Lateral RF MEMS Switch with PZT Actuation - MEM

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Sponsorship

KIMM

Concepts and Key Idea

A new RF MEMS switch with lateral contacts is being designed and developed for wireless mobile communication applications. The objective of this project is to develop a RF switch with much improved robustness, compactness, reliability and low cost comparing to the existing RF switches. The major advantages of the piezoelectric lateral contact RF switch will be very low driving voltage (less than 5 Volt), very low contact resistance (less than 0.1 Ω) and very high reliability (more than 100 billion cycles), which are essential for real applications without scarifying the benefits of MEMS switches, such as low insertion loss, near zero power consumption, and very high isolation, etc. The device is enabled by strain-amplified PZT actuators, which provide the mechanical movement creating the open or short circuit in the RF transmission line.

Design and Fabrication

To achieve the major objectives of very low contact resistance and very high reliability, maintaining a large and real electric contact area is critical, which requires the elastic-plastic deformation of the metal-metal contact layers. PZT actuator is chosen for the large force and displacement it can provide. Lateral contact switch configuration is adopted to take full advantages of the PZT actuators. The switch function of the device is achieved through the lateral contact of two switching components. The mechanical movement and force required for the contact is realized through large-strain thin film piezoelectric actuators, which uses PZT (Pb(Zr,Ti)O_3 as the active material. The displacement from PZT is amplified by more than 10 times by the amplification mechanism for each individual actuator. Actuators are also combined in parallel or series to provide larger displacement or bigger force requirements. Lateral displacement of 10 μm can be achieved with less than 5 volts actuation in a footprint of less than 500 μm x 500 μm. Larger contact area (> 10 μm^2) and larger gap (about 5 μ) are maintained between the two switching components which provide low insertion loss, but high isolation and high power handling capacity. Su-8 has been chosen as the switch structure materials for its unique property of making near vertical sidewall structures and also its good mechanical properties. Mathematical model for the contact behavior and FEM simulation of the device design is being done to optimize the overall performance of the switch. A schematic view of the device with e-beam Au layer on the side and folded Au layer are shown in Fig. 11 and Fig. 12 respectively.

PZT is deposited using Sol-gel method and several approaches have been investigated to fabricate the displacement amplification mechanism of the actuator. Spin-on Su-8 has been chosen as the structure materials for its unique properties and compatibility with the actuator. The most critical part of the switch fabrication is the deposition of contact metal on the contact areas on the sidewall of the Su-8 structure. We have chosen Gold layer for our initial tests. The electrical contacts are crucial for the performance of the switches. Two methods have been investigated to create the metal contact layers. The first one is to fold a thick metal film already deposit on the bottom surface of the structure into the gap between the two contact components, while the second is to deposit the metal film on the contact surface using e-beam evaporation or sputtering process. The Gold layer on the side wall of a Su-8 structure with negative slope using e-beam evaporator is shown in Fig. 13. An initial test shows the resistance across the side wall is less than 0.4 Ω, which can be improved further by having a relatively vertical or positive side wall slope. The sidewall slope due to fabrication will have significant influence not only on the metal layer quality, but also on the ohmic contact. Efforts have been made to ensure high quality metal-metal contacts required. Fabrication of the device is still on going.

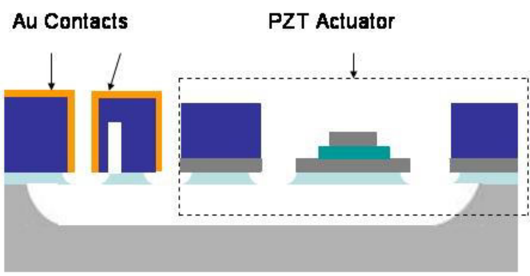

Fig. 11 Schematic view of the switch

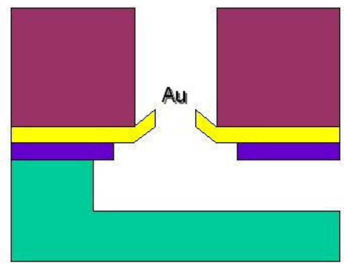

Fig. 12 SEM picture of side wall Au

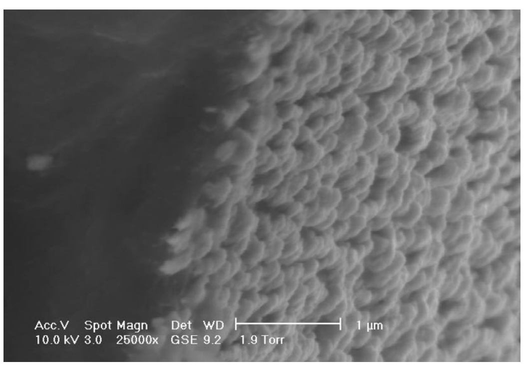

Fig. 13 Au layer on side