MONOLITHIC INTEGRATION OF RF MEMS SWITCH AND GAAS-MMIC PROCESS FOR RF SENSING APPLICATIONS

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Abstract **-** This paper shows the promising results in the integration of low-loss and high isolation RF MEMS switch in OMMIC GaAs MMIC process line. This technology has been used to design building blocs (such as reconfigurable impedance matching network for reconfigurable LNAs) targeting phased arrays applications. This work is part of the FP7 EU-project MEMS-4-MMIC.

I – Introduction

During the last decade, RF-MicroElectroMechanical System (RF-MEMS) switches have attracted more and more attention as this technology has matured enough in terms of performance and long term reliability to be successfully integrated into practical RF systems. Then, the integration of RF-MEMS switches within a Monolithic Microwave Integrated Circuit (MMIC) process is the logical step in the upcoming development and commercialisation of MEMS technology [1].

The main field of applications for RF-MEMS integration in MMIC devices is the implementation of innovative reconfigurable systems with high integration. Reconfigurable satellite communication systems as well as steerable antennas for mobile platforms are ideal candidates for RF-MEMS switches combined with LNA, PA, and phase shift devices.

This paper describes the integration of an ohmic RF-MEMS switch technology with the commercial OMMIC GaAs MMIC foundry process. This work is part of the FP7 EU-project MEMS-4-MMIC [2]. The RF-MEMS switches have been developed for applications up to 40GHz.

II – GaAs RF-MEMS switch design and performances

The RF-MEMS fabricated at OMMIC are metal-to-metal “ohmic” contact switches. For this type of switch the contact is performed by applying a DC voltage on the actuation pad inducing the deformation of the cantilever allowing it to contact the contact bumps. A biasing circuit is needed to provide the actuation voltage (Vact) in order to pull down the cantilever, but as this circuit only provides for an electro-static field to activate the MEMS, the power consumption is limited to only small leakage current (<0.01mA).

The active area of the device is 150x280µm . As it is shown in Figure 1, it is composed of a flexible cantilever fixed by two anchors. A wedge is placed at the end of the arms, before the actuation pad in order to limit stiction problems and allows a more direct on-off transition. The wedge limits the maximum deformation of the cantilever. The cantilever subdivides itself into 4 flexible arms (see

Figure 2) with four terminal fingers in order to ensure a low contact resistance on the contact bumps. The pull-in voltage is comprised between 60 and 80V with contact resistance below 1 ohm. The switching time from open to close and from close to open are below 1µs and below 20µs respectively. The measurement methodology for the switching time is given in [3].

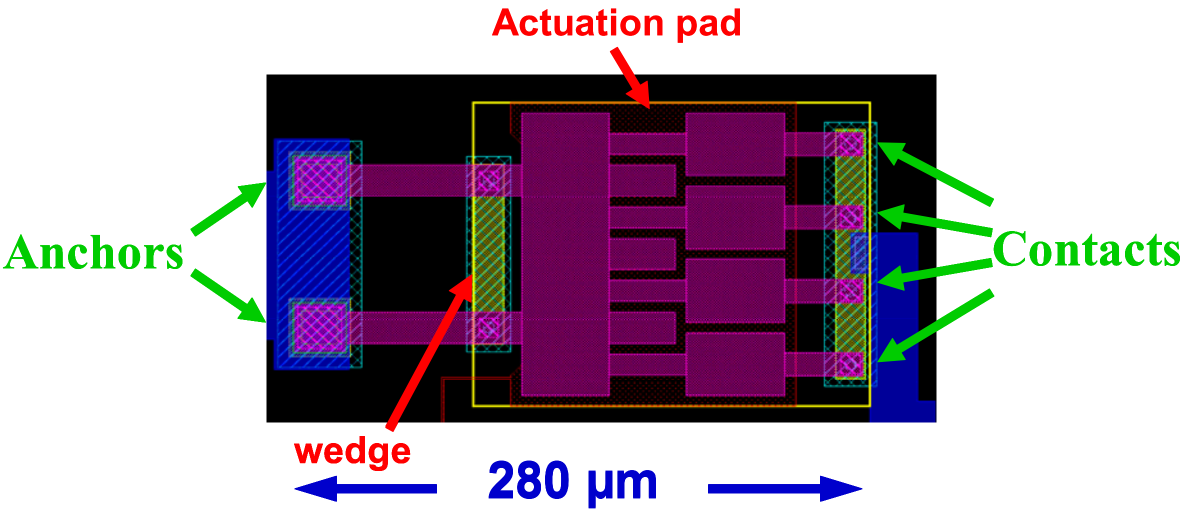

Figure 1: Schematic view of the RF-MEMS switch device.

