

## **Inkjet-Printed Paper/Polymer-Based "Green" RFID and Wireless Sensor Nodes: The Final Step to Bridge Cognitive Intelligence, Nanotechnology and RF**

**Duration:** half day

### **Summary**

In this talk, inkjet-printed flexible antennas, RF electronics and sensors fabricated on paper and other polymer (e.g.LCP) substrates are introduced as a system-level solution for ultra-low-cost mass production of UHF Radio Frequency Identification (RFID) Tags and Wireless Sensor Nodes (WSN) in an approach that could be easily extended to other microwave and wireless applications. The talk will cover examples from UHF up to the millimeter-wave frequency ranges.

A compact inkjet-printed UHF "passive-RFID" antenna using the classic T-match approach and designed to match IC's complex impedance, is presented as a the first demonstrating prototype for this technology. Then, Prof. Tentzeris will briefly touch up the state-of-the-art area of fully-integrated wireless sensor modules on paper or flexible LCP and show the first ever 2D sensor integration with an RFID tag module on paper, as well as numerous 3D multilayer paper-based and LCP-based RF/microwave structures, that could potentially set the foundation for the truly convergent wireless sensor ad-hoc networks of the future with enhanced cognitive intelligence and "rugged" packaging.

Prof. Tentzeris will discuss issues concerning the power sources of "near-perpetual" RF modules, including flexible minaturized batteries as well as power-scavenging approaches involving thermal, EM, vibration and solar energy forms.

The final step of the presentation will involve examples from wearable (e.g. biomonitoring) antennas and RF modules, as well as the first examples of the integration of inkjet-printed nanotechnology-based (e.g. CNT) sensors on paper and organic substrates. It has to be noted that the talk will review and present challenges for inkjet-printed organic active and nonlinear devices as well as future directions in the area of environmentally-friendly ("green") RF electronics and "smart-skin' conformal sensors

**Method of presentation:** oral presentation

### **Autobiography for Professor Manos M. Tentzeris**

Professor Manos M. Tentzeris received the Diploma Degree in Electrical and Computer Engineering from the National Technical University of Athens ("Magna Cum Laude") in Greece and the M.S. and Ph.D. degrees in Electrical Engineering and Computer Science from the University of Michigan, Ann Arbor, MI and he is currently a Professor with School of ECE, Georgia Tech, Atlanta, GA. He has published more than 370 papers in refereed Journals and Conference Proceedings, 5 books and 19 book chapters. Dr. Tentzeris

has helped develop academic programs in Highly Integrated/Multilayer Packaging for RF and Wireless Applications using ceramic and organic flexible materials, paper-based RFID's and sensors, "Green" electronics and power scavenging, nanotechnology applications in RF, Microwave MEM's, SOP-integrated (UWB, mutliband, conformal) antennas and Adaptive Numerical Electromagnetics (FDTD, MultiResolution Algorithms) and heads the ATHENA research group (20 researchers). He is the Georgia Electronic Design Center Associate Director for RFID/Sensors research, and he has been the Georgia Tech NSF-Packaging Research Center Associate Director for RF Research and the RF Alliance Leader from 2003-2006. He was the recipient/co-recipient of the 2010 IEEE Antennas and Propagation Society Piergiorgio L. E. Uslenghi Letters Prize Paper Award, the 2010 Georgia Tech Senior Faculty Outstanding Undergraduate Research Mentor Award, the 2009 IEEE Transactions on Components and Packaging Technologies Best Paper Award, the 2009 E.T.S.Walton Award from the Irish Science Foundation, the 2007 IEEE APS Symposium Best Student Paper Award, the 2007 IEEE IMS Third Best Student Paper Award, the 2007 ISAP 2007 Poster Presentation Award, the 2006 IEEE MTT Outstanding Young Engineer Award, the 2006 Asian-Pacific Microwave Conference Award, the 2004 IEEE Transactions on Advanced Packaging Commendable Paper Award, the 2003 NASA Godfrey "Art" Anzic Collaborative Distinguished Publication Award, the 2003 IBC International Educator of the Year Award, the 2003 IEEE CPMT Outstanding Young Engineer Award, the 2002 International Conference on Microwave and Millimeter-Wave Technology Best Paper Award (Beijing, CHINA), the 2002 Georgia Tech-ECE Outstanding Junior Faculty Award, the 2001 ACES Conference Best Paper Award and the 2000 NSF CAREER Award and the 1997 Best Paper Award of the International Hybrid Microelectronics and Packaging Society. He was the TPC Chair for IEEE IMS 2008 Symposium and the Chair of the 2005 IEEE CEM-TD Workshop and he is the Vice-Chair of the RF Technical Committee (TC16) of the IEEE CPMT Society. He is the founder and chair of the RFID Technical Committee (TC24) of the IEEE MTT Society and the Secretary/Treasurer of the IEEE C-RFID. He is the Associate Editor of IEEE Transactions on Microwave Theory and Techniques, IEEE Transactions on Advanced Packaging and International Journal on Antennas and Propagation. Dr.Tentzeris was a Visiting Professor with the Technical University of Munich, Germany for the summer of 2002, a Visiting Professor with GTRI-Ireland in Athlone, Ireland for the summer of 2009 and a Visiting Professor with LAAS-CNRS in Toulouse, France for the summer of 2010. He has given more than 100 invited talks to various universities and companies all over the world. He is a Fellow of IEEE, a member of URSI-Commission D, a member of MTT-15 committee, an Associate Member of EuMA, a Fellow of the Electromagnetic Academy and a member of the Technical Chamber of Greece. Prof. Tentzeris is one of the IEEE MTT-S Distinguished Microwave Lecturers from 2010-2012.