Abstract

This dissertation presents the design, fabrication, and characterization of low-voltage capacitive RF MEMS switches. Although, RF MEMS switches have shown superior performance as compared to the existing solid-state semiconductor switches and are viable alternate to the present and the future communication systems, not been able to match the commercial standards due to their poor reliability. Dielectric charging due high actuation is one of the major concerns that limit the reliability of these switches. Hence, the focus of this thesis is on the development of low actuation voltage RF MEMS switches without compromising much on their RF and dynamic performances i.e., low insertion loss and high isolation. Four different switch topologies are studied and discussed. Electromechanical and electromagnetic modeling is presented to study the effect of various components that comprise a MEMS switch on the transient and the RF behavior. The analytical expressions for switching and release times are established in order to estimate the switching and release times.

An in-house developed surface micromachining process is adapted for the microfabrication. This process eliminates the need for an extra mask used for the anchors and restricts the overall process to four-masks only. These switches are fabricated on 500 µm thick glass substrate. A 0.5 µm thick gold film is used as the structural material. For the final release of the switch, chemical wet etching technique is employed.

The fabricated MEMS switches are characterized mechanically and electrically by measuring mechanical resonant frequency, quality factor, pull-in, and pull-up voltages. Since, low actuation voltage switches have slow response time. One of the key objectives of this thesis is to realize switches with fast response time at low actuation voltage. Measurements are performed to estimate the switching and release times. The measured *Q*-factors of switches are found to be in between 1.1 - 1.4 which is the recommended value for *Q* in MEMS switches for a suppressed oscillation after the release. Furthermore, the effect of hole size on the switching dynamics is addressed. RF measurements are carried out to measure the *S*-parameters in order to quantify the RF performance.

The measured results demonstrate that these switches need low actuation voltage in range of 4.5 V to 8.5 V for the actuation. The measured insertion loss less than -0.8 dB and isolation better than 30 dB up to 40 GHz is reported.

In addition, the robustness of realized switches is tested using in-house developed LabView-based automated measurement test set-up. The reliability test analysis shows no degradation in the RF performance even after 10 millions of switching cycles. Overall yield of 70 - 80% is estimated in the present work. Finally, the experimentally measured results presented in this work prove the successful development of low actuation voltage capacitive RF MEMS switches and also offers that even with 0.5 µm thick gold film better reliability for MEMS switches can be achieved.