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Evaluation of Losses of the Ridge Gap Waveguide at 100 GHz

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***Abstract*—An evaluation of losses of the Ridge Gap Waveguide (r-GAP) at 100 GHz has been developed in terms of Quality Factor. For this aim, an r-GAP resonator has been designed, simulated and measured. The feeding to the circuit is provided via a transition from Micostrip-to-Ridge Gap Waveguide based in electromagnetic coupling in order to ensure compatibility with the available probe stations.**

I. INTRODUCTION

A new type of guiding structure has been recently obtained and called gap waveguide technology. This technology has been theoretically introduced in [1] and [2], and a first Ridge Gap Waveguide (r-GAP) prototype has been developed and experimentally demonstrated at 15 GHZ in [3].

This new waveguide is based on the presence of two parallel metal plates which are separated by an air gap. One of these plates is a textured surface made by a periodic pattern that is an Artificial Magnetic Conductor (AMC). The AMC establishes a high impedance condition in a specific frequency interval prohibiting the propagation of waves in any direction as long as the air gap is smaller than quarter wavelength. When a metal ridge, groove or strip is introduced in between the periodic pattern, a quasi-TEM mode is allowed to propagate. The elements that compose the textured plate can have different geometrical shapes and dimensions depending on the desired stop band (frequency range with no propagation of parallel plate modes). The achievable stop band obtained by using different periodic structures has been studied in [4].

The r-GAP has been demonstrated to have low loss [5]-[6] and being easy to manufacture since there is no requirement of good metal contact between the different metal plates. Therefore, this technology is very promising for millimeter/submillimeter applications and integration of active devices.

It is crucial to find ways to facilitate the measurement process of micromachined r-GAP components at frequencies above 100 GHz with the available probe stations. With this purpose, a preliminary microstrip-to-ridge gap waveguide transition was investigated in [7].

In this paper, our goal is to evaluate the losses of the r-GAP at 100 GHz. Therefore, an r-GAP resonator working at 100 GHz has been manufactured and measured by using the transition developed in [7].

II. R-GAP RESONATOR DESIGN AND GEOMETRY INCLUDING MICROSTRIP-TO-RIDGE GAP WAVEGUIDE TRANSITION

The complete topology is illustrated by Fig.1.a), and it includes two different parts: an upper metal lid which contains the r-GAP resonator and a lower metal plate where the microstrip-to-ridge gap waveguide transition is placed in a certain location to provide the feeding to the structure.

The top view of the circuit not including the upper metal plate (but keeping the r-GAP interface) is shown in Fig.1, b). The dimensions of the geometry are presented in this figure. The pin and ridge height is $d= 0.75$ mm and the air gap between the end of the pin and the lower metal plate is $g= 0.2$ mm. The electrical length of the ridge ($L= 5.6$ mm) is around four times $\lambda/2$, where λ is the wavelength. Therefore, we will obtain a fourth order mode at around 100 GHz.

In order to calculate the unloaded Quality Factor through the equations explained in [6], the resonator should be weakly coupled to the feeding network. For this reason, one row of pins is introduced between the resonator and a ridge section that should overlap a microstrip rectangular patch (i.e. the microstrip-to-ridge gap waveguide transition). This microstrip patch couples/receives the input/output signal to/from the upper ridge section.

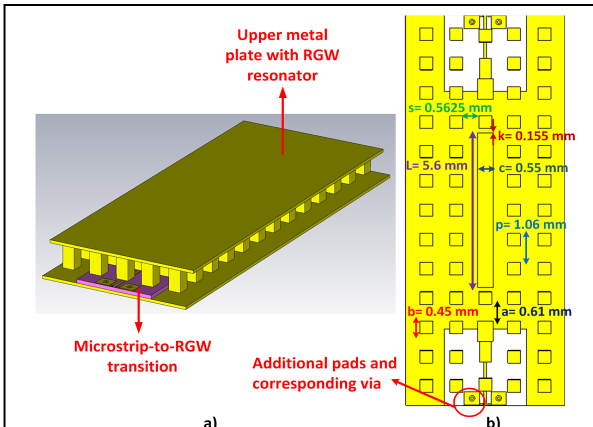

Figure 1. a) Complete topology including upper lid and lower metal plate. b) Top view without the upper metal plate.