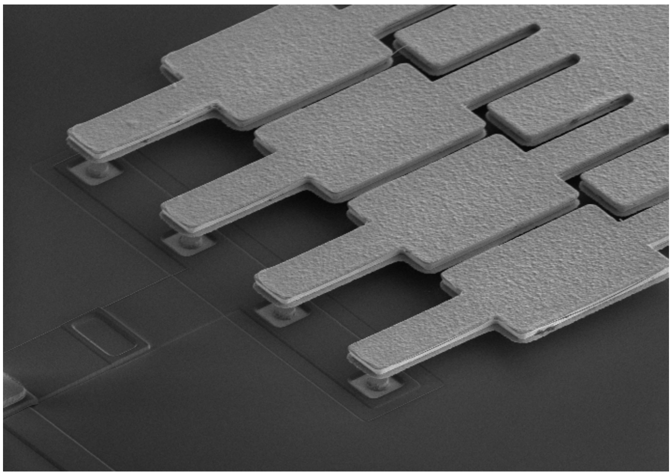
Figure 2: SEM view of the switch processed at OMMIC.

The RF performance of the RF-MEMS switch fabricated using OMMIC GaAs MMIC process technology has been characterized by measuring S-parameters of a coplanar Single-Pole-Single-Throw (SPST) circuit shown in Figure 3. Figure 4 shows measured and simulated S12 parameter over frequency for the open state (0V applied on the DC pad) of a SPST RF-MEMS switch circuit. A very good isolation is maintained on the whole frequency range decreasing from 25dB at 10GHz to around 15dB at 35GHz. Figure 5 shows insertion losses for a closed state (more than 60V is applied on the DC pad) SPST switch. The losses are ranging from 0.18 dB to 0.45 dB from DC to 35GHz. RF-MEMS switches have a higher linearity over a large bandwidth and better isolation at open state in comparison to pin diodes. This type of RF-MEMS switches also shows better properties at low frequency than the capacitive ones.

Additional RF measurements on OMMIC RF-MEMS switches have been performed by FOI [4] up to 110GHz. Those measurements (Figure 6) show that losses are maintain below 1dB up to 95GHz and isolation is above 10dB up to 80GHz. It demonstrates the capability of such device to be integrated in high performances reconfigurable RF front-ends for applications in the DC-100GHz range.

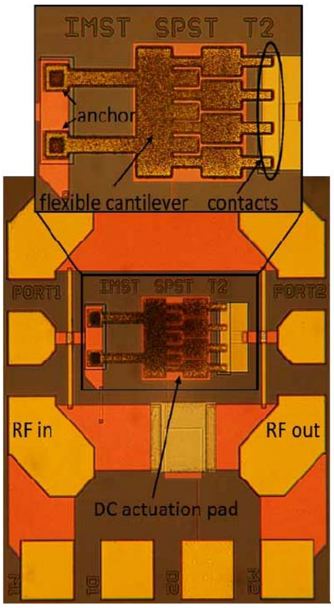

Figure 3: Coplanar SPST RF-MEMS switch processed at OMMIC.

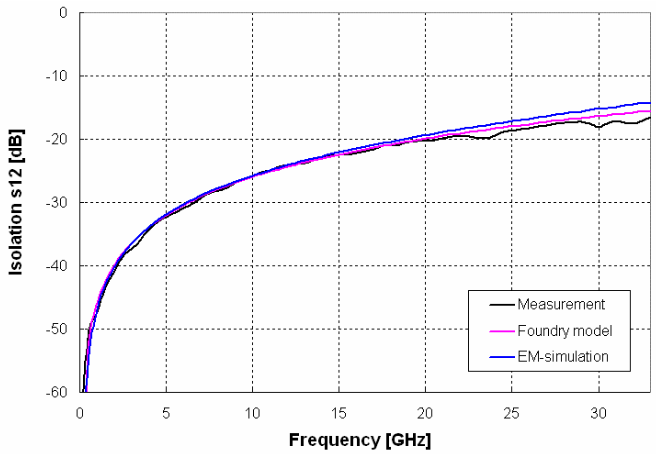

Figure 4: Isolation of the RF-MEMS switch of fig. 3 in the open state.

