A NEW PLANAR TYPE DIELECTRIC RESONATOR FOR MICROWAVE FILTERING

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ABSTRACT

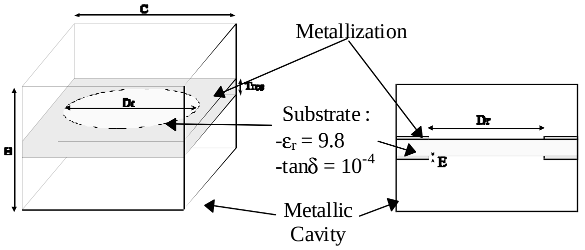
This paper is devoted to high electrical performance resonator realization for multilayer filter applications. A partly metallized substrate is shielded in a metallic cavity and excited by coplanar lines directly integrated on the dielectric resonator. This structure is suitable for high frequencies filtering and power applications, and presents the advantage to be easily manufactured. Moreover, a new coupling technique without tuning is presented to realize a 2 pole filter. Experiments are performed to verify the theoretical design.

INTRODUCTION

Commercial mobile communication systems continue to provide significant challenges to microwave designers. Many technological advances are required to reduce mass and volume of the devices and to increase performances. Higher electrical performances and more limited sizes filters are thus needed.

During the last years, two kinds of narrow bandwidth filters have been developed. The volumic solution, for example dielectric loaded cavities filters, presents high unloaded quality factor but stays big and heavy. The planar solution is less bulky but provides low electrical performances and is generally not suitable for power applications.

The structure presented in this paper is a compromise between these two topologies. A partially metallized substrate is short-circuited in a metallic cavity (figure 1). This device could be easily manufactured and provides high electrical performances [1].



(a) perspective view (b) cross section

- figure 1 : configuration of the structure -

This type of resonator could be excited through an axi-symmetrical TE_{01} mode [1], but we propose to use this resonator on a dual mode, in order to reduce the device size [2]. Moreover, an original coplanar excitation system is described. These lines are integrated in the metallized part of the dielectric substrate. This solution permits both a simplified machining of the filter, and a reproducible control of the coupling level.

First, the configuration of the structure and its electrical performances are described. The three dimensional Finite Element Method (FEM) is applied to this task [3]. In a second part, the excitation system is presented. The theoretical results are compared to measured ones. In the last part, an experimental 2-pole filter is shown using classical filtering techniques. Moreover, a new coupling system without tuning is presented for a 2-pole filtering application and compared to the classical one.

I - RESONATOR CHARACTERISTICS

The structure is composed of a partially metallized dielectric plate enclosed in a parallelepipedic cavity (figure 1). Performing chemical attacks, superimposed circular hollow patches have been made on the upper

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and the lower metallized surfaces of the dielectric substrate. Then, the plate is short-circuited and centered in the cavity. The portion without metallization is used as a resonator. In this paper, we name σ the conductivity of the metallic walls, ε_r the relative dielectric permittivity and $\tan\delta$ the dielectric loss tangent.

	Frequency (GHz)	Polarization number
HEM_1	6.6	1
HEM_2	7.67	2
HEM_3	8.28	1

C = 25.4mm Dr = 22mm H = 20mm
Tres = 0.635mm E = 0.009mm

- figure 2 : modes resonant frequency and polarization -

The FEM has been applied to characterize the first resonant modes of these structures [3]. For each mode, we have computed the structure resonant frequency (figure 2). For filtering applications, it's interesting to select the modes which present two polarizations at the same frequency to reduce the device size. Therefore, we choose to develop computations and measurements on the HEM_2. For this mode, we have computed the unloaded quality factor Q_0 (figure 3) given by $\frac{1}{Q_0} = \frac{1}{Q_m} + \frac{1}{Q_d}$ with :

- Q_m : the metallic quality factor
- Q_d : the dielectric quality factor

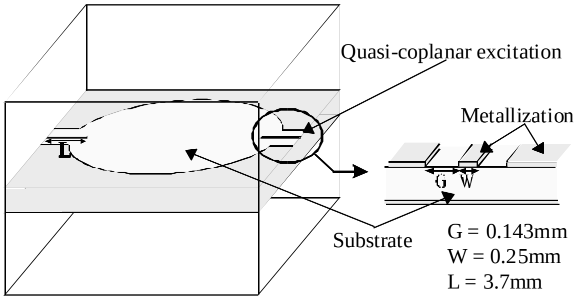
σ ($S.m^{-1}$)	Q d	Q m	Q_0
$1.7.10^7$	20640	6780	5110
$5.6.10^7$	20640	12310	7210

- figure 3 : HEM_2 quality factors -

We can observe that the metallic losses are more important than dielectric ones. Performing optimization on the physical and geometrical resonator dimensions, Q_0 can be improved.

