THz Long Range Plasmonic Waveguide in Membrane Topology

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***Abstract*—In this communication, we present THz Planar Strip Plasmonic (THz-PSP) structures based on Planar Goubau Lines (PGL). In order to improve different propagation characteristics, a membrane approach is studied because it is more convenient for low dispersion propagation and for a long range plasmonic behaviour. Resonating structures such as split ring resonators (SRR) along the plasmonic waveguide can be added to this structure in order to maximize the coupling between them.**

I. INTRODUCTION AND BACKGROUND

PLASMONICS are an exciting and very promising research field in different frequency bands [1]. There is an interest at optical frequencies, where the waveguiding properties of these modes are of prime interest, with Long-Range Surface Plasmons Polaritons (LRSPP) [2-3]. THz propagation has also been demonstrated on cylindrical metallic wires [4].

Recently we have proposed several original THz Planar Strip Plasmonic (THz-PSP) structures based on Planar Goubau Line (PGL) : efficient excitation of this plasmonic mode and waveguides [5-6], filters, bendings and superfocusing [7]. The filtering effect is obtained by corrugating the metallic strip. We also know that bendings are important for the routing of plasmons [8], and we have also used this excitation for metallic strips with 90° bendings. We have obtained low loss bendings. Potential applications, like recently published superfocusing effects by S. A. Maier et al. [9], with these THz-PSP structures is also possible.

II. RESULTS

We present electromagnetic simulation results obtained on original planar plasmonic waveguides in a membrane topology. In order to minimize the propagation losses and also dispersion effects, low permittivity substrates are more convenient. Moreover a symmetrical structure is also more appropriate for a long range behaviour. On Figure 1, we have represented the electric field distribution at different transverse sections of the back-to-back structure : (a) a coplanar waveguide (CPW) , (b) a tapered transition used for the launching of the mode and (c) the pure planar Goubau-Line section. As we can observe on Figure 1(d), the electric field is radially polarized even in this planar topology.

On Figure 2, we have represented the signals in time domain. We have a relatively high transmission parameter with a high pass behaviour. From electric-field probes placed along the structure, we can observe on Fig. 2.b the low dispersion of the propagation on this long-range strip plasmonic waveguide (LRSPW).

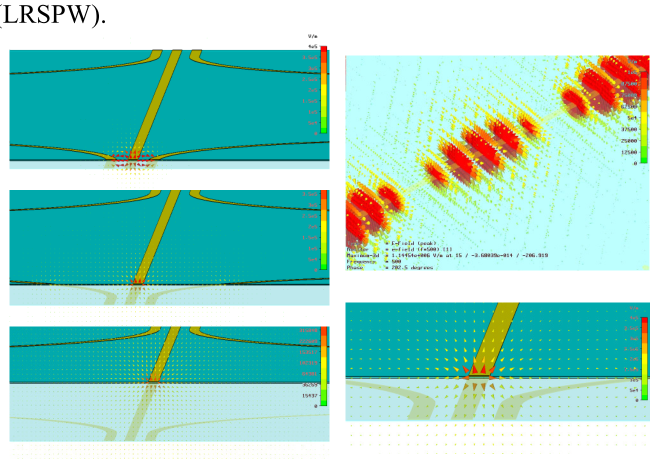

Figure 1.: Electric field at different positions on the LRSPW: (a) CPW section, (b) plasmon launching section. Single strip section (c), 3D view (d) and zoom (e). The membrane thickness is 2µm.