As it is appreciated in Fig.1.b), small pads are added at both sides of the input and output microstrip line in order to fit the coplanar probes used in the measurement set up. These two pads are designed in such a way that the characteristic impedance in the input and output is kept around 50 Ω. Moreover, they need to be grounded for avoiding the excitation of higher order modes. The location and dimensions of the vias were studied in advance following the data sheet from the manufacturer and taken into account for the final simulations.

III. SIMULATIONS AND PRELIMINAR MEASUREMENT RESULTS

The manufacturing of the r-GAP resonator was realized by MEMS technology, which is a very precise method of fabrication at frequencies above 100 GHz. The micromachined silicon chips are golden platted. A top view of the entire prototype is shown in Fig.2.a), the upper lid with the r-GAP circuit is illustrated in Fig.2.b), and the lower metal plate with the transitions can be seen in Fig.2.c).

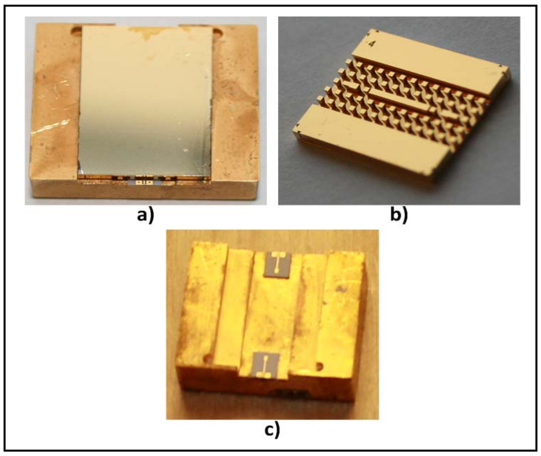

Figure 2. a) Complete prototype, b) Top view of the RGW circuit, c) Lower metal plate with the transitions.

The computation of the S parameters for the whole structure including the transition was performed by using CST Microwave Studio. A comparison between measurements and simulations is illustrated in Fig.3. The simulated S_{21} presents a resonance at 108.85 GHz, and the measured S_{21} shows a resonance at 107.3 GHz. Therefore, there is a deviation in frequency of 1.4% between simulation and measurements because of mechanical tolerances.

The unloaded Q-factor of the resonator was calculated through CST Eigenmode Solver being equal to 1168. The measured Q-factor is 755. The discrepancy between these two values could be due to the surface roughness which has not been considered in the simulations, and to the few number of points that were used in the measurement setup.

IV. CONCLUSIONS

A preliminary evaluation of losses of the ridge gap waveguide at 100 GHz has been presented. This study has been performed by means of the Q-factor of a ridge gap waveguide resonator fed by a microstrip-to-ridge gap waveguide transition at 100 GHz. The resonator shows a clear resonance at the operation frequency. The difference between the measured and the simulated Q-factor could be caused by the surface roughness which was not taken into account during the simulations, and to the small number of points settled in the calibration. Therefore, more accurate measurements will be done soon.

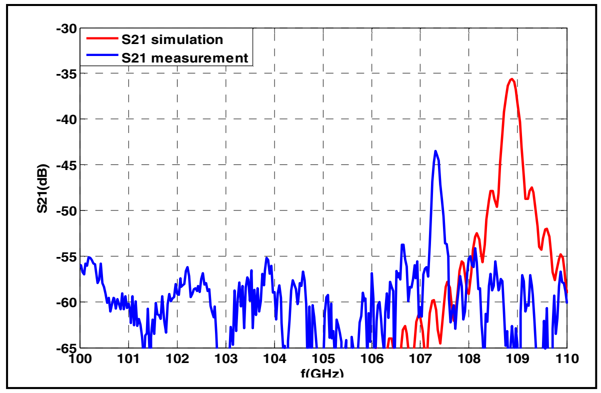

Figure 3. Computed and measured S parameters.

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