II - RESONATOR EXCITATIONS

Our purpose is here to present a way to excite the structure. We want the excitations to be easily manufactured and easily integrated in the structure. The figure 4 shows the chosen solution.



- figure 4 : 1-pole filter configuration -

A coplanar line is drawn on the upper surface of the substrate. This original excitation is easily integrated in the structure and avoids a manufacturing additional stage. Longer is the central excitation line, more important is the input coupling (figure 5).

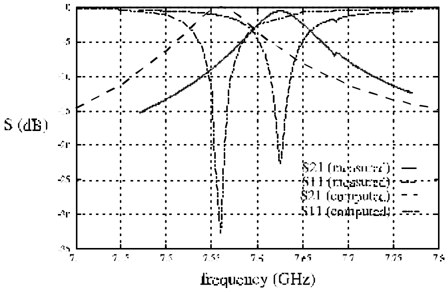
L (mm)	Qe
2.7	1280
3.7	220

- figure 5 : Qe evolution -

The scattering parameters are computed with the FEM [3]. Losses of the materials aren't here taken into account. We compare the theoretical results with experimentation (figure 6). As losses in the structure are small, external Q_e factor can be deduced from the relation :

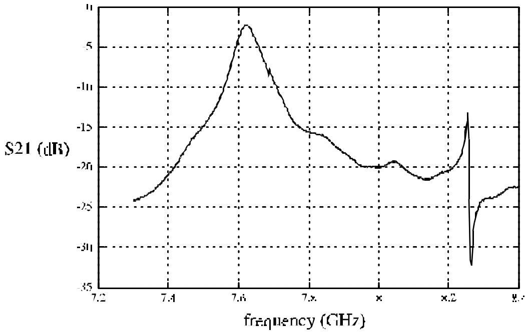
$$\frac{1}{Q_L} = \frac{1}{Q_0} + \frac{1}{Q_{e1}} + \frac{1}{Q_{e2}}$$

with $Q_{e1}=Q_{e2}$ (symmetrical structure) and $\frac{1}{Q_0} = 0$ then $Q_e=2\ Q_L$



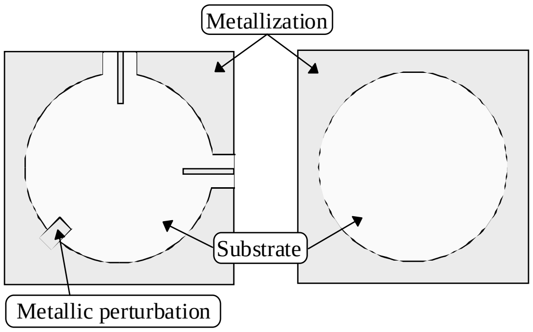
- figure 6 :transmission response -

We observe a slight shift of the resonant frequency of about 0,7 % between measurements and calculations : the measured resonant frequency (7,62 GHz) is approximately equal to the calculated value (7,56 GHz). Moreover, the theoretical Q_e (220) is equal to the experimental one. At last, the insertion losses at the resonant frequency are slight (0,6 dB including coaxial connectors contribution). The resonant frequency of the next mode (HEM_3) is equal to 8,25 GHz. The first hybrid mode HEM_1 is not excited considering the excitation system. So, the HEM_2 presents a satisfactory isolation (figure 7). Therefore, the experimentation is in good agreement with theory and we can work the HEM_2 mode for filtering application.



