Regular paper

TRANSITION BETWEEN COPLANAR WAVEGUIDES AND MICROSTRIPLINES WITH INTEGRATED BOND-WIRES

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Abstract: The analysis of interfaces between different line types with the method of finite differences in time domain to solve an interface problem is demonstrated. Results of simulated structures with integrated bond-wires are shown for different materials as well as measurement results. A new approach for design description of transition between microstripline and coplanar waveguide is proposed.

Keywords: Numerical field computation, time domain, transition microstripline coplanar waveguide, bond-wires.

INTRODUCTION

Using frequencies in the gigahertz band, conventional wires are not suitable for signal transmission. Therefore striplines, coaxial wires and waveguides are necessary. The consideration of loss, radiation and dispersion become more important with raising frequencies.

Connecting superconducting chips with structures on a carrier board requires bond-wires. Ground connection is realized by using coplanar structures that allow direct galvanic connection of signal and ground lines. Superconducting Single-Flux-Quantum electronic uses microstrip lines to connect Josephson junctions. Input and output signals have to be transmitted to a normal conducting carrier chip. Hence a transformation

between these two line types is required to establish connections via bond-wires.

Different transitions can be found in Edwards[1] and with a comparison of different transitions

especially for the described problem in [2]. Basic ideas for the used transition are taken from Safwat and Zheng [3-4].

Fig. 1 shows the schematic structure of the transformation between microstriplines and a coplanar waveguide with ground and the integrated bond-wires.

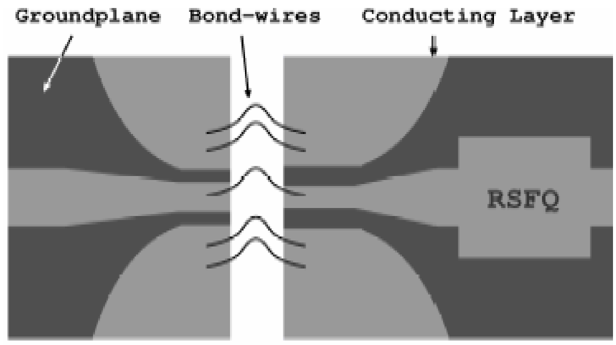


***Fig.* 1** - *Draft of the symmetrical transition between microstriplines and coplanar waveguides with integrated bond-wires.*

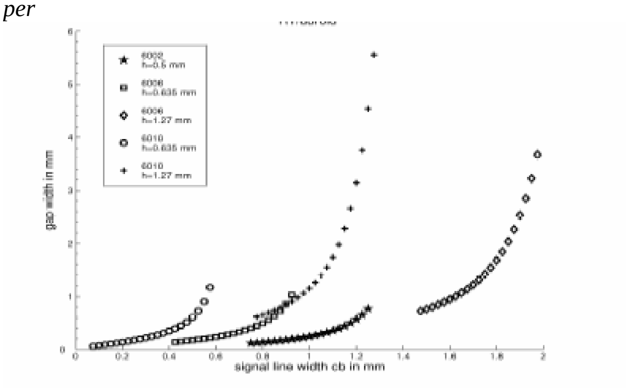
Dimension, simulation and measurement of manufactured structures as well as the analysis of the superconducting case are the basic challenges. To create a low reflecting connection with a constant low reflection coefficient of the input S_{11} over the given frequency range is the aim.

With the Finite Differences Time Domain (FDTD) method voltage, current, S-parameters and impedances as functions of frequency are created. This method allows the geometrical localization of discontinuities that cause reflections. With this information a rating of different designs is enabled. It turned out that loss plays an unimportant role, so the simulation could be performed without considering them.

THEORETICAL ISSUES

The description of the line transition is presented in the following section. Starting with a stepwise dimension of coplanar gaps with a linear variation of the signal line width (linear taper) a new approach for the theoretical description for the coplanar gap was developed, which allows an easier and faster design. Fig. 2 shows the gap dependency on the signal line width. With parameters permittivity and substrate height h an approximation function can be found, valid for materials used in this context. All materials are high frequency laminates with substrate heights between 0.5 mm and 1.27 mm and εr between 2.94 and 10.5. Challenges are the elliptic integrals describing the impedances of microstriplines and coplanar waveguides possibly approximated with a polynomial.

