CPS STRUCTURE POTENTIALITIES FOR MMICS : A CPS/CPW TRANSITION AND A BIAS NETWORK

D.Prieto°*, J.C. Cayrou*, J.L. Cazaux*, T.Parra°, and J. Graffeuil°

° LAAS-CNRS and Université Paul Sabatier, 7 av. du Colonel Roche, 31077 Toulouse, France
*** ALCATEL TELECOM, 26 av. J.F. Champollion, B.P. 1187, 31037 Toulouse Cedex, France**

ABSTRACT

Present paper deals with new applications of coplanar waveguides (CPW) and coplanar strips (CPS) based designs. As examples, a new reversible 50Ω CPS/CPW transition and a bias network are reported. The designed circuits show significant improvements over size reduction and measured electrical broadband performances (losses less than 1dB and reflection better than -10dB are observed for the transition).

INTRODUCTION

Uniplanar interconnections become increasingly attractive for new low cost and high electrical performances MMICs [1]. Because the use of via holes is avoided, some process steps and inductive parasitics associated with these components are eliminated. Moreover, these interconnection lines are usually less dispersive than microstrip lines and can be very useful for millimeter wave designs. Finally, they show a significative reduction of the dimensions over their more classical competitors.

Most of previous published uniplanar designs are based on coplanar waveguides (CPW) and slotlines (SL) featuring very wide metallic planes. Therefore, when a SL/CPW transition is used, because of the interconnect topology or because the SL circuit needs to be tested under coplanar probing, it requires resonant terminations (using a λg/4 cross-junction, or combinations of CPW shorts or CPW radial opens ... and λg/4 SL shorts or SL circular opens ...) [2-5], or an ending SL with a 90° angle between the SL and the CPW [5,6].

The introduction of these elements in a MMIC design is rather difficult in regard of their large area or their bent configuration. To overcome these drawbacks, we propose the use of coplanar strips (CPS) [7,8] instead of SL.

In this paper, we will present some benefits of this process through two examples that are a CPS/CPW transition and a simple bias network.

CPS AND CPW LINES FEATURES

CPS lines consist in two finite widths W metallic strips separated by a slot of width S. Compared to slotlines (quasi-TE mode propagation), CPS are less dispersive exhibiting quasi-TEM mode propagation properties [8,9].

A trade-off between two conditions for the choice of W must be observed : firstly W has to verify W•4S in order to minimize the losses, and secondly W has to be reduced enough both to exclude parasitic non-TEM phenomena [9] and obviously to reduce MMICs area.

In the same way, the CPW ground planes width Wm can be reduced, in relation to the distance D between ground planes, down to Wm<D/2 without too much influence on the propagation characteristics [8], [10].

The optimized design of these CPS and CPW lines was achieved by the electromagnetic simulations software "Sonnet" (@ Sonnet Software Inc.) and the structures were made by the Philips Microwave Limeil foundry process. This one features a substrate thickness H=600µm,

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a dielectric constant $\varepsilon_r \approx 12.3$, and a metal thickness t=1.25µm.

CPS/CPW TRANSITION DESCRIPTION AND PERFORMANCES

The reduction of the metallic strips width makes easier the design of a transition between a two slots line (CPW) and a one slot line (here a CPS line). One slot of the CPW just terminates by an open circuit where an air bridge connects the two ground strips of the CPW (fig.1).

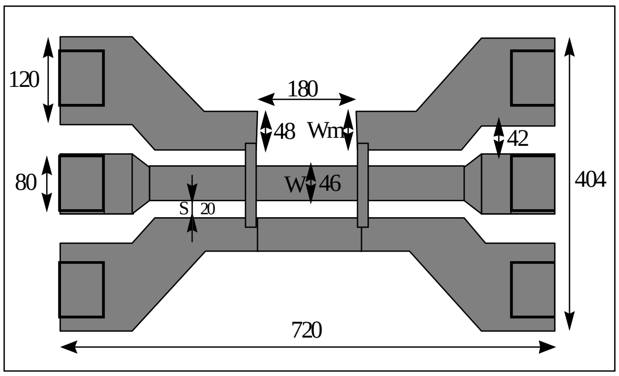


fig.1 : double transition layout for probing (dimensions in µm)

The presented structure on figure 1 is constituted with two CPS/CPW transitions in order to perform wafer probing.

