5-bit MEMS Phase Shifter

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Abstract

This work presents the latest progresses on the CONFIRM “reCONFIrable circuits by Rf Mems” project. Previously the design of three different typologies of 5-bit MEMS phase shifters at 20.7GHz was developed and the most promising design options were identified and selected [1]. In this paper we present the design, manufacturing and RF tests of three 5-bit K-band MEMS phase shifters based on similar architectures but working in different frequency bands, namely 20.7GHz, 30.5GHz and 35GHz. The phase shifters are intended to be used in Phased Array Antennas for SOTM Terminals and ESA (Electronically Scanned Antenna) seekers, in both the transmitting and receiving channels [2-8].

A hybrid architecture has been developed: for the first two prototypes (20.7 GHz and 30Ghz) a switched line topology has been chosen to realize the first four bits, 180°, 90°, 45° and 22.5°. On the other hand the fifth bit, 11.25°, is based on a loaded line topology, which is convenient for this bit since a small phase shift is required. In the 35GHz device both 22.5°and 11.25° bits are realized in loaded line topology since this turned to be more convenient at high frequencies.

All phase shifters are based on series ohmic cantilever switches. The suspended membrane of the switch has a size of 110μm × 170μm and an air gap of 2.7μm (Fig. 1). In the OFF state the switch introduces a very low series capacitance (10fF) given by the interface area between the suspended membrane and the signal line below underneath. On the contrary, in the actuated state the metal to metal contact introduces a series resistance RON, whose value is about 0.9Ω. The devices have been monolithically manufactured on 200μm thick HR Si substrate by using the eight-mask surface micro-machining process available at FBK [9]. The device single bits as well as the complete phase shifters have been measured on 5

different wafers in order to check their performance repeatability. Preliminary measurements show very promising results and high yield of the manufactured MEMS switch.

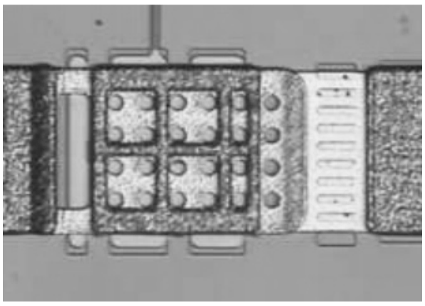
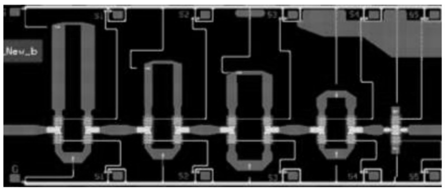


Fig. 1. MEMS ohmic cantilever switch used in the phase shifters.

The layout masks of the two prototypes are shown in Fig. 2. Excellent RF performances have been measured for the three devices, with an average insertion loss of 2, 2.5 and 2.7 for the 5-bit device at 20.7GHz, 30.5GHz and 35GHz respectively (Fig. 3).



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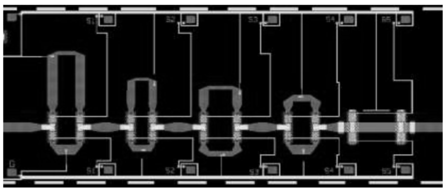

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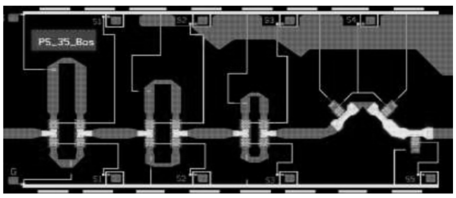
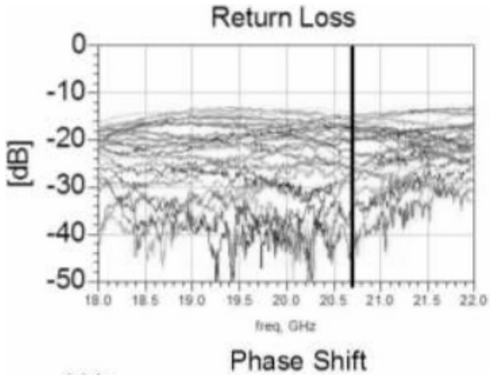


c)

Fig. 2. Layouts of the 5-bit K-band MEMS phase shifters.
(a) 20.7 GHz device (b) 30 GHz device (c) 35 GHz device.

Return loss better than 14 dB and average phase shift error lower than 2 degrees (for the single bits) has been obtained for all states. More data on the wafer uniformity will be presented in the final paper as well as RF test on the packaged devices.



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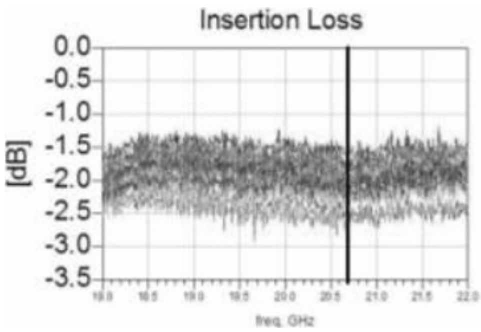

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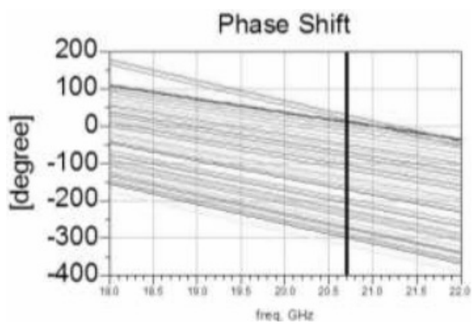

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Fig. 3. On-wafer measured performances of the 32 stated of the 20.7 GHz 5-bit MEMS phase shifter (a) Return loss (<14dB for all states) (b) Insertion Loss(=2dB in average, 1dB dispersion) (c) Phase shift (average error= 2degrees).

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