Center for

Wireless and Microwave Information Systems

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

Department of Electrical Engineering
University of South Florida

Annual Report 2017

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)

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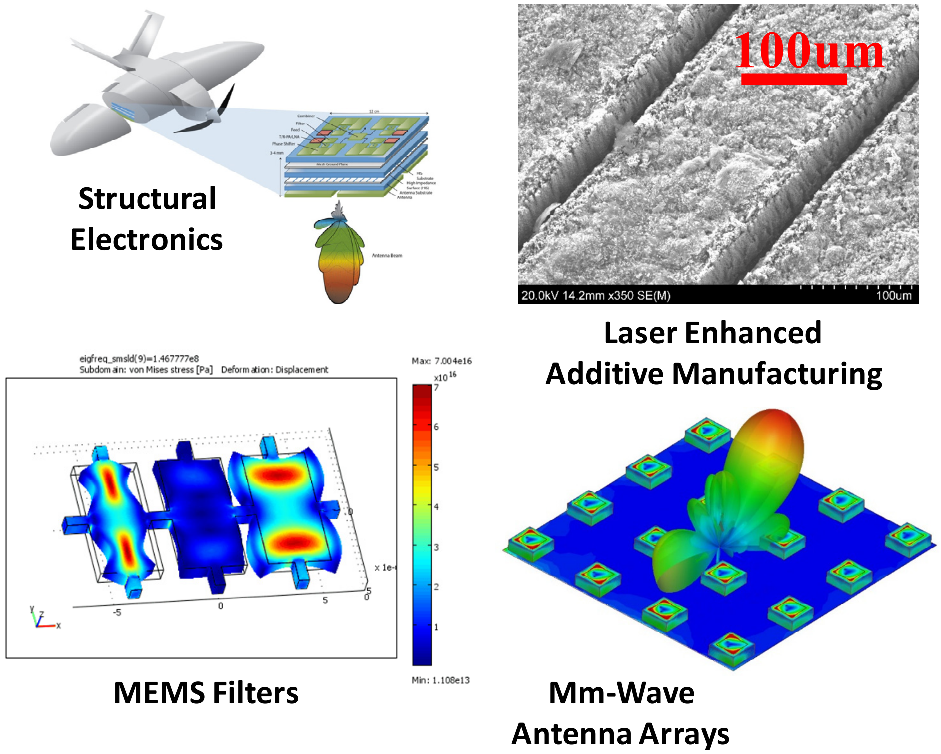


Summary

Now in its 20th year, the Center for Wireless and Microwave Information Systems conducts research across a broad range of technical areas that include device modeling and characterization, 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 2016/17 the Center supported 40 MS and PhD students, 2 post-doctoral fellows and 7 undergraduate students. Center faculty submitted 33 research proposals in the past year; of these 11 proposals were funded. The WAMI faculty had more than 80 publications in journals, conferences and book chapters, 17 patents and gave 19 invited talks. The students and faculty received 4 awards and distinctions including best paper/poster awards and recognition for professional achievement. Since 2012, the productivity of the center includes:

- Paper published: 475
- Patents granted: 73
- Invited talks: 76

Newsworthy Notes

- The **2017 Rudolf E. Henning Distinguished Mentoring Award** was presented to ***Dr. Constantine Balanis*** at WAMICON 2017. Dr. Balanis (S'62 - M'68 - SM'74 - F'86 – LF'04) received the BSEE degree from Virginia Tech, Blacksburg, VA, in 1964, the MEE degree from the University of Virginia, Charlottesville, VA, in 1966, and the Ph.D. degree in Electrical Engineering from Ohio State University, Columbus, OH, in l969. From 1964-1970 he was with NASA Langley Research Center, Hampton VA, and from 1970-1983 he was with the Department of Electrical Engineering, West Virginia University, Morgantown, WV. Since 1983 he has been with the School of Electrical, Computer and Energy Engineering, Arizona State University, Tempe, AZ, where he is Regents' Professor. His research interests are in computational electromagnetics, flexible antennas and high impedance surfaces, smart antennas, and multipath propagation. He received in 2004 a Honorary Doctorate from the Aristotle University of Thessaloniki, the 2014 James R. James, Lifetime Achievement Award, LAPC, Loughborough, UK, the 2012 Distinguished Achievement Award of the IEEE Antennas and Propagation Society, the 2012 Distinguished Achievement Alumnus Award (College of Engineering, The Ohio State University), the 2005 Chen-To Tai Distinguished Educator Award of the IEEE Antennas and Propagation Society, the 2000 IEEE Millennium Award, the 1996 Graduate Mentor Award of Arizona State University, the 1992 Special Professionalism Award of the IEEE Phoenix Section, the 1989 Individual Achievement Award of the IEEE Region 6, and the 1987-1988 Graduate Teaching Excellence Award, School of Engineering, Arizona State University. Dr. Balanis is a Life Fellow of the IEEE. He is the author of Antenna Theory: Analysis and Design (Wiley, 2005, 1997, 1982), Advanced Engineering Electromagnetics (Wiley, 2012, 1989) and Introduction to Smart Antennas (Morgan and Claypool, 2007), and editor of Modern Antenna Handbook (Wiley, 2008) and for the Morgan & Claypool Publishers, series on Antennas and Propagation series, and series on Computational Electromagnetics.

- 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 Keysight Technologies, National Instruments and Modelithics for providing our students with no-cost access to their exceptional software tools.

- Recent masters and Ph.D. graduates from the WAMI Center are now working for Embry Riddle Aeronautical University, Georgia Tech Research Institute, Maxlinear, Harris Corporation, Intel, Samsung Research, Qorvo, Qualcomm, Cummins, Vectra AI (Silicon Valley startup), Sandia National Laboratories, and NTIA (The National Telecommunications and Information Administration).

Student Recognition

- **Derar Hawatmeh,** a WAMI Ph.D. student, received first prize in the Student Paper Competition at the 2017 Wireless and Microwave Technology Conference.

- **Charles Curtiss** and **Kiran Shila** received the 2017 "Professor Rudy Henning Award for Excellence in Wireless and Microwave Studies." This award provides up to two $250 awards each year to undergraduate students who demonstrate outstanding technical potential in the area of wireless engineering and a strong interest in helping others. Charlie is now in the MSEE program at USF, while Kiran will complete the BSEE program in spring 2018.

- **Di Lan, Esad Zekeriyya Ankarali,** and **Adrian Avila**, who are WAMI Ph.D. students, both received the USF Dissertation Completion Fellowship in support of their dissertation research.

Research Highlights from Current & Recent Projects

Title: **Base Station Prediction and Proactive Mobility Management in Virtual Cells using Recurrent Neural Networks**

Authors: Dilranjan S. Wickramasuriya, Calvin A. Perumalla, Kemal Davaslioglu, and Richard D. Gitlin

Conference: WAMICON 2017

Abstract—Multicell cooperation in 5G next-generation wireless networks is essential to increasing multiuser channel capacity. Multiple base stations need to coherently process their transmitted (or received) data streams to mitigate inter-cell interference and achieve significant diversity gains. This is only possible if the correct base stations are selected. As users demand higher data rates at higher mobility, the time required to predict the optimal set of base stations to create a virtual cell is significantly reduced. In this paper, a method based on a Recurrent Neural Network (RNN) is presented to rapidly predict the next base station that a mobile node will associate with. RNNs have been used in machine learning to identify sequential data patterns such as required in protein sequence classification. In this research a RNN, trained using sequences of Received Signal Strength (RSS) values, is used to predict base station association. Simulation results demonstrate that the proposed machine learning method achieves an accuracy of over 98% to predict the optimal virtual cell topology in the time required based on the mobility of users.

