Theoretical Study of Phase and Amplitude Characteristics of Microwave Coplanar Delay Line Containing Thin Ferroelectric Layer

V. Nikolaevtsev1, S. Yankin2, S. Suchkov1, D. Suchkov1, A. Litvinenko1
1. Saratov State University, Laboratory “Metamaterials”, 83, Astrakhanskaya st., Saratov, Russian Federation, 410012;
2. Joint International Laboratory LICS/LEMAC, IEMN UMR CNRS 8520, EC Lille, B.P. 48, 59651, Villeneuve d’Ascq, France

Introduction: It was shown in [1] that it is possible to create the microwave delay line controlled by voltage by means of using a thin film of ferroelectric material. Our aim was to estimate controllability of coplanar delay line. Relative permittivity of the film changed significantly under voltage applied to the ground (Fig.1). It will effect on velocity of electromagnetic wave changing the delay time.

Computational Methods: We computed electric field of electromagnetic wave that propagates along the coplanar delay line using the environment of 3D modeling in Comsol, RF module, Frequency Domain. Our line delay was surrounded by a sphere on which were set the scattering boundary conditions. To enter the radiation into the delay line, we used lumped port. We carried out the calculations for the different turns undercuts geometry. Shown in Figure 2 is the microwave coplanar delay line metallization for the rounded undercuts.

Results: The parameters of the delay line and the frequency are shown in Table 1. The most important results are presented in Figures 3-5. We can observe that velocity of electromagnetic wave change significantly with film relative permittivity.

![Figure 1. Microwave coplanar delay line with thin ferroelectric film](image1)

![Figure 2. Microwave coplanar delay line metallization](image2)

![Figure 3. E3 component ε = 600](image3)

![Figure 4. E3 component ε = 2000](image4)

![Figure 5. Velocity dependence upon film relative permittivity](image5)

**Table 1. Parameters of structure**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substrate relative permittivity</td>
<td>9.7</td>
<td></td>
</tr>
<tr>
<td>Film thickness</td>
<td>30</td>
<td>nm</td>
</tr>
<tr>
<td>Metal thickness</td>
<td>1</td>
<td>μm</td>
</tr>
<tr>
<td>Frequency</td>
<td>10</td>
<td>GHz</td>
</tr>
<tr>
<td>Substrate sizes</td>
<td>500 X 130X20</td>
<td>μm³</td>
</tr>
</tbody>
</table>

Conclusions: The results of the calculations show that the time delay under external field can be changed by 20%. It provides to create the delay line controlled by voltage. Creating the delay line with delay time of 50 ns we can obtain the time tuning up to 10 ns.

References:

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