WWD (IMS) Wednesday 13:00 – 17:00 BCEC Room 151AB

RF MEMS Testing, Reliability, and Power Handling

Half-day workshop reviewed by MTT-21, MTT-8, MTT-12

Organizer(s):

John L. Ebel, Air Force Research Laboratory; MTT-21, IMS TPC.
Daniel J. Hyman, XCOM Wireless; MTT-21.

RF MEMS devices continue to demonstrate steady increases in lifetime, reliability, and other critical performance metrics. Reliability issues, however, continue to be the primary impediments to mainstream commercial adoption of these technologies. As a result, potential users of RF MEMS technology have an increased interest both in understanding the methods used by manufacturers to evaluate their devices, and in developing their own methods to evaluate devices for particular applications. In this workshop, reliability and lifetime issues will be addressed and analyzed with respect to various RF MEMS devices, as well as testing and experimentation for the characterization of the electrical and mechanical performance of the devices. Concepts that address several of the present problems and improve the MEMS device performance will also be presented.

Speakers:

1. John Maciel, Radant MEMS
"A High-Reliability, High-Power Ohmic MEMS Switch"

MEMS switches will be important building blocks for phase shifters, antennas, ATE, cellular, instrumentation and filters, to name a few. Low power consumption, large ratio of off-impedance to on-impedance, extreme linearity and the ability to be integrated makes MEMS switches an attractive alternative. Radant has developed an electrostatically actuated broadband ohmic microswitch based on a cantilever beam that is fabricated using a surface micromachining process. It operates in a hermetic environment obtained through a wafer-bonding process. Extensive lifetime testing has been conducted by Radant and each of the three DoD service laboratories. Testing at 20 dBm at X-band on a batch of 64 switches by the DoD lead to a median cycle to failure beyond 1 trillion cycles with the longest recorded lifetimes exceeding 1.5 trillion cycles. Further, Radant has developed a high-power MEMS switch that has demonstrated greater than 200 billion cycles with 10W of cold-switched RF power at X-Band.

2. Daniel Hyman, XCOM Wireless
"Ohmic-contact RF MEMS Repeatability and Environmental Test Methods"

The RF MEMS industry has demonstrated superior device performance for decades, but applications have been plagued by poor reliability and immature packaging solutions. This work discusses test methods and results used for qualifying and screening RF MEMS relays in the industrial and commercial marketplace. The author presents a comprehensive set of industrial and military standards and methods for testing, and details the process of qualification. The test results and lessons learned from years of commercialization efforts are shared with workshop participants.

3. Jeffrey S. Pulskamp, US Army Research Laboratory
"Reliability Testing, Characterization, and Design in Piezoelectric RF MEMS"

Inherent to the design of a lead zirconate titanate (PZT) switch is a four-layer laminated composite that can have significant deformations with temperature creating a critical need for thermal testing for robust, repeatable operation. Additionally, the effects of piezoelectric coefficient aging, poling of the domain structure, bipolar fatigue, piezoelectric hysteresis, and unipolar drive need to be addressed for contact resistance reproducibility. With proper testing and evaluation, followed by re-design, a PZT switch is ready to tackle the seemingly daunting challenges of ohmic contact switch cycle reliability and reproducibility testing.

4. Jeremy Muldavin, MIT Lincoln Laboratory
"Challenges in and Results from Reliability Testing of Capacitive and DC RF MEMS Switches"

Reliability testing and characterization is an important and often overlooked aspect of RF MEMS research and development. Today, it is one of the last hurdles to be crossed before we can see RF MEMS deployed in real-world systems. In the past, reliability was often secondary in importance to other device performance metrics, such as insertion loss, isolation, and power handling. Despite this lack of focus and funding, MIT-LL has performed a variety of reliability testing and failure analysis on capacitive and DC RF MEMS devices over the past 8 years. This talk will cover the basic types of reliability testing and results: cycle testing, hold-down testing, threshold voltage drift, package integrity, and power handling for capacitive and DC devices. The effects of bias voltage, temperature, and radiation on capacitive switches will also be presented.

5. George Papaioannou, University of Athens
"Dielectric Charging in MEMS by Material, Structure and Temperature"

Dielectric charging constitutes a major problem that still inhibits the commercialization of RF MEMS capacitive switches. Materials such as SiO2, Si3N4, AlN, Al2O3, Ta2O5 are commonly used due to deposition method maturity and high dielectric constant. These materials consist of covalent or ionic bonds, including one piezoelectric, that significantly affects the charging processes. The presence or absence of dielectric film as well as its expansion on the insulating substrate constitute a key issue parameter that influences the charging process. Finally, the device temperature accelerates the charging and discharging processes by providing energy to trapped charges and to dipoles to overcome potential barriers and randomize orientation

6. James Hwang, Lehigh University
"Surface vs. Bulk Charging of the Dielectrics in RF MEMS Capacitive Switches"

A novel technique is used to distinguish the charging of the surface from that of the bulk of the dielectrics of different types of RF MEMS capacitive switches under different electric fields and humidity levels. In general, bulk charging dominates in dry air, while surface charging increases linearly with increasing humidity. The bulk charges and discharges at about the same rate; the surface charges very quickly and discharges very slowly and, therefore, is detrimental to the switch lifetime. The present technique can be used to evaluate the effectiveness of dielectric preparation and switch packaging in preventing surface charging, as well as to predict the switch lifetime due to bulk charging alone.

7. Steve Patton, University of Dayton Research Institute
”Tribological Challenges in MEMS/NEMS Devices”