Understanding and Improving Longevity
In RF MEMS Capacitive Switches

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Abstract: Capacitive switching technology possesses many benefits over both conventional electronic switching devices and ohmic-contact MEMS switches at microwave and millimeter-wave frequencies. These benefits include a very high figure of merit, low effective on-resistance, reliable hot-switched operation, miniscule power consumption, and ultra-high linearity. To date, the lifetime limiting mechanism within capacitive switching has been dielectric charging of the switch insulator. This has limited the cycle lifetimes and continuous “on” operation of these switches. Recent advancements in our understanding of dielectric charging are paving the way to improved device operation. Developments in electronic characterization have demonstrated that transient current spectroscopy can be effectively used to characterize the charging phenomenon within MEMS capacitive switches. Using the appropriate charge models, relevant characteristics of the charged carriers can be extracted, including such important characteristics as carrier lifetimes and densities as a function of voltage and temperature. This improved understanding of the charging phenomena enables improved switch designs which reduce the amount of dielectric charging and ensure sufficient restoring force to overcome stiction due to charging. Strategies for improving capacitive switch lifetime include 1) reducing operating bias voltages, 2) incorporating electrical designs which trade capacitance ratio for lifetime (typically achieved through a change in the dielectric to air ratio), and 3) innovative materials development. This presentation overviews the challenges, successes, and failures associated with the quest to improve capacitive RF MEMS switch lifetime. Data featuring lifetime demonstrations over 100 billion cycles will be included.

Bio: Dr. Chuck Goldsmith received Bachelors and Masters Degrees in Electrical Engineering from the University of Arizona. He received his Ph.D. degree from the University of Texas at Arlington. Since 1982, he has been involved in the design and development of microwave/millimeter wave circuits and subsystems. He has been employed by M/A COM, Texas Instruments, and was previously an Engineering Fellow at Raytheon Company. Dr. Goldsmith formed MEMtronics Corporation in 2001, where he is currently pursuing business opportunities for RF MEMS in the defense and commercial markets. Dr. Goldsmith has been developing RF MEMS devices and circuits since 1993, and is the inventor of the capacitive membrane RF MEMS switch. He has spent the last decade dedicated to the development and application of this technology. These activities include the innovation of switches, phase shifters, and tunable antennas for radar and satcomm applications, as well as variable capacitors and tunable filters for microwave receiver front-ends. Dr. Goldsmith has authored or co-authored over 50 publications on microwave circuits, photonics, and RF MEMS. He is also inventor or co-inventor of eleven granted and two pending patents in related fields. He has been the guest editor for three “Special Issues on RF Applications of MEMS Technology” for the International Journal of RF and Microwave Computer-Aided Engineering (Wiley – 1999, 2001, and 2004). Dr. Goldsmith is a Senior Member of the IEEE (Microwave Theory & Techniques Society and Electron Device Society) and a member of Tau Beta Pi. He has served as Chairman and Vice-Chairman of the IEEE LEOS Dallas Chapter, and currently serves on the IEEE MTT Technical Coordinating Committee (TCC-21) on RF MEMS.