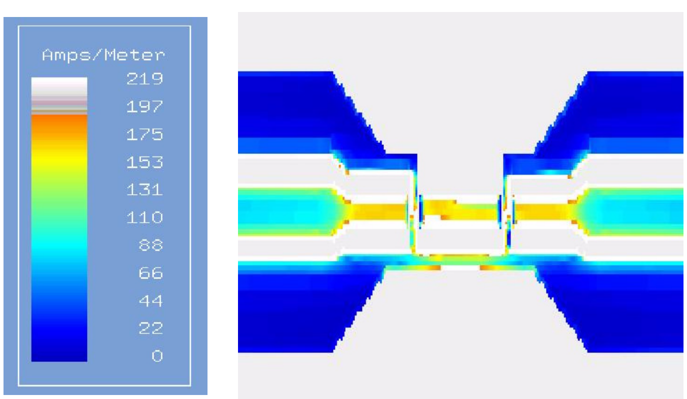
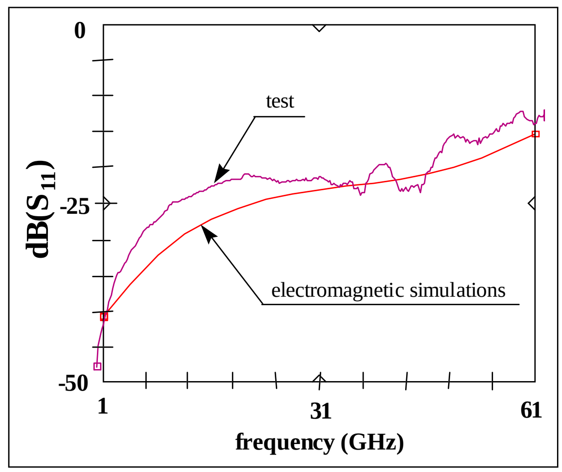


fig.2 : CPS/CPW transitions current density distribution view

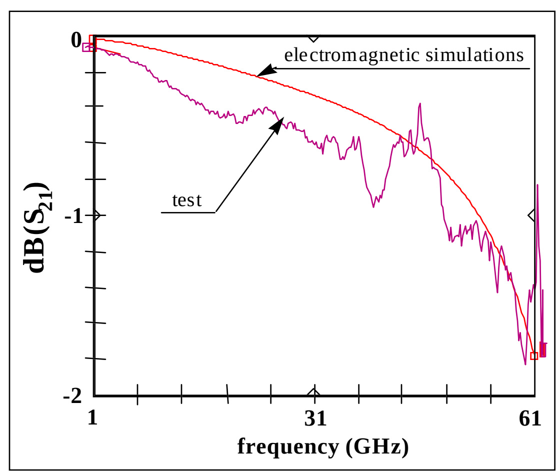
CPS and CPW lines have been also designed to exhibit impedances close to 50Ω. The air bridge is necessary for the odd mode recombination and conservation, as illustrated in figure 2 where the current densities are represented along the structure.

We can note on this figure that the current lines are concentrated around the slots for a frequency of 20GHz as example. Therefore, the ground planes width Wm can be reduced without too much effect on electrical performances.

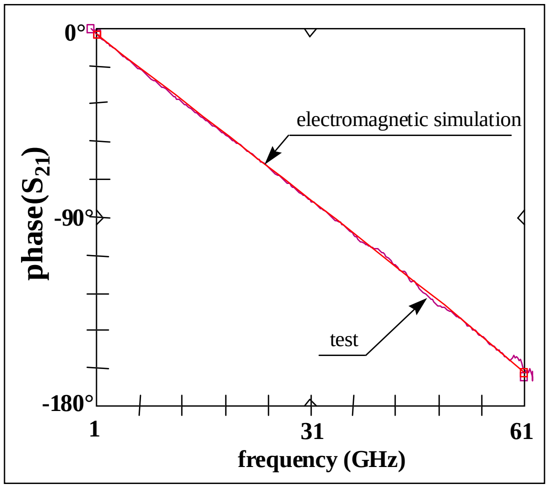
Results of electromagnetic simulations and measurements performed from 1GHz to 65GHz are presented on figure 3 for the double CPS/CPW transition.



