed linear power amplifiers (LPAs) and transmitters for mobile communication applications including LPAs based on feed-forwarding techniques, pre-distortion, base-band error correction architectures and most recently Doherty amplifiers. He had worked for the GTE Labs and the Central Research Labs of Texas Instruments. At TI, his research was devoted to the monolithic microwave integrated circuits (MMICs) and devices. He pioneered the development of power MESFETs at millimeter wave frequencies. He built the first MMIC at mm-wave frequency and the first semiconductor based oscillator operating at frequencies over 100 GHz. Dr. Kim is a fellow of IET and IEEE. He is a member of Korean Academy of Science and Technology and also a member of the National Academy of Engineering of Korea. He was a distinguished microwave lecturer, is an AdCom member of the IEEE MTT society and a member of general assembly of European Microwave Association.
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- The WAMI Center was very pleased to participate in the recognition of **Harvey Kaylie, President and Founder of Mini Circuits**, as he received an **Honorary Doctorate of Engineering** from the University of South Florida at the 2012 summer commencement ceremony. Mini Circuits has supported the WAMI Center since its inception in 1996, providing funding to more than 20 graduate students through the Mini Circuits Fellowship and Tuition Support Scholarship. Mini Circuits has also donated RF/microwave components to support the operation of the WAMI teaching laboratory each year, impacting over 1500 students in the past 15 years. In 2012 Mini Circuits donated nine Agilent 8753E vector network analyzers to the Center. The WAMI Center was honored to host Mr. Kaylie's visit and share in the University's recognition of his extensive accomplishments and contributions to the microwave industry.
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- **The 13<sup>th</sup> annual IEEE Wireless and Microwave Technology (WAMI) Conference** was held in Cocoa Beach, FL on April 15-11, 2012. The conference technical program included one workshop, two paper tracks and one tutorial track over three days consisting of authors presenting state-of-the-art multidisciplinary research on wireless RF and microwave technologies. Approximately two hundred attendees came to the conference made up of academia, industry and government from the US/Canada, Europe, Asia, and Latin America. 
- The WAMI Center has established a new relationship with TriQuint providing access to their GaAs foundry services for students taking RF/microwave courses. The TriQuint process design kit (PDK) will be integrated across multiple courses – RF/Microwave Circuits I and II, MMIC Design, and RF/MW Power Amplifier Design – to allow students the opportunity to design, layout and eventually test their own GaAs MMIC designs. Details can be found at <http://wami.eng.usf.edu/education/courses.htm>.
- 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 facilities. 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 next **WAMI Advisory Board** meeting is planned for spring 2013 in association with the 2013 WAMICON.



## Student Recognition



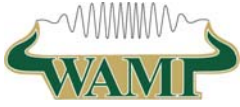
**WAMI Student Recognition:** NASA GSRP Fellowship, 2011 IEEE AP-S Student Paper Award, 2011 ARFTG Fellowship Award, 57<sup>th</sup> American Vacuum Society International Symposium Poster Award, 2011 HENAAC Poster Competition Award, Outstanding EE Undergraduate Award, USF Graduate Student Success Fellowship, USF Doctoral Student Leadership Institute Participant, 2012 internships at TI and Motorola.

- **Tony Price**, a WAMI Ph.D. student, received First Prize in the WAMICON 2012 Student Paper Competition. Tony is currently employed at Intel in Arizona.



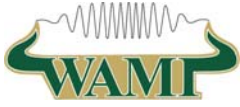
- **Ibrahim Nassar**, a WAMI Ph.D. student, received the Best Paper Award at the IMAPS Advanced Technology Workshop on 3D and Conformable Printed Electronic Packaging Materials, Manufacturing and Applications.

- **Federico Diamante and Robert Donatto**, undergraduate student researchers in the WAMI Center, received First Place in the Engineering Poster Competition at the 2012 Louis Stokes Alliance for Minority Participation Conference. These students also received First Place in the USF Electrical Engineering Department Senior Capstone Design Poster Competition. This team of students is mentored by Vinicio Carias, who is a WAMI Ph.D student, and Dr. Weller.