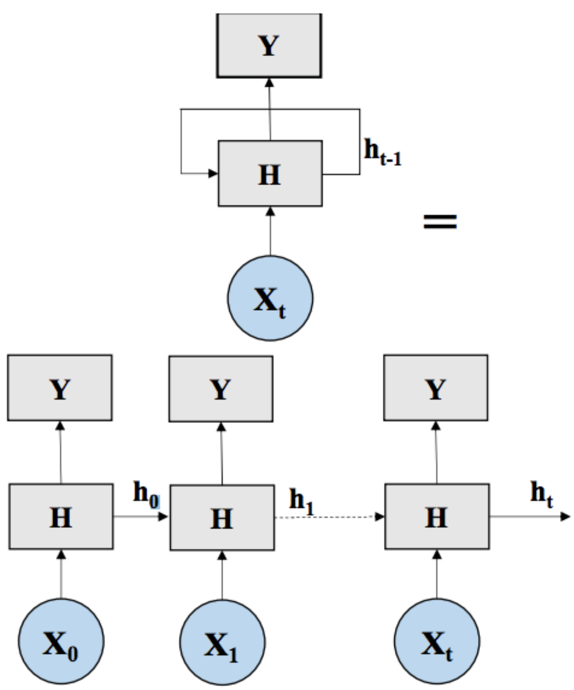


Fig. 2. Top figure shows a typical RNN structure and bottom figure show shows the same structure unrolled in time.

Title: **Energy Efficiency Optimization of Channel Access Probabilities in IEEE 802.15.6 UWB WBANs**

Authors: Y. Liu, K. Davaslioglu, and R. D. Gitlin

Conference: IEEE Wireless Communications and Networking Conference (WCNC), 2017,

Abstract—Energy efficiency is essential for Wireless Body Area Network (WBAN) applications because of the battery-operated nodes. Other requirements such as throughput, delay, quality of service, and security levels also need to be considered in optimizing the network design. In this paper, we study the case in which the nodes access the medium probabilistically and we formulate an energy efficiency optimization problem under the rate and access probability constraints for IEEE 802.15.6 Impulse Radio Ultra-wideband (IR-UWB) WBANs. The proposed algorithm, dubbed Energy Efficiency Optimization of Channel Access Probabilities (EECAP), determines the optimal access probability and payload frame size for each node. The simulation results show that our algorithm rapidly converges to the optimal solution. We also provide detailed insights on the relationship between the optimal access probabilities and other network parameters such as the link distance, the number of nodes, and the minimum rate constraints

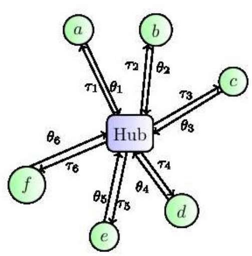


Figure 2. One-hop WBAN star network topology consisting of multiple nodes and a hub. Nodes send their application requirements and the hub sends back their channel access probabilities.

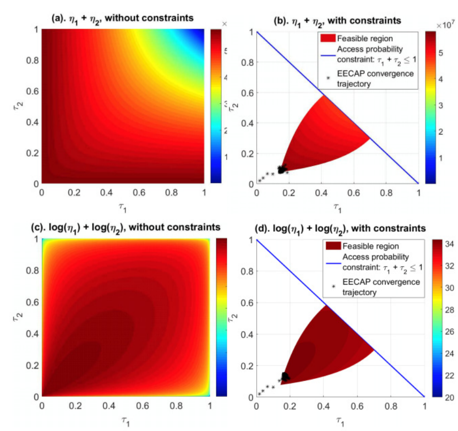


Figure 3. Feasibility regions of the **(EE)** and **(LogEE)** problems with and without constraints are depicted. Link distances are 1 meter and the minimum rate constraint taken as 1 Mbits/sec for node 1 and 0.5 Mbits/sec for node 2.

Title: **Characterization and Modeling of K-Band Coplanar Waveguides Digitally Manufactured using Pulsed Picosecond Laser Machining of Thick-Film Conductive Paste**

Authors: Eduardo A. Rojas-Nastrucci, Student Member, IEEE, Harvey Tsang, Paul I. Deffenbaugh, Ramiro A. Ramirez, Student Member, IEEE, Derar Hawatmeh, Student Member, IEEE, Anthony Ross, Student Member, IEEE, Kenneth Church, and Thomas M. Weller, Senior Member, IEEE

Abstract— Micro-dispensing of thick-film conductive paste has been demonstrated as a viable approach for manufacturing microwave planar transmission lines. However, the performance and upper frequency range of these lines is limited by the cross-sectional shape and electrical conductivity of the printed paste, as well as the achievable minimum feature size which is typically around 100 µm. In this work a picosecond Nd:YAG laser is used to machine slots in a 20-25 µm-thick layer of silver paste (Dupont CB028) that is micro-dispensed on a Rogers RT5870 substrate, producing coplanar waveguide transmission lines with 16-20 µm-wide slots. It is shown that the laser solidifies an about 2 um wide region of the edges of the slots, thus significantly increasing the effective conductivity of the film and improving the attenuation constant of the lines. The extracted attenuation constant at 20 GHz for laser machined CB028 is 0.74 dB/cm. CPW resonators and filters show that the effective conductivity is in the range of 10-30 MS/m, which represents a 100x improvement when compared to the values obtained with the exclusive use of micro-dispensing. This work demonstrates that a hybrid approach of additive manufacturing and laser machining enables the fabrication of higher frequency circuits (up to at least 40 GHz) with improved performance.

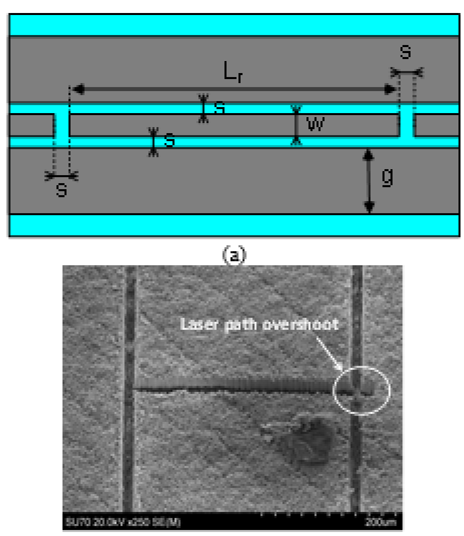
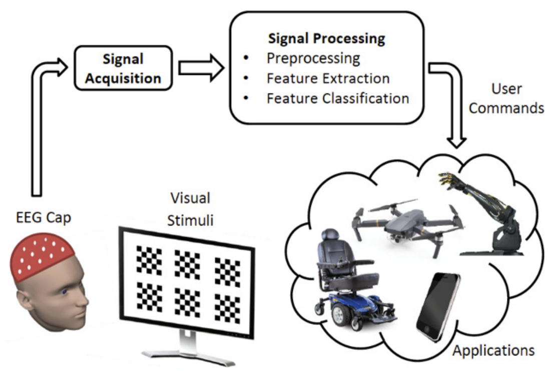


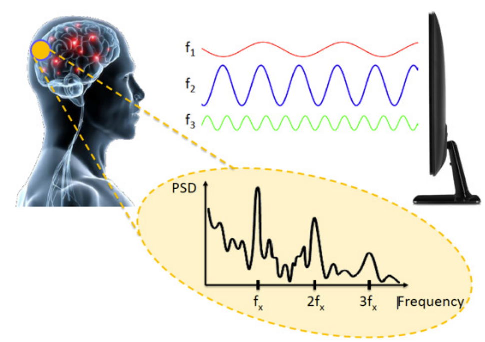
Fig. 7. (a) Illustration of series resonator. (b) Micrographs of resonator coupling slot.

