FULL WAVE ANALYSIS OF CONDUCTOR-BACKED AND MULTI-LAYER HIGH-$T_c$ SUPERCONDUCTING COPLANAR WAVEGUIDE

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Received October 8, 1994

ABSTRACT

Dispersions, attenuation and characteristic impedance of shielded conductor—backed coplanar waveguide (CBCPW) and shielded three—layer coplanar waveguide (CPW) with finite conductor thickness as well as their superconducting applications are calculated. The method of lines (MoL) is employed to analyze these coplanar waveguides. The analysis is validated by a comparison of the calculated results with those published previously. Effects of finite width of grounded strip for a CPW are considered. Extensive investigation of the numerical convergence for calculation of the characteristic impedance is also described.

I. Introduction

The coplanar waveguide transmission line has the advantage of avoiding via holes. It shows increasing importance in more and more applications of microwave integrated circuits[1,2,3,4]. In our consideration of high—$T_c$ superconducting applications, it is an important technological advantage that a ground layer metallization is not needed at the back side of the substrate for
this type of transmission line. Authors have presented a lot of contributions on analysis of coplanar waveguide transmission lines as well as superconducting applications. Kwok K.M. Cheng and Jeremy K.A. Everard have presented the quasi-TEM analysis of CBCPW structure with normal metal as conductor[1]. Leizhu and Eikichi Yamashita have given full wave analysis but without calculation of characteristic impedance and superconducting application[2]. Jocken Kessler and his cooperators have investigated superconducting coplanar waveguide transmission line using a partial wave synthesis[3]. However, they haven’t analyzed characteristic impedance. In fact, they only considered conductor-backed coplanar line. For superconducting coplanar lines, most authors use the concept of surface impedance to introduce the two-fluid model and London theory. As a result, the accuracy is limited to that of using quasi-TEM method. Complex dielectric constant is also used in a few papers but with complicated analysis and longer calculating time.

In this paper, a unified computing program is developed to analyze various shielded coplanar waveguides, only some parameters are changed and can be chosen according to user’s convenience. Analysis procedures and High-$T_c$ superconductor model are introduced. The numerical convergence of characteristic impedance calculation using MoL has been investigated and solved. At last, the effects of finite width of grounded strip of CPW are discussed. Comparison of calculated results with published data shows good agreement.

II. Analysis

A. Procedures of analysis

Fig.1 is a cross section view of a three-layer coplanar waveguide. It will become CBCPW when $\varepsilon_{r_L1} = \varepsilon_{r_L2}$ or $H_{L1} = 0$, so a unified procedure of analysis can be used for CBCPW and three-layer CPW.

The two independent field components in each separate layer shown in Fig.1 should satisfy the Helmholtz equation