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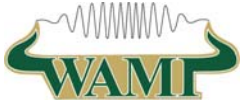
- **David Cure**, a WAMI Ph.D. student, received Honorable Mention in the 2012 International Antennas and Propagation Symposium Student Paper Competition. David also received an award in the USF College of Engineering Research Day Poster Competition.
- **Olawale Ajayi**, a WAMI Ph.D. student, received the Third Place in the Technical Papers and Poster Competition during the 24<sup>th</sup> Annual HENAAC Conference in Buena Vista, Florida, October 11-13, 2012.
- **Lan Di**, a WAMI Ph.D. student, received USF Graduate Student Success (GSS) Fellowship in fall 2012 to support his dissertation research.
- **Juan Castro**, a WAMI Ph.D. student, received a Scholarship from CONACYT (the Mexican National Council of Science and Technology) in fall 2012 to support his dissertation research.
- **Timothy Palomo**, a WAMI Ph.D. student, received honorable mention for his poster presented in USF College of Engineering Research Week, October 2012.



## Research Highlights – Current & Recent Projects

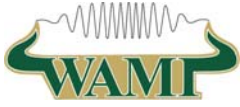
- **Collaborative Research: A Systems-Centric Foundation for Electrical and Computer Engineering Education**, P.I. S. Thomas, Co-P.I. T. Weller, Granting Agency: National Science Foundation. Development of systems-centric, hands-on learning modules for the introductory circuits course. This is a joint project with U. Hawaii, U. Minnesota, U. Vermont and Northern Arizona U.
- **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).
- **GOALI – Flexible Ferroelectric-Based Antenna for Conformal Radiometric Imaging**, P.I. T. Weller, Co-P.I. A. Kumar and D. Hoff, Granting Agency: National Science Foundation. In this project the development of tunable conformal antennas and integrated radiometers are being investigated for biomedical sensing and monitoring applications. A provisional patent application was filed based on research performed in this project: *Flexible Low Profile Microwave Antenna*, Provisional Patent Application filed 10/2009, USF Ref. No.: 09B103PR
- **GOALI: Integrated Microwave Microneedle-Electrode System for Fine Scale Material and Device Characterization**, P.I. S. Bhansali, Co-P.I. T. Weller, Granting Agency: National Science Foundation. MEMS-based uni-axial and co-axial microneedles are being integrated with microwave electronics to develop miniature systems for microwave microscopy.
- **GOALI: COLLABORATIVE RESEARCH: Passive, Diamagnetic Inertial Sensing Integrated with High-Sensitivity Telemetry**, P.I. J. Wang, Co-P.I. T. Weller, Granting Agency: National Science Foundation. This is a collaborative project being conducted with the University of Vermont to develop passive sensor networks using high-sensitivity, MEMS-based diamagnetic accelerometers.



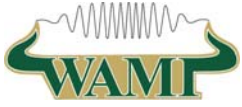


- **Miniature X-band Filters with Coupled Metamaterial Resonators**, P.I.: Gokhan Mumcu, co-P.I.: Thomas M. Weller, Granting Agency: Raytheon. Investigate designs for miniaturized X-band band-stop and band-pass filters.
- **GOALI: COLLABORATIVE RESEARCH: Antenna-Coupled ALD-Enabled Metal-Insulator-Insulator-Metal 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).
- **Miniature Low-Loss Ka-Band Phase-Shifter Using Broad-Band CRLH Unit Cells Integrated With High Reliability RF MEMS Switches**, PI T. Weller, Co-PI G. Mumcu, Granting Agency: TECOMSYS (Air Force STTR sub-contract). The purpose of this project is to investigate broad-band metamaterial based Ka-band phase shifters using RF MEMS devices.
- **Design and Characterization of 6 GHz True-Time-Delay Phase Shifter Fabricated Using Additive Manufacturing Techniques**, PI T. Weller, Granting Agency: Sciperio (Air Force SBIR sub-contract). The purpose of this project is to investigate direct-write phase shifter designs for C-band.
- **Acoustic Emission Technology on a Chip**, PI J. Wang, Co-PI R. Guldiken, WavesinSolids, LLC through National Science Foundation (NSF) SBIR Phase I 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.
- **(Pending) 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.