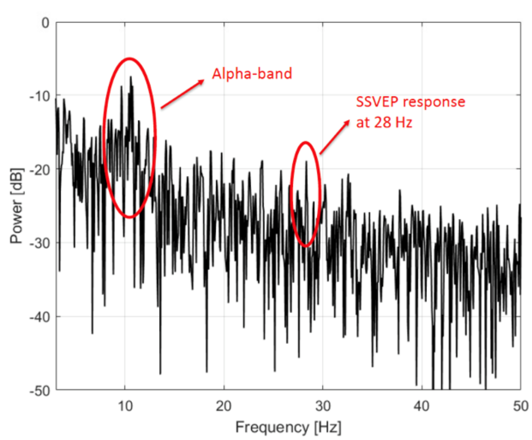
Title: **Bio-Inspired Filter Banks for SSVEP-based Brain-Computer Interfaces**

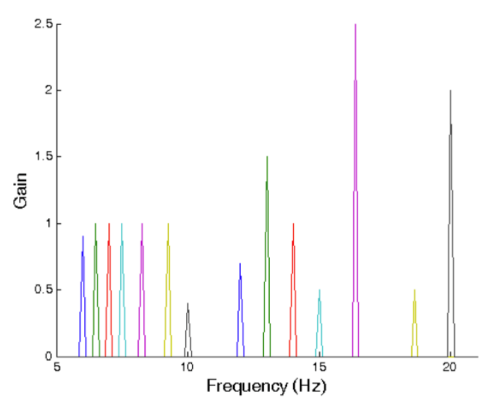
Project: SCEEE – Young Investigator Research Initiation Award – 2016-003 / PI: Ismail Uysal

Abstract— Brain-computer interfaces (BCI) have the potential to play a vital role in future healthcare technologies by providing an alternative way of communication, control, and security. More specifically, steady-state visual evoked potential (SSVEP) based BCIs have the advantage of higher accuracy and higher information transfer rate (ITR). In order to fully exploit the capabilities of such devices, it is necessary to understand the features of SSVEPs and design the system considering its inherent characteristics. This project introduces bio-inspired filter banks (BIFB) for a novel SSVEP frequency detection method. It is known that SSVEP response to a flickering visual stimulus is frequency selective and its power gets weaker as the frequency of the stimuli increases. In the proposed approach, the gain and bandwidth of the filters are designed and tuned based on these characteristics while also incorporating harmonic SSVEP responses. Furthermore, the proposed approach incorporates the variation of SSVEP response over time. This method not only improves the accuracy but also increases the number of available commands by allowing the use of stimuli frequencies elicits weak SSVEP responses. The results show the potential of bio-inspired design which will be extended to include further SSVEP characteristics for future SSVEP based BCIs.









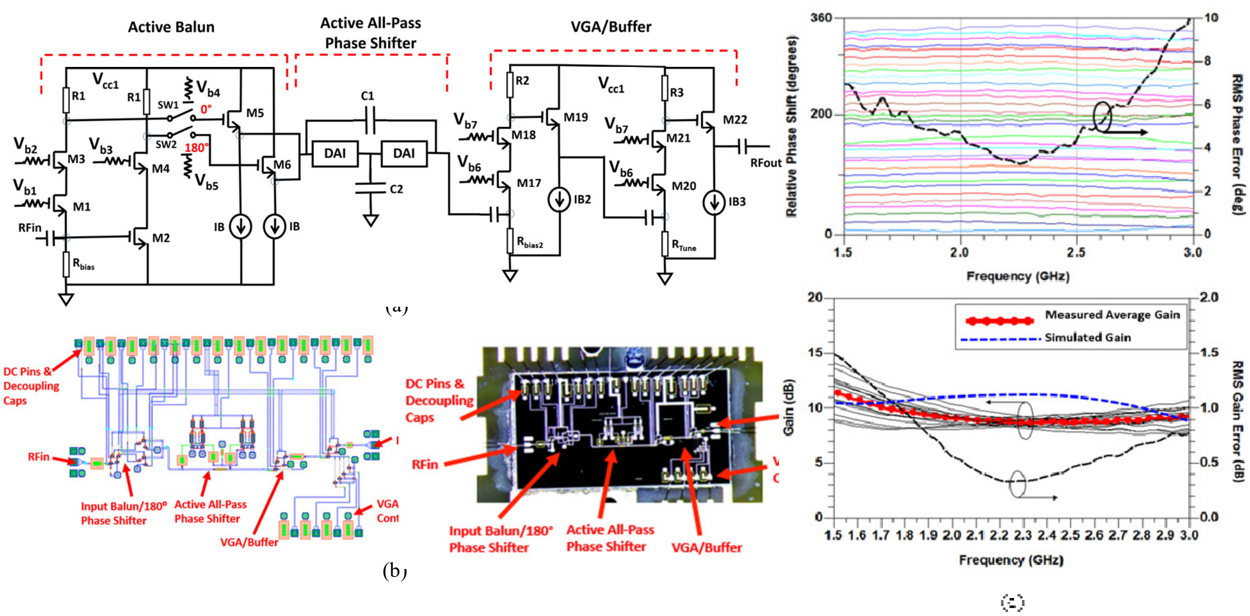
(b) Sample BIFB design for Dataset-B.

Title: **Compact and Wideband MMIC Phase Shifters Using Tunable Active Inductor Loaded All-Pass Networks**

Authors: David M. Zaiden, John E. Grandfield, Thomas M. Weller, and Gokhan Mumcu

Publication: IEEE Transactions on Microwave Theory and Techniques

Abstract— To address the challenging needs of small size, wide bandwidth and low frequency applicability, a novel phase shifter implementation is introduced that utilizes tunable active differential inductors within all-pass networks. The inductor tuning is used to achieve phase shifts up to 180º. A switchable active balanced to unbalanced transition (balun) circuit is included in front of the all-pass network to complement its phase shift capability by another 180°. In addition, the all-pass network is followed by a variable gain amplifier (VGA) to correct for gain variations among the phase shifting states and act as an output buffer. The approach is demonstrated with an on-chip design and implementation exhibiting wideband performance for S and L band applications by utilizing the 0.5 µm TriQuint pHEMT GaAs MMIC process. Specifically, the presented phase shifter exhibits 1 × 3.95 mm^2 die area and operates within the 1.5 GHz to 3 GHz band (i.e. 2:1 bandwidth) with 10 dB gain, less than 1.5 dB RMS gain error and less than 9° RMS phase error. Comparison with the state-of-the-art MMIC phase shifters operating in S and L bands demonstrates that the presented phase shifter exhibits a remarkable bandwidth performance from a very compact footprint with low power consumption.