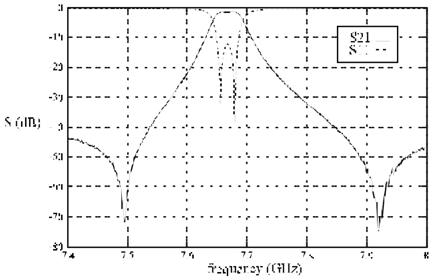
- figure 7 :broadband measured result -

III - 2 POLE FILTER



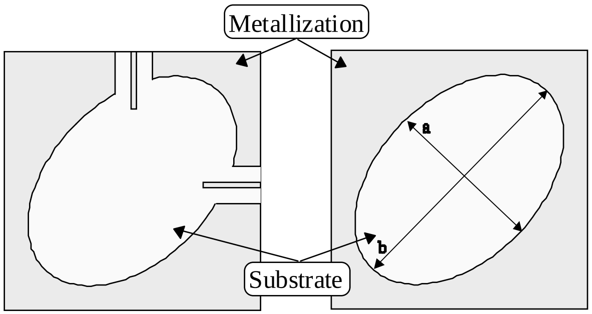
(a) upper surface (b) lower surface

- figure 8 : classical 2-pole filter configuration -



- figure 9 : experimental 2-pole filter response -

To obtain a 2-pole filter, the 2 polarizations of the mode must be coupled. The classic way is to place a metallic perturbation at $\frac{\pi}{4}$ from the excitation axis [4] (figure 8). An experimental response is obtained thanks to this technique (figure 9). The center frequency is 7,67 GHz with 53 MHz of bandpass. Insertion losses at the resonant frequency are equal to 1,3 dB including coaxial connectors contribution. So this technique increases losses and a tuning is necessary. Therefore we propose to study a new coupling system. This coupling results from resonator geometrical modification. Before modification, circular hollow patches are drawn on the substrate. The final geometry is elliptic (figure 10). The big radius of the ellipse is the same as the circle one. The modification consists in decreasing the small radius. Moreover, the elliptic axis is placed at $\frac{\pi}{4}$ from the probe axis. Using this solution, discontinuities are not created around the resonator, which may be important to decrease the filter losses, or to avoid parasitic mode generation. Moreover, this technique introduces no manufacturing additional stage.



(a) upper surface (b) lower surface

- figure 10 : new 2-pole filter configuration -

The coupling coefficient K between the 2 polarizations of the mode is given by [4] :

$$K = \frac{f_2^2 - f_1^2}{f_2^2 + f_1^2}$$

with f_1 = resonant frequency of one polarization
f_2 = resonant frequency of the other polarization

The coupling coefficient K variations as a function of the difference between big and small radius is given on figure 11. A theoretical response filter is shown on

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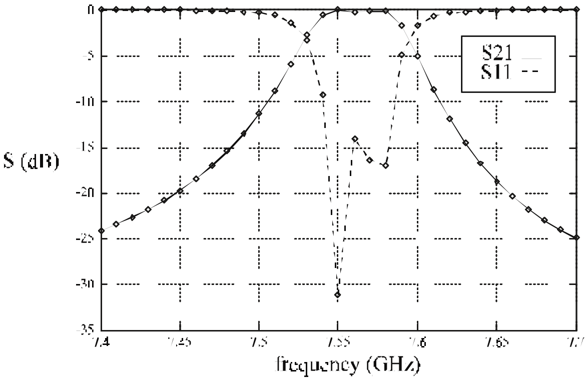
figure 12. Losses of the materials aren't taken into account. The center frequency is 7,56 GHz with 64 MHz of bandpass.

b-a (mm)	K*10^{3}
0	0
0.2	6.6
0.3	13.8
0.4	18

- figure 11 : coupling coefficient evolution -



- figure 12 : theoretical 2-pole filter response -

Therefore, this new technique seems to be suitable for filtering applications.

CONCLUSION

This new structure adds the advantages of high electrical performances, small size and manufacturing easiness. Moreover, the new excitation and coupling systems presented in this paper are realized in the same manufacturing stage as the resonator and need no tuning. For n-pole filtering applications, two techniques can be applied. The first one permits to fabricate the resonators on the same dielectric substrate. The coupling beetween resonators can be obtained by lines graved on the substrate [5]. The second technique uses superimposed resonators coupled by cross metallic irises [2]. The two techniques can be combined. At last, computing shows us that this device can be used for wide bandwidth and high frequencies applications.

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