Fig. 1 - *Value of gap width relatively to the symmetry line of a linear taper*



MODELING BOND-WIRES

The simulation of three dimensional objects with MaYA (our homemade 2,5D code) requires a modeling of bond-wires by approximating the bond-wire-curve with slices. The used ball-wedge method causes the unsymmetrical form. Therefore equation (1) is created. Other objects are directly defined via bricks of constant material in a non-uniform mesh. Different geometries result in different impedances. The impedances in case of the bond-wires are between 51Ω and 53Ω (Fig. 3), whereby the reflection in practical cases at this position is not as important as at the line type conversion.

$$f(x)=\begin{cases} h\sin^2(x) & 0\leqslant x\leqslant\frac{2}{3}l \\ h\cos^2(x) & \frac{2}{3}l\leqslant x\leqslant l \end{cases} \quad (1)$$

The difference between curve 1 and 5 is the position relatively to the gap. Best behavior results from flat bond-wires close to the gap. Increasing the number of slices goes along with a reduction of the minimal structure size in one direction which is directly connected with a raising computation time.

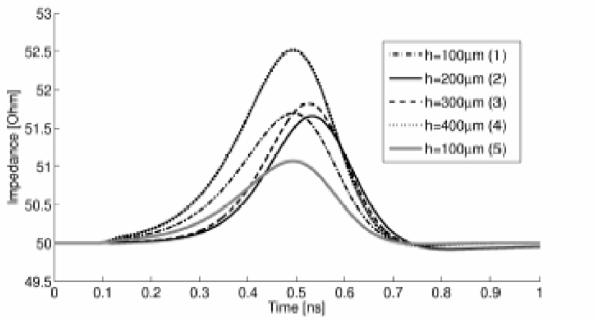


Fig. 3 - *Profile of the impedance in the area of the bond-wires with parameter bond-wire height and distance to gap*

MEASUREMENT

Because only a non-galvanic coupling between the ground layers exists, the influence of direct ground connection is analyzed. Including vias along the coplanar waveguide advances the reflection behavior of the transition as easily can be seen in Fig. 4.

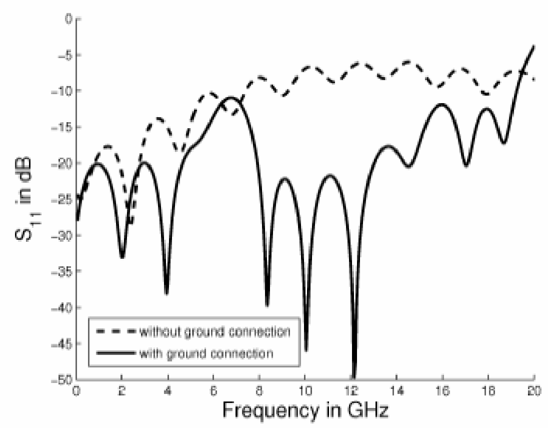


Fig. 4 - *Input reflection of the symmetrical transition from microstripline to coplanar waveguide with and without a ground connection between both lines*

Because simulation of bond-wires are created for the superconducting case, dimensions are very small and not suitable for the technology used for the prototypes. Therefore the measurement is based on a symmetrical transition from microstripline to coplanar waveguide and back.

CONCLUSION

After development and simulation different variations of the normal electron based conducting line conversion have been produced and measured. Fig. 3 shows S_{11} of the transition with and without the use of vias between both ground layers. This illustrates the positive aspect using the connection between the ground of the microstripline and the ground of the coplanar line. The reflection-parameter for frequencies between 8 and 19 GHz could be decreased obviously. Compared with the simulation measurement results were little worse, but tendency was experimentally confirmed. The reason for the difference is a strong undercutting while manufacturing structures. The coplanar gap width for example differs 30 percent. That is why a correction depending on the used technology is necessary. Even with these strong geometry variations the good usability of the design is shown.

The theoretical approach for the description of transitions between microstriplines and coplanar waveguides is presented schematically and demonstrated for different materials and substrate heights. To fulfill requirements the behavior of bond-wires is analyzed. Therefore an equation has been chosen describing the unsymmetrical geometry of the wires. After simulating the structure measurements have been done to proof the results. Discrepancies in geometry of manufactured structures caused by a strong undercutting reduce the quality, but even then the expectations could be fulfilled.

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