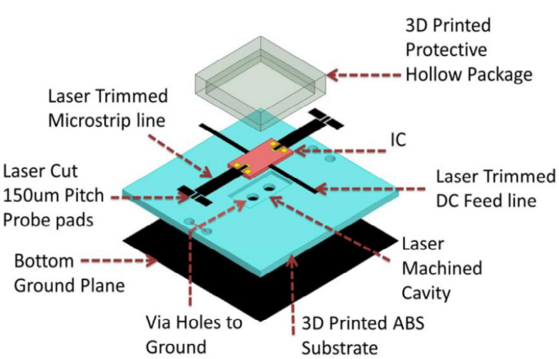
Expanded circuit schematic of the phase shifter (a); layout and fabricated die (b); measured phase shift and gain performances (c)

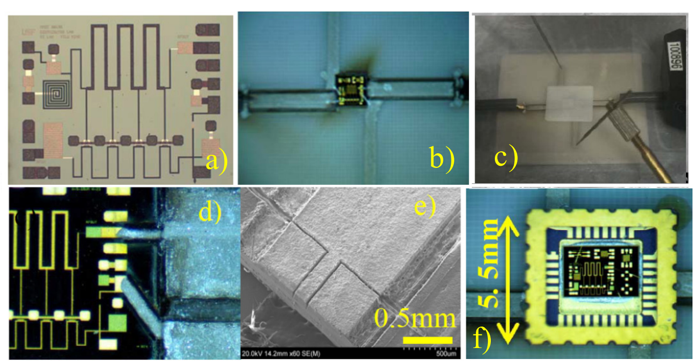
Title: **MMIC packaging and on-chip low-loss lateral interconnection using additive manufacturing and laser machining**

Authors: Ramiro A Ramirez, Di Lan, Jing Wang and Thomas M. Weller

Conference: 2017 IEEE MTT-S International Microwave Symposium (IMS)

Abstract— A new and versatile 3D printed on-chip integration approach using laser machining is demonstrated in this paper for microwave and mm-wave systems. The integration process extends interconnects laterally from a MMIC to a chip carrier. Laser machining techniques are studied and characterized to enhance the 3D printing quality. Specifically, the width of microdispensed printed traces is accurately controlled within micrometer range and probe pads are formed by laser cutting to facilitate RF measurement. S-parameters of a distributed amplifier integrated into the package are simulated and measured from 2 to 30 GHz. The overall performance is significantly better than traditional wirebonded QFN package. The attenuation of the microstrip line including interconnects is only 0.2 dB/mm at 20 GHz and return loss with the package is less than 10 dB throughout the operating frequency band. The measured S-parameters of the QFN-packaged distributed amplifier (DA) are plotted in comparison with the 3D printed packaged DA. Due to strong parasitic effects of the wirebonds and the frequency limitation of the QFN package, the bandwidth of the DA is limited to 12 GHz showing a gain reduction of 2 dB when compared to the DA integrated in the 3D printed package. Table I summarizes the obtained attenuation results of the interconnection in dB/mm and compares them with those of similar prior works. As shown, the DPAM package outperforms previous printed interconnects in terms of insertion loss by at least 0.125 dB at 5 GHz and 1.2 dB at 20 GHz.





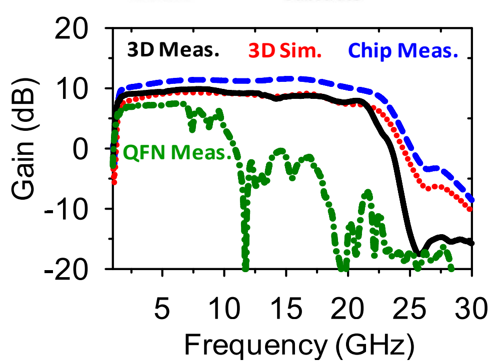


TABLE I
COMPARISON OF MEASURED PERFORMANCE

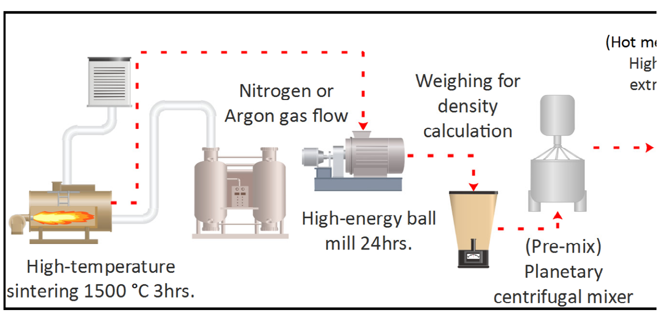
Reference	Substrate	IC Pad width (um)	Attenuation (dB/mm) 5GHz	Attenuation (dB/mm) 20GHz
DPAM	ABS	100	0.125	0.20
Tehrani [6]	Glass	200	0.25	1.45
Tehrani [7]	SU-8	230	0.40	0.60
Mehta[8]	Kapton	90	0.5	1.5
QFN_P	ABS	100	0.32	NA

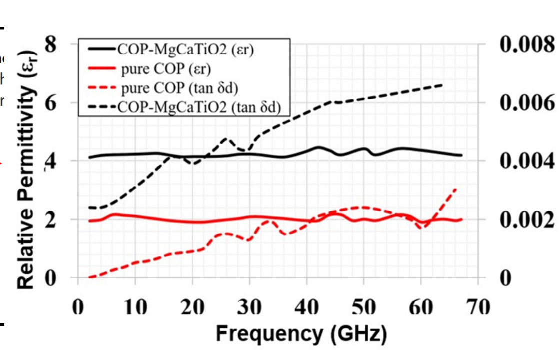
Title: **Fabrication, Modeling, and Application of Ceramic Thermoplastic Composites for Fused Deposition Modeling of Microwave Components**

Authors: Juan Castro, Eduardo Rojas, Anthony Ross, Thomas M. Weller, and Jing Wang

Publications: IEEE Transactions on Microwave Theory and Techniques

Abstract— A new kind of high permittivity (high-k) and low-loss composite material for fused deposition modeling (FDM) technology based on a cyclo-olefin polymer (COP) thermoplastic matrix embedded with sintered ceramic fillers was developed and characterized up to Ku-band. FDM printed samples made of 30 vol.% COP-$MgCaTiO_2$ composites, with filler particles sintered at 1200 °C, show a relative permittivity (ε_r) of 4.82 and a loss tangent (tan δ) below 0.0018. Meanwhile, 3-D-printed samples composed of 25 vol.% COP-$Ba_{0.55}Sr_{0.45}TiO_3$ with particles sintered at 1340 °C exhibit a ε_r of 4.92 and a tan δ lower than 0.0114. Also, 30 vol.% COP-TiO_2 specimens with filler particles sintered at 1200 °C exhibit a εr of 4.78 and a low tan δ lower than 0.0012, whereas acrylonitrile butadiene styrene-$Ba_{0.55}Sr_{0.45}TiO_3$ specimens with a 6% volume fraction loading of microparticle fillers sintered at 1340 °C have demonstrated a ε_r of 3.98 and a tan δ less than 0.0086. Edge-fed microstrip patch antennas operating at 17 GHz were fabricated by a direct digital manufacturing (DDM) approach that combines FDM of electromagnetic composites and microdispensing for deposition of conductive traces and compared with reference designs implemented using commercial microwave laminates regarding antenna size and performance. Evidently, the newly developed ceramic-thermoplastic composites are well suited for microwave device applications up to Ku-band and can be adapted to 3-D printing technologies.