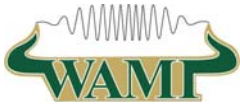


- **Simulation and Modeling of Ion Mobility Separative Capability**, P.I. J. Wang, Granting Agency: Draper Laboratory and Florida High Tech Corridor. The goal of the proposed work will be the optimization of resolution of the Differential Mobility Spectroscopy (DMS) which is currently limited to  $\sim 50$ . 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.
- **Metamaterial based Antennas & Coupling reduction for Miniature Anti-Jam GPS Arrays**, PI: G. Mumcu, Raytheon IDEA Program and Florida High Tech Corridor. The proposed dual band miniature ( $\leq \lambda/10 \times \lambda/10$ ) GPS antenna elements and their coupling reduction within a tightly packed array environment through the use of metamaterial structures will pave the way for realization of miniature anti-jam GPS arrays, potentially realizing performance of a 14" diameter Complex Radiation Pattern Antenna (CRPA) within  $< 5$ " diameter Fixed Radiation Pattern Antenna (FRPA) size.
- **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.
- **Miniaturized Low Frequency Resonant Antennas**, PI: G. Mumcu, co-PI: T. M. Weller, Granting Agency: Lockheed Martin, Develop small antennas that would work in contact with a metamaterial lens to provide superior imaging resolution at low frequency imaging applications.
- **Development of a High-Density Cylindrical Ion Trap Array Mass Spectrometer using Micro-Fabrication Techniques**, P.I. F. Amerom, Co-P.I. J. Wang, S. Bhansali, T. Short, T. Greely, Granting Agency: National Science Foundation. The objective is to develop high-density cylindrical ion-trap array mass spectrometers using micro-fabrication techniques. The devices will have lower system power and vacuum



requirements, compared to more traditional mass spectrometer designs. The mass spectrometers will be used to analyze environmental water samples.

