Surface Micromachined MEMS Switches

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For switchable routing in RF system front-ends, the cantilever MEMS switches using electrostatic actuation for operation was developed. These switches relied on direct metal-to-metal contact to establish the RF signal path. Fig. 1 shows an optical microscope image of the fabricated RF MEMS switch. Two beams are floating over the ground and signal lines. When a voltage is applied between one of the floating beams and bottom ground electrode, the beam will be pulled down (switch on) and unbiased another beam will be pulled up (switch off). So RF path will be selected as desired.

The primary goals of the MEMS switch are low pull-in voltage, fast switching speed, and low insertion loss. For low pull-in voltage, narrow gap (~0.8μm) and large capacitance area (~3500μm^2) between the floating beam and the bottom ground electrode and the flexible beams were designed and fabricated. For fast switching speed, small contact area between the floating beam and the bottom signal electrode was designed.

The fabricated devices are visualized through Scanning Electron Microscopy (SEM), as shown in Fig. 2. The beam length was ~150μm, width ~60μm, and thickness ~1μm. The spacing between the top beam and the bottom electrode was approximately 0.8μm.

Pull-in voltage was measured as low as ~10V and DC resistance was ~2Ω. The switching speed and potential lifetime of the switch were measured. For these tests, a square wave signal was applied to the switch and the current flowing between the beam and the bottom electrode was monitored. All testing were performed in air[1]. A fast switching speed of ~60μs was observed. The switches operated over 10^6 cycles.

RF characteristics of the MEMS switch were measured using HP 8510 network analyzer and Cascade probe station in order to check insertion loss, return loss, and isolation. S parameter values were extracted over the 40MHz to 30GHz frequency range. Insertion losses and return loss in the on state are shown in Fig. 3. The return loss is due to the parasitic capacitance caused by the proximity of the signal line to the ground line.[2]

The isolation of the MEMS switch in the off state was shown in Fig. 4.

Reference

[1] M. Ruan, J. Shen, and C. B. Wheeler, *The 198th Meeting of The Electrochemical Society*, Abstract No. 616, Oct. 2000.
[2] C. Goldsmith, Z. Yao, and D. Denniston, *IEEE Microwave and Guided wave Letters*, Vol. 8, No. 8, p. 269, Aug. 1998.

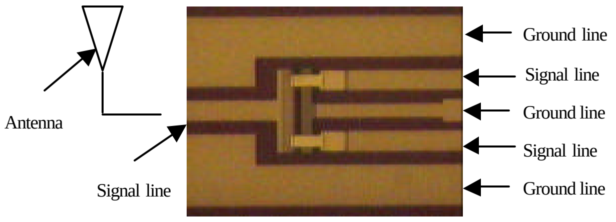
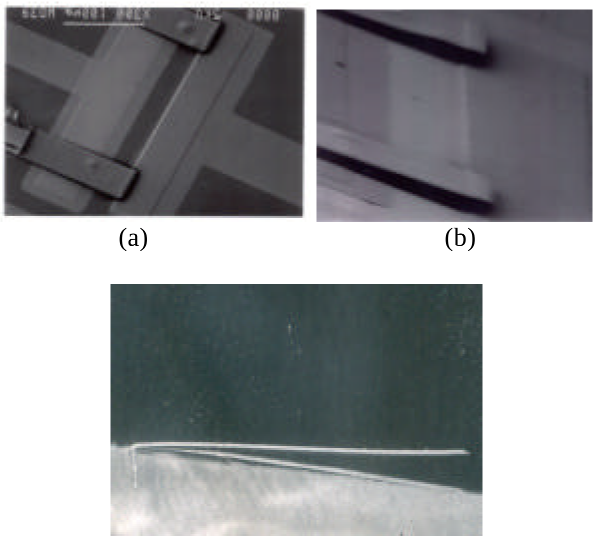


Fig. 1. Schematic diagram and optical microscope image of the fabricated RF MEMS switch.


(a) (b)

(c)

Fig. 2. Scanning electron microscopy (SEM) images of the fabricated device. (a) top view, (b) angled view, and (c) cross-sectional view of the MEMS switches.

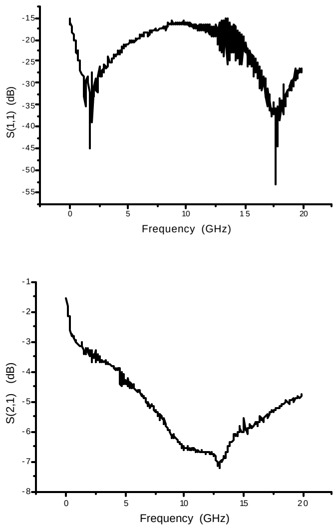


Fig. 3. Insertion loss and return loss in on switch.

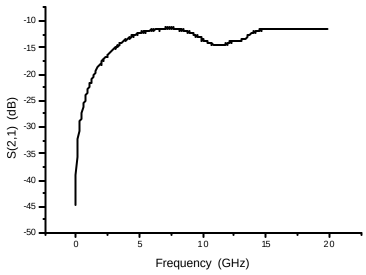


Fig. 4. Isolation characteristic of open MEMS switch.