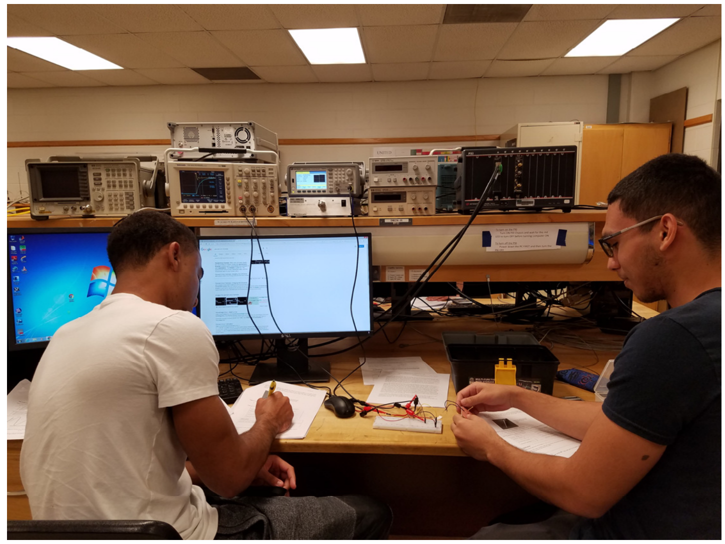




Sample	Thickness (mm)	ε_r	Test f (GHz)	Loaded Q	Unloaded Q	Loss Tangent
Plastic #1	1.082	2.15	93.7620	77097	241234	0.001018
Plastic #2	1.102	2.12	90.2817	92128	258967	0.000786
Pure ABS	1.095	2.18	82.5162	10469	250255	0.010506
Composite #1	0.721	4.78	95.1977	36596	264509	0.003849
Composite #2	0.656	4.82	101.8766	29318	277986	0.005456

Selected Curriculum Activities

The instrumentation in the Wireless Circuits and Systems Design Laboratory had a major upgrade at the end of 2017, thanks to a very generous discount (90%) on $0.5M in new network and spectrum analyzers. Five of the seven benches in the lab are now equipped with 9 GHz network analyzers and 26.5 GHz spectrum analyzers, both controlled through a PXI chassis. The teaching assistants managed to update all experiments and documents in time for the spring 2018 semester. A modulation/demodulation lab was newly introduced in the fall 2017 semester, as well.



One of the major curriculum activities that involved WAMI faculty during 2016-2017 was the restructuring of the undergraduate course on electromagnetics. The USF EE Department decided to drop Physics II (taught by the Physics Department) as a pre-engineering requirement, because there is significant overlap with the EE course on electromagnetics. When this change was made, the EE course was renamed EE Science II – Electromagnetics and it was increased to a 4 credit-hour course. With the additional 1 credit hour it is now possible to teach a weekly laboratory session that gives students hands-on experience with EM concepts. (Ironically, in 1997, what was then a 1 credit hour "EM Laboratory" was converted to the Wireless Circuits and Systems Design Laboratory, i.e. our well-known WAMI Lab.) WAMI faculty and graduate students were heavily involved with developing the new laboratory content, and we believe this has been a great addition to the EM course. Along with this change, the WAMI Lab was changed from a 2 credit hour course to a 3 credit hour course. The net result is that we gained 2 credit hours in the WAMI-related curriculum.

To keep up with a growing student interest in wireless communications, Dr. Arslan has been offering a new wireless course on Foundation Technologies on LTE advanced and Beyond for the first time in Spring 2018 semester.

Professional Activities

- **IMS 2017 Project Connect** – Dr. Weller served on the organizing committee for this NSF-sponsored project which brings undergraduate and first-year graduate students from under-represented groups to the International Microwave Symposium (Honolulu, June 2017) for professional development training.

- **International Journal of RF Technologies: Research and Applications** – Dr. Uysal was selected to the editorial board.

- **Dr. Gitlin** was inducted into the Florida Inventors Hall of Fame. (Dr. Weller accepted the award on his behalf...)

- **Dr. Uysal** received SCEEE's 2016-2017 Young Investigator Research Initiation Award. Dr. Uysal has served as the Smart Cities Technical Program Co-Chair in 2017 IEEE International Conference on RFID and Technical Program Committee Member for 2017 IEEE International Conference on RFID Technologies and Applications. Dr. Uysal was invited to present his research at the largest RFID showcase in the world, RFID Journal Live 2017 in Phoenix for the 10th year in a row.

- **Dr. Arslan** has offered tutorials in various IEEE conferences on 5G and Beyond Waveforms. He is also guest co-editor on the same topic for a special issue in PHY Communications Journal during 2018.

- **Dr. Mumcu** had invited talks in 2017 IEEE Radio and Wireless Symposium and 2017 URSI - National Radio Science Meeting on mm-wave beam-steering antennas and frequency tunable RF band pass filters using microfluidics based reconfiguration techniques.

Publications

1. D. M. Zaiden, J. E. Grandfield, T. M. Weller and G. Mumcu, "Compact and Wideband MMIC Phase Shifters Using Tunable Active Inductor-Loaded All-Pass Networks," in IEEE Transactions on Microwave Theory and Techniques, vol. PP, no. 99, pp. 1-11.
2. E. A. Rojas-Nastrucci; H. Tsang; P. I. Deffenbaugh; R. A. Ramirez; D. Hawatmeh; A. Ross; K. Church; T. M. Weller, "Characterization and Modeling of K-Band Coplanar Waveguides Digitally Manufactured Using Pulsed Picosecond Laser Machining of Thick-Film Conductive Paste," in IEEE Transactions on Microwave Theory and Techniques, vol. 65, no. 9, pp. 3180-3187, Sept. 2017.
3. J. Castro, E. A. Rojas-Nastrucci, A. Ross, T. M. Weller and J. Wang, "Fabrication, Modeling, and Application of Ceramic-Thermoplastic Composites for Fused Deposition Modeling of Microwave Components," in IEEE Transactions on Microwave Theory and Techniques, vol. 65, no. 6, pp. 2073-2084, June 2017.
4. E. A. Rojas-Nastrucci, J. T. Nussbaum, N. B. Crane and T. M. Weller, "Ka-Band Characterization of Binder Jetting for 3-D Printing of Metallic Rectangular Waveguide Circuits and Antennas," in IEEE Transactions on Microwave Theory and Techniques, vol. 65, no. 9, pp. 3099-3108, Sept. 2017.
5. R. Ramirez, E. Rojas-Nastrucci, and T. M. Weller, “UHF RFID Tags for On/Off-Metal Applications Fabricated using Additive Manufacturing,” IEEE Antennas and Wireless and Propagation Letters, Vol. 16, Issue 1, pp. 1-4, 2017.
6. Kenneth H. Church, Nathan Crane, Paul I. Deffenbaugh, Thomas P. Ketterl, Clayton Neff, Patrick Nesbitt, Justin Nussbaum, Casey Perkowski, Harvey Tsang, Jing Wang, and Thomas M. Weller, “Multi-Material and Multi-Layer Direct Digital Manufacturing of 3D Structural Microwave Electronics,” Proceedings of the IEEE, Vol. 105, Issue 4, 2017.
7. Eduardo Rojas-Nastrucci, Ramiro Ramirez, Derar Hawatmeh, Di Lan, Jing Wang and Thomas Weller, “Laser Enhanced Direct Print Additive Manufacturing for Mm-Wave Components and Packaging,” ICEAA 2017, Verona, Italy, September 2017.
8. Clayton Neff, Darrell Griffin, Eduardo Rojas, Justin Nussbaum, Thomas Weller, Nathan Crane, “Characterization of Thermal and Vapor Smoothing on Surface Roughness of Extruded Components for Printed Electronics,” submitted to the 2017 Annual International Solid Freeform Fabrication Symposium (SFF Symp 2017), April 2017.
9. M. Kacar, C. Perkowski, P. Deffenbaugh, J. Booth, G. Mumcu, and T. Weller, “Wideband Ku-Band Antennas using Multi-Layer Direct Digital Manufacturing,” 2017 International Antennas and Propagation Symposium, July 2017.
10. Q. Bonds and T. Weller, “Multi-Layer RF Tissue Phantoms for Mimicking a Human Core,” submitted to IMBIOC 2017, January 2017.
11. M. Grady and T. M. Weller, "Comparison of coherent and non-coherent scattering models for stratified media," 2017 IEEE 18th Wireless and Microwave Technology Conference (WAMICON), Cocoa Beach, FL, 2017, pp. 1-5.