magnitude of reflection coefficient (S_{11})



magnitude of transmission coefficient (S_{21})



phase of transmission coefficient (S_{21})

fig.3 : CPS/CPW transitions electrical performances (test/electromagnetic simulation comparison)

Good transmission and reflection are obtained up to 65GHz ($|S_{21}| > -2$dB and $|S_{11}| < -12$dB). A good agreement between test and simulations can be also noted. As these results are observed for the double transition, a better $|S_{11}|$ and a $|S_{21}| > -1$ dB can be expected for only one transition.

BIAS ACCESS DESIGN

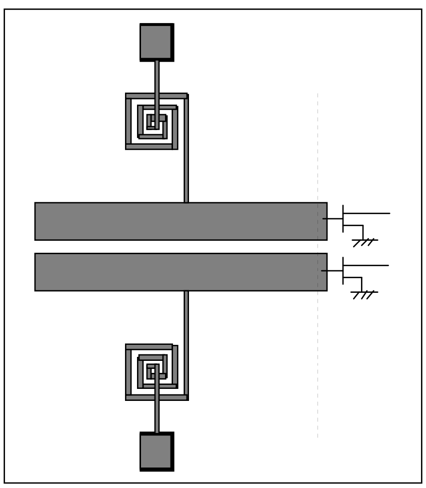


fig.4 : CPS with bias access lines

As shown in figure 4, a CPS structure is firstly particularly suited for differential applications since none of the metallic strips are referred to ground. As example, such a transmission line can be used to easily convey two out of phase signals in a balanced mixer, like +RF/-RF and/or +OL/-OL for inputs, and +FI/-FI for output.

Secondly, because the wave flows along the slot, currents are concentrated near the slot. So, the bias can be supplied with a simply inductive line or through a small value inductance (low area) (fig.4) while a shock inductance (large area) is needed in microstrip line design.

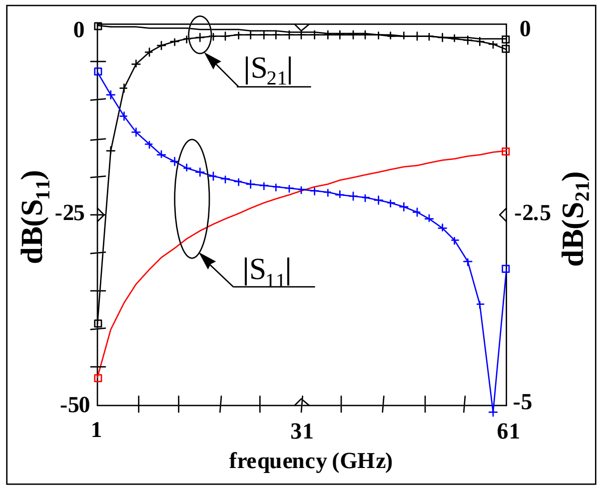


fig.5 : electrical performances of the CPS with (+) and without (-) bias access lines

Figure 5 reports on the electromagnetically simulated electrical performances of a CPS line with two bias accesses.
This figure shows that beyond 13GHz, a bias network involving only a 1nH inductance has an insignificant effect on RF transmission and reflection of the CPS line.

CONCLUSION

An original reversible CPW/CPS compact transition has been fabricated, using only an open circuit and an air bridge for achieving adaptation and conservation of the fundamental mode.
Measured insertion losses are better than 1dB up to 65GHz for the simple transition. Moreover, a

CPS based circuit allows a simpler MMIC design and a very compact layout compared to those involving SL, particularly for active components bias networks as reported in this paper.

These new structures can find some interest for millimeter wave MMIC designs based on uniplanar interconnections which are now being widely addressed for advanced applications (by example balanced circuits requiring differential structures).

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