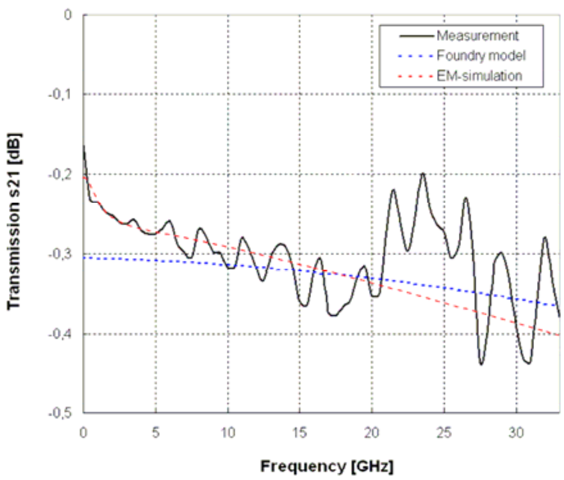

Figure 5: Insertion losses of the RF-MEMS switch of fig. 3 in the closed state.

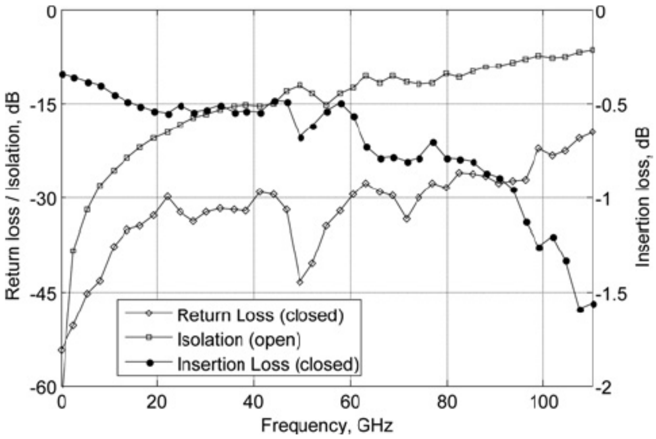

Figure 6: S-parameters measurements of the RF-MEMS SPST up to 110GHz [4].

III – Reviews of applications and circuits

Within the MEMS-4-MMIC project several applications have been considered such as automotive radar, satellite terminals or phased array antennas. Some basic building blocks needed in components for steerable/agile RF-frontends have been designed by different project partners and fabricated [5-8]. The targeted applications for which circuits were designed are summarized in Figure 7.

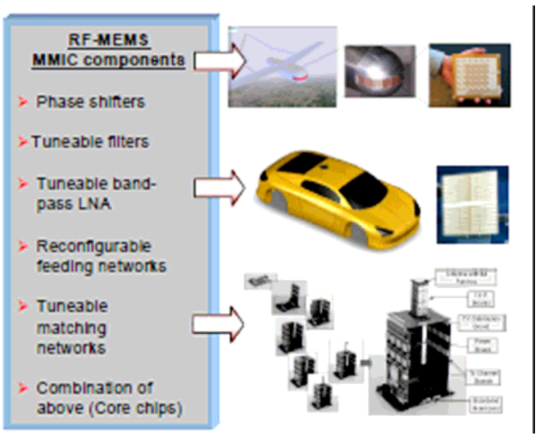

Figure 7: Applicative domain for RF-MEMS MMIC.

The validated MEMS switches made on GaAs have been used to design reconfigurable RF circuits such as 24 GHz and 35 GHz phase shifters showing close to adequate performance up to the millimetre-wave range [6]. First demonstration of working switching network using OMMIC RF-MEMS switch has been given in [7] by connecting two commercially available GaAs C-band LNAs to a SPDT circuit by wire bonding. In [8] a 16-24GHz reconfigurable impedance matching network as been fabricated on the same wafer as integrated active RF devices (LNAs).

IV – Conclusion

We have presented the technology and performances of RF-MEMS ohmic switches fabricated using the OMMIC GaAs MMIC foundry process. The validated MEMS switch technology on GaAs has been used to design different building blocks of RF circuits. A review of those circuits is made (e.g. 35GHz phase shifters) showing close to adequate performances. Then the use of RF-MEMS switch based on GaAs MMIC as a key part in the realisation of reconfigurable front-ends in wireless communication or RF-sensing systems has been validated.

Acknowledgement

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