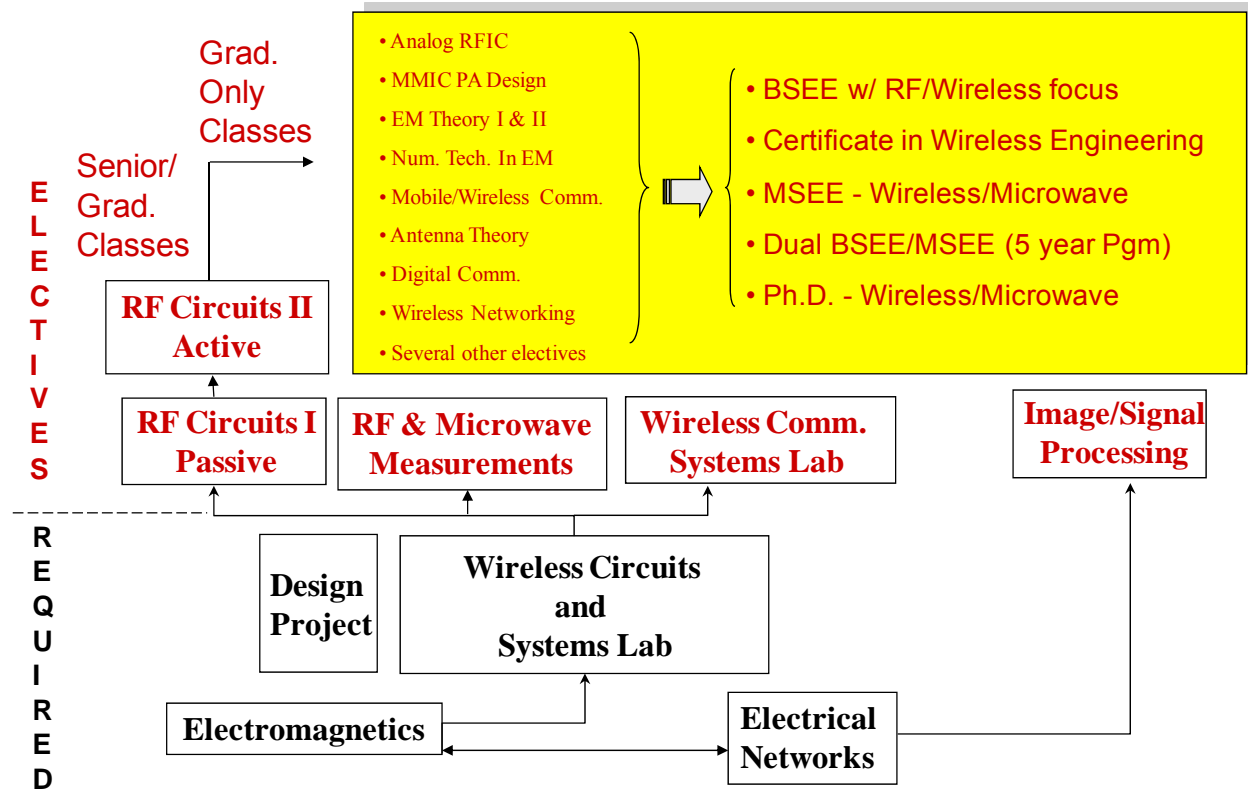
- **Virtually Transparent Epidermal Imagery**, P.I. Y. Sun, Co-P.Is. A. Anderson and R.D. Gitlin. This work has recently been funded by the NSF as a Cyber-Physical System (CPS) award. The objective of this research is to develop a cyber-physical system capable of displaying the in vivo surgical area directly onto patients' skin in real-time high definition. This system will give surgeons an “x-ray” vision experience, since they see directly through the skin, and remove a spatial bottleneck and additional scarring caused by laparoscopes in minimally invasive surgery. The approach is to develop wireless micro-cameras that: occupy no space required for surgical tools, produce no additional scarring to the patient, and transfer wireless high-definition video images. A virtual view generating system will project the panoramic videos from all cameras to the correct location on the patient’s body with geometry and color distortion compensation. The results will be a potential paradigm shift in minimally invasive surgery.
- **Interference Cancellation and Avoidance for OFDM based Future Generation Wireless Cellular Communications Systems**, PI: H. Arslan. This project is supported by NTT DoCoMo USA Labs, San Jose, CA. The goal of the project is the investigate interference scenarios for future fourth generation wireless communication systems. Especially, interference cancellation and avoidance for future OFDM based wireless communication system has been studied.
- **Signal Intelligence for Next Generation Wireless Communications Systems**, co-PI: H. Arslan. This is a collaborative project with Texas A&M University and its campus in Qatar –TAMUQ. The project is supported by QNRF (NSF of Qatar), subcontracted to USF through TAMUQ. PI (Dr. Qaraqi) is from TAMUQ. The goal for the project is to analyze wireless signals so that critical information about the received signals (or interference) can be extracted. The extracted information include location of interference, source of interference, modulation and signaling type of interference, bandwidth and carrier frequency of interference etc.
- **(Pending) Project Summary: Innovative Non-linear RF System Modeling Solutions Validated within a Re-configurable SDR Test Environment** PI: H. Arslan, NSF STTR Proposal with Modelithics Inc. This Small Business Technology Transfer Program (STTR) Phase I project will investigate emerging and new nonlinear RF system modeling solutions verified in a re-configurable physical hardware and simulation-based SDR test environment. By verifying the model performance in such an environment, we can evaluate how accurate the generated models are in system-level simulations. Of interest are metrics such as error-vector-magnitude (EVM), bit error rate (BER) and adjacent channel power ratio (ACPR). A key focus will be on the system impact of power amplifier behavior under variations in bias voltages, compression level and carrier frequencies.

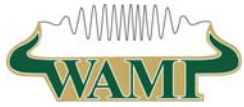


## Selected Curriculum Activities

The WAMI faculty was engaged in several on-going and new activities in 2011/2012 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.
- Through a new partnership with TriQuint, WAMI faculty will integrate the use of their GaAs process design kit into several of our RF/microwave courses. Students will now have the opportunity to design, layout and test circuits fabricated by TriQuint.
- We are continuing the process of converting the Wireless Circuits and Systems Design Laboratory to an on-line format in order to expand accessibility to remote students.
- WAMI faculty members are also involved in the new, fully on-line MSEE degree that will be offered by the USF EE Department through the USF's University College organization. Details of this new program are available at <http://uc.usf.edu/ee/apply/online-masters-degree.html>.





## Professional Activities

- **WAMI Advisory Board Meeting**  
– The 14<sup>th</sup> meeting of the WAMI Center's External Advisory Board was held in Cocoa Beach, FL in April 2012 prior to WAMICON 2012.
- **2013 International Antennas & Propagation Symposium** – Dr. Mumcu is Technical Program Committee co-chair for this conference which will be held in Orlando in summer 2013.
- **2014 International Microwave Symposium** – Drs. Dunleavy and Weller are chair and vice-chair, respectively, for the IEEE MTT Society's flagship conference that will be held in Tampa in 2014.

