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ANALYSIS AND CHARACTERIZATIONS OF PLANAR TRANSMISSION STRUCTURES AND COMPONENTS FOR SUPERCONDUCTING AND MONOLITHIC INTEGRATED CIRCUITS

by

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ABSTRACT

The research effort has been continued to design and characterize superconducting transmission line structures. The research during this period was concentrated on the implementation of a superconductor into coplanar waveguide structures. First, the superconducting coplanar waveguide was examined, and compared with a superconducting microstrip line in terms of loss characteristics and their design aspects. Then, the research was carried on the design and characterization of the coplanar waveguide family in the packaging environment. The transition between the coaxial line to the conductor backed coplanar waveguide was also designed for the measurement of the superconducting conductor backed coplanar waveguide.

(1) Design Aspects and Comparison Between High T_c Superconducting Coplanar Waveguide and Microstrip Line.

The high T_c superconducting microstrip line and coplanar waveguide were compared in terms of the loss characteristics and the design aspects. The quality factor "Q" values for each structure were compared in respect to the same characteristic impedance with the comparable dimensions of the center conductor of the coplanar waveguide and the strip of the microstrip line. Also, the dielectric loss between the two structures were compared since the dielectric loss becomes a critical design aspect in the superconducting transmission line structures as the conductor loss is reduced. It is observed that the superconducting microstrip line has an advantage over the coplanar waveguide structure in terms of getting less conductor loss. However, the coplanar waveguide provides the advantage over the microstrip line in the aspect of the design flexibility and the reduction of the substrate loss.

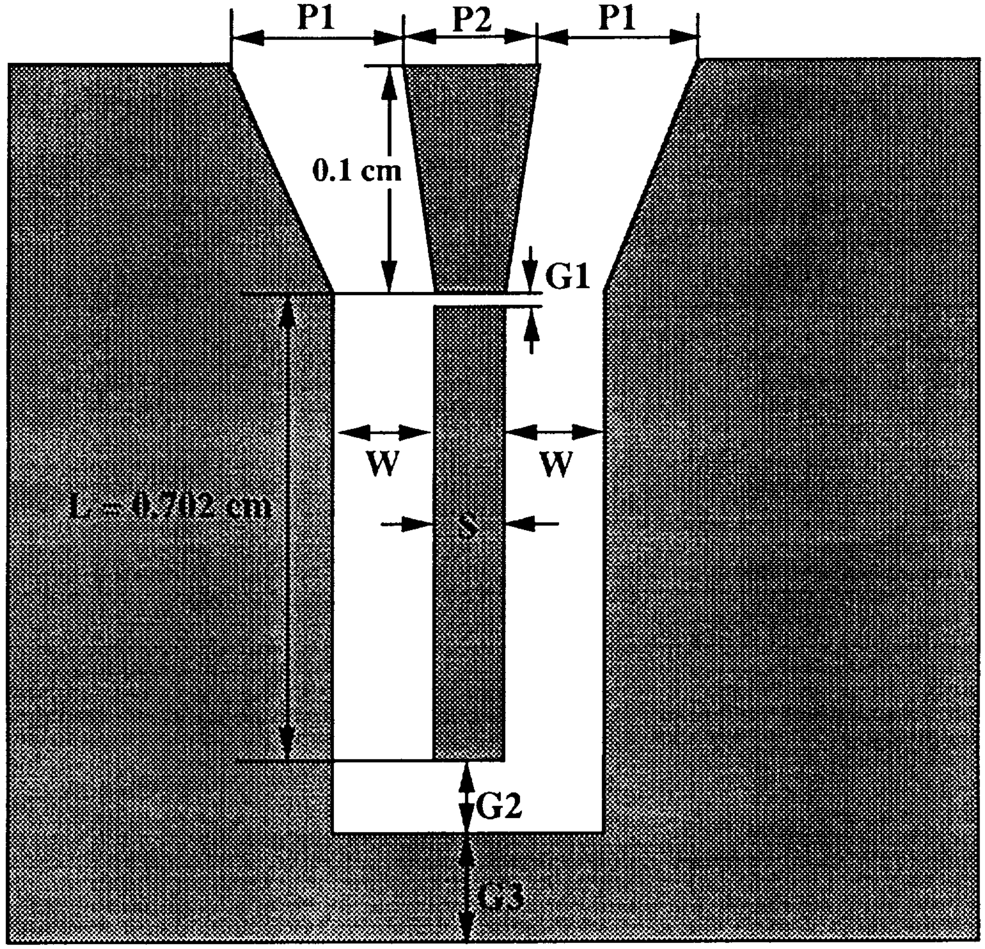
(2) Superconducting Conductor Backed Coplanar Waveguide.

In the last research period, the conductor backed coplanar waveguide was proposed and examined as the practical transmission line structure for the coplanar waveguide in the packaging environment. Particularly, the coplanar waveguide appears to be a good structure for the application of a superconductivity because the conventional coplanar waveguide is not compatible with a cooling system. We calculated the conductor loss of a high T_C superconducting conductor backed coplanar waveguide. The inductance was calculated by the modified Spectral Domain Method(SDM). Then, the geometric factor was obtained by a numerical derivative of the inductance. This factor was used to calculate a conductor loss by the Phenomenological Equivalence Method(PEM). The conductor loss of the conductor backed coplanar waveguide was compared with the one of the conventional coplanar waveguide. It was observed that the conductor loss of the conductor backed coplanar waveguide is larger than the one of the conventional coplanar waveguide. This is due to the additional conductor loss from the backed ground plane of the conductor backed coplanar waveguide. However, the decrease is less than 15 %. As a result, it was concluded that it is worth to implement a superconductor to the conductor backed coplanar waveguide. The experiment was carried out at NASA based on our design and close technical communications. The measurement was done by using a coaxial line transition. Figure 1 shows the conductor backed coplanar waveguide resonator and its dimensions. The resonator consists of sputtered $YBa_2Cu_3O_{7-x}$ top plane (center conductor and ground plane) and gold ground plane. A quality factor of 470 at 77 K was measured in this resonator. According to the calculation, a quality factor of 820 is expected to be achieved from the structure with $YBa_2Cu_3O_{7-x}$ on both planes.

PUBLICATIONS

1. K. -S. Kong, K. B. Bhasin and T. Itoh, "Design Aspects and Comparison between High T_C Superconducting Coplanar Waveguide and Microstrip Line", SPIE's International Symposium on Optical Engineering and Photonics in Aerospace Sensing, Orlando Florida, April 1-5, 1991.

2. F. A. Miranda, K. B. Bhasin, K.-S. Kong, T. Itoh and M. A. Stan, "Conductor-Backed Coplanar Waveguide Resonators of $YBa_2Cu_3O_{7-x}$ on LaAlO3", submitted to " IEEE Microwave and Guided Wave Letter".



P1= 21 mils, P2 = 22 mils, W = 530 μm, S = 200 μm,
G1 = 50 μm, G2 = 530 μm, G3 = 630 μm

Figure 1. Top view of the conductor backed coplanar waveguide (open circuit resonator).