A Low-Voltage High-Speed Ohmic RF MEMS Switch on Silicon

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RF MEMS switches have recently become a popular switching technology for several applications due to their small size, excellent RF performance, and high linearity. However, these devices have shown several limitations including high actuation voltage, low switching speed, and low power handling capability. This work reports on an ohmic cantilever RF MEMS switch for operating up to a frequency of 10 GHZ. Low actuation voltage (order of 20 volts) and relatively high speed (order of 10-20 µsecs) are targeted.

One straight-forward way to control the actuation voltage and speed of a MEMS switch is by changing the membrane geometry. In this way, the fabrication process does not change, which makes it a desirable and cost-effective way. COMSOL 3.3 is used in this work to design several switch geometries of interest. For our simulations, we used an aluminum cantilever bridge with a thickness of 1µm. The bridge is suspended 2µm above the substrate. The switch geometry, the location and the area of the applied force were optimized to yield low actuation voltages (around 15 volts) and high switching speeds. Small diameter holes were also made in some of the switches to reduce the squeeze film damping and increase the switching speed of the MEMS switch. The RF performance of the switches were simulated using ANSOFT HFSS to provide low insertion loss and high isolation up to 10 GHz. RF MEMS performance limitations are often in conflict with each other and improving the switch performance in one aspect degrades it in another. For instance, improving the switching speed usually increases the actuation voltage as well. Therefore, we try to provide reasonable compensation between all the limiting factors. The reported switch makes a good candidate for low-frequency applications, including the cell phone market.

The switches were also fabricated on high-resistivity silicon substrates and measured in the lab. The measured actuation voltages were between 20-30 volts which agreed well with simulations, although they were slightly higher. The minimum voltage was measured by starting at 0V and increasing by 3V. S-parameter measurements were taken with an Agilent 8510 vector network analyzer in the up and down states. The switches showed good RF performance up to 10 GHz. Less than 0.6 dB insertion loss in the down-state and higher than 20 dB isolation was seen up to 10 GHz. Switching speed was also measured in the lab. For our best switches an actuation time of 8-23 µsec and release time of 52-69 µsec was measured. However, applying a higher actuation voltage will reduce the switching time. We did not go to higher voltages in order maintain the low actuation voltage requirement.