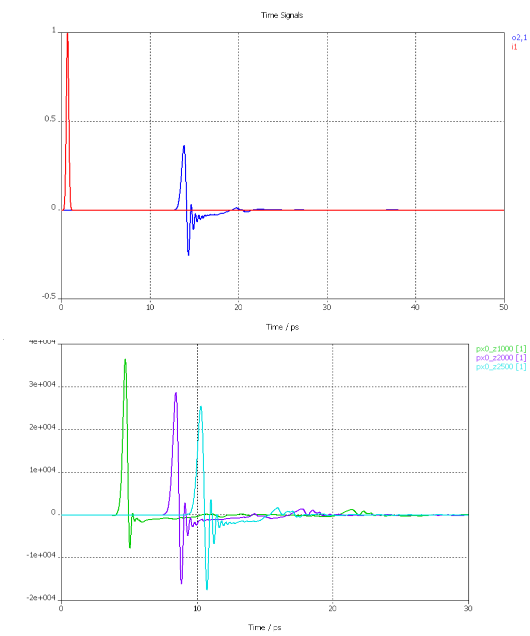

Figure 2.: Time domain simulations: incident and transmitted signal (a) and electric field probes placed along the waveguide at 1mm, 2mm and 2.5mm from the beginning of the structure showing low loss and low dispersion.

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The S-parameters of a back-to-back structure are shown on Figure 3. We can clearly observe a very broadband behaviour in this membrane topology since no substrate modes can be excited in this frequency range as observed experimentally in [6]. The thickness of the membrane is 2µm.

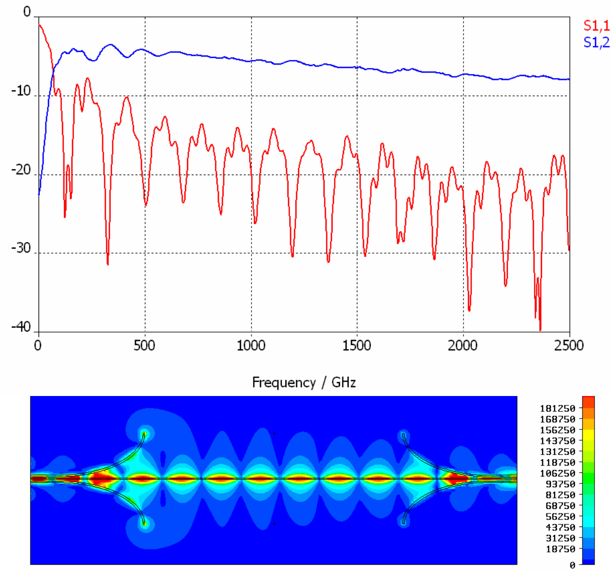

Figure 3.: (a) S-parameters (dB scale) of a back-to-back structure with a 3 mm long PGL section. The plasmonic wave launchers are 600µm long. (b) Electric field at f=0.5THz. We can clearly observe the confinement along the plasmonic waveguide.

From this structure we can also add resonating structures on the top of the substrate. We can use ring resonators, single or double split ring resonators. The coupling between the planar Goubau-line and resonating structures periodically placed along the line is demonstrated on Figure 4.

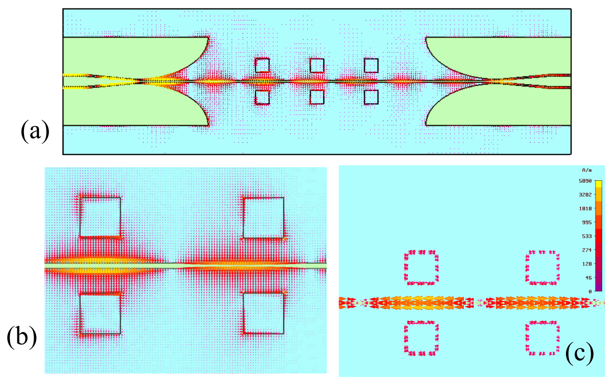

Figure 4.: (a) and (b): Electric Field at f=330GHz showing the coupling between the metallic strip and the square shaped ring resonators. (c): Surface current at f=300GHz.

III. CONCLUSION

We have presented a structure for long range surface plasmon propagation at THz frequencies. We have observed a low dispersion and very wideband behaviour with this membrane topology. The confinement around the metallic strip also permits the coupling with resonating structures such as closed or split ring resonators (SRR). This is the first demonstration of this effect with a planar Goubau-Line.

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