12. D. Hawatmeh and T. Weller, "Embedded 6 GHz 3D-printed half-wave dipole antenna array," 2017 IEEE 18th Wireless and Microwave Technology Conference (WAMICON), Cocoa Beach, FL, 2017, pp. 1-3.
13. D. C. Lugo, R. A. Ramirez, J. Castro, J. Wang and T. M. Weller, "Ku-band additive manufactured multilayer dielectric rod waveguide," 2017 IEEE 18th Wireless and Microwave Technology Conference (WAMICON), Cocoa Beach, FL, 2017, pp. 1-3.
14. D. Hawatmeh and T. Waller, "A S/C-band high Q resonator architecture for direct print additive manufacturing," 2017 IEEE 18th Wireless and Microwave Technology Conference (WAMICON), Cocoa Beach, FL, 2017, pp. 1-4.
15. J. Castro, E. Rojas, T. Weller and J. Wang, "High-k and Low-loss Electromagnetic Composites for Direct Digital Manufacturing of mmWave Devices," 2017 Antennas and Propagation Symposium, July 2017
16. D. Lugo, R. Ramirez, J. Castro, J. Wang and T. Weller, "3D Printed Multilayer mm-Wave Dielectric Rod Antenna with Enhanced Gain," 2017 Antennas and Propagation Symposium, July 2017.
17. R. Ramirez, D. Lugo, M. Golmohamadi, J. Frolik and T. Weller, "Additive Manufactured Tripolar Antenna System for Link Improvement in High Multipath Environments," presented at 2017 Antennas and Propagation Symposium, July 2017.
18. R. A. Ramirez, D. Lan, J. Wang and T. M. Weller, "MMIC packaging and on-chip low-loss lateral interconnection using additive manufacturing and laser machining," 2017 IEEE MTT-S International Microwave Symposium (IMS), Honololu, HI, 2017, pp. 38-40.
19. M. Golmohamadi, R. Ramirez, B. Hewgill, J. Jamison, J. Frolik and T. Weller, "Characterization of a geometrically constrained tripolar antenna under M2M channel conditions," 2017 11th European Conference on Antennas and Propagation (EUCAP), Paris, 2017, pp. 2998-3002.
20. Mercier, S., Marcos, B., & Uysal, I. (2017). Identification of the best temperature measurement position inside a food pallet for the prediction of its temperature distribution. International Journal of Refrigeration, 76, 147-159.
21. Mercier, S., Villeneuve, S., Mondor, M., & Uysal, I. (2017). Time–Temperature Management Along the Food Cold Chain: A Review of Recent Developments. Comprehensive Reviews in Food Science and Food Safety, *16*(4), 647-667.
22. Ferdous, A., Jeevarathnam, N.G., & Uysal, I. (2017). Comparative analysis of tag estimation algorithms on RFID EPC Gen-2 performance. In RFID Technology and Applications (RFID-TA), 2017 IEEE International Conference on. pp 186-190.
23. Mercier, S., & Uysal, I. (submitted Summer 2017). Neural network models for predicting perishable food temperatures along the supply chain. Biosystems Engineering (to be published in 2018).
24. Kilinc, O., & Uysal, I. (submitted Summer 2017). GAR: An Efficient and Scalable Graph-based Activity Regularization for Semi-Supervised Learning. Neurocomputing (to be published in 2018).

25. Mercier, S., & Uysal, I. (submitted Summer 2017). Noisy matrix completion on a novel neural network framework. Chemometrics and Intelligent Laboratory Systems (to be published in 2018).
26. M. Baghelani, D. Lan, J. Wang, “Design of spurious mode-free elliptical ring resonators,” *Journal of Microsystem Technologies* (2016). doi:10.1007/s00542-016-3158-y.
27. V. Carias, Z. Nemati, K. Stojak, J. Alonso, H. Srikanth, J. Rühe, R. Toomey, and J. Wang, “Remotely Controlled Micromanipulation by Buckling Instabilities in Fe3O4 Nanoparticle Embedded Poly(N-isopropylacrylamide) Surface Arrays,” *ACS Applied Materials & Interfaces*, Vol. 8, No. 41, pp. 28012-28018, 2016. DOI: 10.1021/acsami.6b05899
28. M. Wei, I. Rivera, A. Avila, M. Baghelani, J. Wang, “ZnO on Nickel RF Micromechanical Resonators for Monolithic Wireless Communication Applications,” Published in *Journal of Micromechanics and Microengineering*, February 17, 2017.
29. X. Qiu, Z. Yang, Y. Sun, L. Lai, Z. Jin, G. Ding, X. Zhao, J. Yao, and J. Wang, “Shock-Resistibility of MEMS-Based Inertial Microswitch under Reverse Directional Ultra-High g Acceleration for IoT Applications,” *Scientific Reports-Nature*, March 31, 2017; 7: 45512. http://doi.org/10.1038/srep45512
30. A. Alsolami, A. Zaman, I. F. Rivera, M. Baghelani and J. Wang, "Improvement of Deep Reactive Ion Etching Process For Motional Resistance Reduction of Capacitively Transduced Vibrating Resonators," in IEEE Sensors Letters, vol. 2, no. 1, pp. 1-4, March 2018.
31. D. Lugo, R. A. Ramirez, J. Wang and T. Weller, "3D Printed Multilayer mm-Wave Dielectric Rod Antenna with Enhanced Gain," *accepted by 2017 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, San Diego, California, July 9-14, 2017.
32. J. Castro, E. A. Rojas-Nastrucci, T. Weller, J. Wang, “High-k and Low-loss Electromagnetic Composites for Direct Digital Manufacturing of mmWave Devices,” *accepted by 2017 IEEE International Symposium on Antennas and Propagation and USNC-URSI Radio Science Meeting*, San Diego, California, July 9-14, 2017.
33. D. Lugo, R. A. Ramirez, J. Wang and T. Weller, “Ku-band Additive Manufactured Multilayer Dielectric Rod Waveguide,” *accepted by 2017 IEEE 18th Wireless and Microwave Technology Conference (WAMICON)*, Cocoa Beach, FL, April 24-25, 2017.
34. R. A. Ramirez, D. Lan, T. Weller and J. Wang, "MMIC Packaging and On-Chip Low-Loss Lateral Interconnection using Additive Manufacturing and Laser Machining," *accepted by 2017 IEEE MTT-S International Microwave Symposium (IMS)*, Honolulu, Hawaii, 2017.
35. J. Castro, E. Rojas, A. Ross, T. Weller and J. Wang, "High Permittivity and Ultra Low-Loss Thermoplastic Composites Based on Co-fired Titanium Oxides for Fused Deposition Modeling and Their Application to 3D-Printed Microwave Devices," *HENAAC Conference 2016*, Anaheim, CA, October 5-9, 2016.
36. Eren Balevi and R. D. Gitlin, "Unsupervised Machine Learning in 5G Networks for Low Latency Communications," IEEE International Performance Computing and Communications Conference-IPCCC-2017, December 2017, San Diego, CA. **PDF**.

