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Survey on Various Types of RF Mems and Its Classification

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Abstract - RF MEMS technology for microwave applications is in the area of surface micromachined actuators for the realization of microwave switches. These possess very high linearity, low dc standby power and low insertion loss. These switches are based on electrostatic attraction counterbalanced by suitable mechanical forces on the beam to pull the switch into the right position. This switch can be designed to present nearly 50 impedance across a broad range of frequencies when closed and nearly an open circuit when there is no connection. This property makes this an attractive choice for microwave applications. Several new switch architectures have also been reported, including the air-bridge structure. This structure utilizes very high capacitance variation to achieve the switching action. This scheme, however, suffers from relatively high switching voltage requirements.

Key Words; Micromachined, Actuators, Frequencies, Air-Bridge.

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INTRODUCTION

The continuous advance in microelectro-mechanical systems (MEMS) technology attracted researchers towards the development of MEMS devices for radio frequency (RF) applications. RF MEMS devices have a broad range of potential applications in wireless communication, navigation and sensor systems. They could be used in switches, phase shifters, signal routings, impedance matching networks, exciters, transmitters, filters, and IF/RF receivers. Compared with the common electronic solid state switches (FET's and PIN diodes), RF MEMS based switches are characterized by very low insertion loss, low power consumption, high isolation (up to 100 GHz), low fabrication cost, and very low intermodulation.

REVIEW OF LITERATURE

The literature shows more than 32 different types of RF MEMS with a variety of actuation mechanisms (electrostatic, magnetostatic, piezoelectric or thermal), contact modes (capacitive or metal-to-metal), and circuit implementation.

Electrostatic actuation is the most used actuation scheme in RF MEMS. However, this type of triggering requires a relatively high DC voltage (up to 30 volts) and thus requires an additional CMOS integrated up-converter to raise the usually used 5 volts control voltage to the required level. The current paper focuses on the design and fabrication of RF MEMS switch using Shape Memory Alloys (SMA) based actuator. Shape memory alloys are thermally activated. At low temperatures the crystalline structure of the alloy is in the martensitic phase which provides flexibility and allows relatively large deformations. When the temperature is raised, transformation to austenitic phase takes place and the material loses its flexibility and thus the strain is recovered. Usually heating of SMA actuators is based on joule's heating effect and the voltage needed could be around 5 volts, which makes it superior to the electrostatic actuator in that sense. In addition to the low driving voltage, SMA actuators provide high energy density and large forces. Unfortunately, the drawback of SMA actuators is their relatively high response time (~ 50 ms) compared to the electrostatic actuators that have a response time on the order of micro seconds. The paper provides a scheme to improve the performance of SMA actuation of the RF switch by allowing rapid heating and fast cooling of the SMA beam. Applying high currents results in rapid heating but requires temperature monitoring in order to avoid overheating of the SMA layer. A thermodiode temperature sensor with a feedback control is used to monitor the temperature of the SMA wire. As for rapid cooling, different methods are available, including water immersion, heat sinking and forced air cooling. Heat sinking is herein used to improve the cooling rate and thus provide faster switching time.

MATERIAL AND METHOD

RF MEMS development to date can be classified into the following categories based on whether one takes an RF or MEMS view point:

1 RF extrinsic

RF extrinsic is the category, in which the MEMS structure is located outside the RF circuit and actuates or controls other devices in the RF circuit. In this class, one would consider the example of a tunable microstrip transmission line and associated phased shifters and arrays. Microstrip lines are extensively used to interconnect high-speed circuits and components because they can be fabricated by easy automated techniques.

2 RF intrinsic

RF intrinsic is the category, in which the MEMS structure is located inside the RF circuit and has both the actuation and RF-circuit function. In this class, one could consider traditional cantilever and diaphragm type MEMS which can be used as electrostatic micros witch and comb-type capacitors. With the invention of electroactive polymers (EAPs), multifunctional smart polymers and microstereo lithography, these types of RF MEMS can be easily conceived with polymer-based systems. They are also flexible, stable and long lasting. Moreover, they can be integrated with the organic thin film transistor.

3 RF reactive

RF reactive is that category, in which the MEMS structure is located inside, where it has an RF function that is coupled to the attenuation. In this class, capacitively coupled tunable filters and resonators provide the necessary RF function in the circuit. Microwave and millimeter wave planar filters on thin dielectric membrane show low loss, and are suitable for low-cost, compact, high-performance mm-wave one-chip integrated circuits.

4 Silicon based RF MEMS

One of the earliest reported applications of silicon-based RF MEMS technology for microwave applications is in the area of surface micromachined actuators for the realization of microwave switches. These possess very high linearity, low dc standby power and low insertion loss. These switches are based on electrostatic attraction counterbalanced by suitable mechanical forces on the beam to pull the switch into the right position. This switch can be designed to present nearly 50 □ impedance across a broad range of frequencies when closed and nearly an open circuit when there is no connection. This property makes this an attractive choice for microwave applications. Several new switch architectures have also been reported, including the air-bridge structure. This structure utilizes very high capacitance variation to achieve the switching action. This scheme, however, suffers from relatively high switching voltage requirements.

CONCLUSION

MEMs technology is also used for RF applications in the area of variable capacitors, as a replacement for varactor diodes as tuners. Here, either a lateral or a parallel plate capacitance variation can be obtained with suitable fabrication approaches. The capacitance variation in the parallel plate version is over 3 : 1 making them attractive for wide-band tuning of monolithic voltage-controlled oscillators (VCOs). However their range is often limited by the low-frequency mechanical resonance of the structure.

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