37. Eren Balevi and R. D. Gitlin, "Performance Analysis of Local Anchor Based 5G HetNets Using Stochastic Geometry," International Journal of Wireless & Mobile Networks (IJWMN) Vol. 9, No. 5, October 2017 **PDF**.
38. N. Sulieman, Eren Balevi, K. Davaslioglu, and R. D. Gitlin, "Diversity and Network Coded 5G Fronthaul Wireless Networks for Ultra Reliable and Low Latency Communications," IEEE International Symposium on Personal, Indoor and Mobile Radio Communications 2017, Montreal, QC, Canada, Oct 2017, **PDF**.
39. N. Sulieman, K. Davaslioglu, and R. D. Gitlin, "Diversity Coded 5G Fronthaul Wireless Networks," IEEE Wireless Telecommunications Symposium (WTS), 2017, Chicago, IL, April 2017, DOI: **10.1109/WTS.2017.7943537**.
40. D. S. Wickramasuriya, C. A. Perumalla, K. Davaslioglu, and R. D. Gitlin, "Base Station Prediction and Proactive Mobility Management in Virtual Cells using Recurrent Neural Networks," IEEE 18th Wireless and Microwave Technology Conference (WAMICON), April 2017, DOI: **10.1109/WAMICON.2017.7930254**.
41. F. Al Rabee, K. Davaslioglu, and R. D. Gitlin, "The Optimum Received Power Levels of Uplink Non- Orthogonal Multiple Access (NOMA) Signals," IEEE 18th Wireless and Microwave Technology Conference (WAMICON), April 2017, DOI: **10.1109/WAMICON.2017.7930242**.
42. A. Mazin, K. Davaslioglu, and R. D. Gitlin, "Secure Key Management for 5G Physical Layer Security," IEEE 18th Wireless and Microwave Technology Conference (WAMICON), April 2017, DOI: **10.1109/WAMICON.2017.7930246**.
43. N. Sulieman, K. Davaslioglu, and R. D. Gitlin, "Link Failure Recovery via Diversity Coding in 5G Fronthaul Wireless Networks," IEEE 18th Wireless and Microwave Technology Conference (WAMICON), April 2017, DOI: **10.1109/WAMICON.2017.7930241**.
44. Y. Liu, K. Davaslioglu, and R. D. Gitlin, "Energy Efficiency Optimization of Channel Access Probabilities in IEEE 802.15.6 UWB WBANs," IEEE Wireless Communications and Networking Conference (WCNC), 2017, San Francisco, CA, March 2017, DOI:**10.1109/WCNC.2017.7925609**.
45. D. S. Wickramasuriya, C. A. Perumalla, and R. D. Gitlin, "Predicting Episodes of Atrial Fibrillation using RR-Intervals and Ectopic Beats," IEEE/EMB joint International Conference on Biomedical and Health Informatics (BHI), Orlando, FL, February 2017, DOI: **10.1109/BHI.2017.7897294**.
46. Y. Liu, K. Davaslioglu, and R. D. Gitlin, "Energy Efficiency and Resource Allocation of IEEE 802.15.6 IR-UWB WBANs: Current State-of-the-Art and Future Directions," Information Theory and Applications Workshop (ITA), 2017, San Diego, CA, February 2017, **PDF**.
47. K. Davaslioglu, Y. Liu and R. D. Gitlin, "CLOEE - Cross-Layer Optimization for Energy Efficiency of IEEE 802.15.6 IR-UWB WBANs," IEEE GLOBECOM 2016, December 2016, DOI: **10.1109/GLOCOM.2016.7841659**.
48. A. F. Demir, Z. E. Ankaral, Q. H. Abbasi, Y. Liu, K. Qaraqe, E. Serpedin, H. Arslan and R. D. Gitlin, "*In Vivo* Communications: Steps Toward the Next Generation of Implantable

Devices, " IEEE Vehicular Technology Magazine (Volume: 11, Issue: 2), pp. 32-42, June 2016, DOI: **10.1109/MVT.2016.2520492**.

49. A. F. Demir, Z. E. Ankaral, Y. Liu, Q. H. Abbasi, K. Qaraqe, E. Serpedin, H. Arslan and R. D. Gitlin, "*In Vivo* Wireless Channel Modeling," Book Chapter in: *Advances in Body-Centric Wireless Communication: Applications and State-of-the-art*, IET, 2016, ISBN: **978-1-84919-989-6**.
50. K. Davaslioglu and R. D. Gitlin, "5G Green Networking - Enabling Technologies, Potentials, and Challenges," IEEE 17th Wireless and Microwave Technology Conference (WAMICON), April 2016, DOI: **10.1109/WAMICON.2016.7483860**.
51. C. He and R. D. Gitlin, "System performance of cooperative massive MIMO downlink 5G cellular systems," IEEE 17th Wireless and Microwave Technology Conference (WAMICON), April 2016, DOI: **10.1109/WAMICON.2016.7483862**.
52. C. He and R. D. Gitlin, "Limiting Performance of Massive MIMO Downlink Cellular Systems," Information Theory and Applications Workshop (ITA), 2016, San Diego, CA, February 2016, DOI: **10.1109/ITA.2016.7888139**
53. M. H. Yilmaz, E. Guvenkaya, H. M. Furqan, S. Kose, H. Arslan, "Cognitive Security of Wireless Communication Systems in the Physical Layer," Hindawi Wireless Communications and Mobile Computing, vol. 2017, 9 pages, Dec. 2017.
54. Z. E. Ankarali, A. Sahin, H. Arslan "Joint Time-Frequency Alignment for PAPR and OOBE Suppression of OFDM-Based Waveforms," IEEE Communications Letters, 21(12), 2586-2589, Dec. 2017.
55. J. M. Hamamreh, E. Basar, H. Arslan, "OFDM-Subcarrier Index Selection for Enhancing Security and Reliability of 5G URLLC Services," IEEE Access, 5, 25863-25875, Dec. 2017.
56. Z. E. Ankarali, H. Arslan, "Cyclic Feature Suppression for Physical Layer Security," Physical Communication (PHYCOM) by Elsevier, 25(2), 588-597, Dec. 2017.
57. M. H. Yilmaz, S. Kose, N. H. Chamok, M. Ali, H. Arslan, "Partially Overlapping Filtered Multitone with Reconfigurable Antennas in Uncoordinated Networks," Physical Communication (PHYCOM) by Elsevier, 25(1), 249-258, Dec. 2017.
58. E. Guvenkaya, J. M. Hamamreh, H. Arslan, "On Physical-Layer Concepts and Metrics in Secure Signal Transmission," Physical Communication (PHYCOM) by Elsevier, 25(1), 14-25, Dec. 2017.
59. M. Yusuf, H. Arslan, "On Signal Space Diversity: An Adaptive Interleaver for Enhancing Physical Layer Security in Frequency Selective Fading Channels," Physical Communication (PHYCOM) by Elsevier, 24, 154-160, Sept. 2017.
60. Z. E. Ankarali, B. Pekoz, H. Arslan, "Flexible Radio Access Beyond 5G: A Future Projection," IEEE Access, 5, 18295-18309, Sept. 2017.
61. A. F. Demir, Q. H. Abbasi, Z. E. Ankarali, A. Alomainy, K. Qaraqe, E. Serpedin, H. Arslan, "Anatomical Region-Specific In Vivo Wireless Communication Channel Characterization," IEEE Journal of Biomedical and Health Informatics, 21(5), 1254-1262, Sept. 2017.
62. Z. E. Ankarali, B. Pekoz, H. Arslan, "Enhanced OFDM for 5G RAN," ZTE Communications: Special Issue on 5G New Radio (NR): Standard and Technology, 15(S1), 11-20, June 2017.
63. J. M. Hamamreh, H. Arslan, "Secure Orthogonal Transform Division Multiplexing (OTDM) Waveform for 5G and Beyond," IEEE Communications Letters, 21(5), 1191-1194, May 2017.

64. M. H. Yilmaz, E. Guvenkaya, G. Mumcu, H.Arslan, "Millimeter-Wave Wireless Channel Control using Spatially Adaptive Antenna Arrays," IEEE Communications Letters, 21(3), 680-683, Mar. 2017.
65. H. M. Furqan, H. Arslan, "User Association for Enhancing Physical Layer Security in Heterogeneous Network," International Telecommunications Conference (ITelCon), Dec. 28-29, 2017.
66. J. M. Hamamreh, H. Arslan, "Time-Frequency Characteristics and PAPR Reduction of OTDM Waveform for 5G and Beyond," 10th International Conference on Electrical and Electronics Engineering (ELECO), Nov. 30 – Dec. 2, 2017.
67. A. F. Demir, H. Arslan, "The Impact of Adaptive Guards for 5G and Beyond," IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Oct. 8-13, 2017.
68. H. M. Furqan, J. M. Hamamreh, H. Arslan, "Enhancing Physical Layer Security of OFDM-based Systems Using Channel Shortening," IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Oct. 8-13, 2017.
69. B. Pekoz, S. Kose, H. Arslan, "Adaptive Windowing of Insufficient CP for Joint Minimization of ISI and ACI Beyond 5G," IEEE International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC), Oct. 8-13, 2017.
70. J. M. Hamamreh, H. M. Furqan, H. Arslan, "Secure Pre-coding and Post-coding for OFDM Systems along with Hardware Implementation," IEEE International Wireless Communications and Mobile Computing Conference (IWCMC), 1338-1343, Jun. 26-30, 2017.
71. H. M. Furqan, J. M. Hamamreh, H. Arslan, "Secure Communication via Untrusted Switchable Decode-and-Forward Relay," IEEE International Wireless Communications and Mobile Computing Conference (IWCMC), 1333-1337, Jun. 26-30, 2017.
72. M. Nemati, H. Takshi, H. Arslan, "Discrete Fourier Transform Spread Zero Word OFDM," IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom), 1-6, Jun. 5-8, 2017.
73. M. Nemati, H. Takshi, H. Arslan, "A Flexible Hybrid Waveform," IEEE International Black Sea Conference on Communications and Networking (BlackSeaCom), 1-5, Jun. 5-8, 2017.
74. A. Yazar, H. Arslan, "Waveform Design Priorities in Different Wireless Communications Systems for 5G Beyond," IEEE Signal Processing and Communications Applications Conference (SIU), 1-4, May 15-18, 2017.
75. M. Helmy, Z. E. Ankarali, M. Siala, T. Baykas, H. Arslan, "Dynamic Utilization of Low-Altitude Platforms in Aerial Heterogeneous Cellular Networks," IEEE Wireless and Microwave Technology Conference (WAMICON), 1-6, Apr. 24-25, 2017.
76. T. Palomo and G. Mumcu, "Microfluidically Reconfigurable Microstrip Line Combline Filters with Wide Frequency Tuning Capabilities," IEEE Transactions on Microwave Theory and Techniques, vol. 65, no. 10, pp. 3561 – 3568, Oct. 2017.
77. A. Dey, R. Guldiken, and G. Mumcu, "Microfluidically Reconfigured Wideband Frequency Tunable Liquid Metal Monopole Antenna," IEEE Transactions on Antennas and Propagation, vol. 64, no. 6, pp. 2572 – 2576, June 2016.
78. A. W. Khan, T. Wanchoo, G. Mumcu, and S. Kose, "Implications of Distributed On-Chip Power Delivery on EM Side-Channel Attacks," IEEE International Conference on Computer Design (ICCD), pp. 329 – 336, 5 – 8 Nov. 2017.

79. E. Gonzalez and G. Mumcu, "Mm-Wave 2D Beam-Steering Focal Plane Array with Microfluidically Switched Feed Network," IEEE Antennas and Propagation Society Symposium, pp. 1 – 2, San Diego, CA, July 9 – July 14, 2017.
80. T. Palomo and G. Mumcu, "Frequency-Agile RF Filters Using Microfluidically Reconfigurable Selectively Metallized Plates," IEEE Radio and Wireless Symposium, Phoenix, AZ, USA, Jan. 2017 (invited).
81. E. Gonzalez and G. Mumcu, "MM-Wave High Gain Beam-Scanning Focal Plane Arrays with Microfluidically Switched Feed Networks," URSI - National Radio Science Meeting, Boulder, CO, USA, Jan. 2017 (invited).
82. A. Dey and G. Mumcu, "Microfluidic Based High Resolution Microwave Imaging System," presented in IEEE Antennas and Propagation Society Symposium, Fajardo, Puerto Rico, Jun. 26 – Jul. 1 2016.
83. E. Gonzalez and G. Mumcu, "Low-Loss Wideband Feed Networks for High Gain Microfluidic Beam-Scanning Focal Plane Arrays," IEEE Antennas and Propagation Society Symposium, pp. 1 – 2, Fajardo, Puerto Rico, Jun. 26 – Jul. 1 2016.