Vertical Via Transition Using a Coaxial Line for SMT Pad Applications

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ABSTRACT

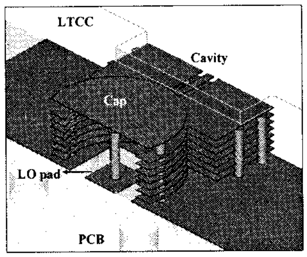
In this paper, a vertical via transition using a coaxial line is presented for LTCC SMT package applications. A part of outer conductor is cut off due to overlap between a CPW on PCB and transition. For reduction of radiation and return path, a cap is designed on the top layer. The measured S11 and S21 are -14 and 0.9 dB, respectively at 15 GHz.

Key words)

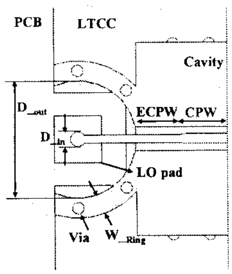
LTCC, Transition, Coaxial structure

I. Introduction

Multi-layer low temperature co-firing ceramic (LTCC) based system-on-package (SoP) integrating monolithic microwave integrated circuits (MMICs) and passive devices have been widely used for microwave and millimetre-wave applications, because of its low loss, integration capability, similar temperature coefficient of expansion (TCE) value to MMICs, and cost effectiveness.For SMT interconnection between PCB and LTCC SoP, low-loss vertical transitions are required. Several types of vertical via transition such as CPW-to-stripline (SL) transition [1, 2], microstrip-to-SL transition [3, 4] and CPW-to-CPW transition [1, 5] have been proposed and characterized. In these previously reported literatures, various interesting methods for the improvement of their RF performance have been presented. They are roughly divided into two categories: impedance matching [2, 3, 5] and parasitic compensation [1, 2]. In order to match the transition impedance close to 50 Ω, the coaxial-like transition using shielding vias [3, 5] and intermediate ground planes [2] have been investigated. For reduction of the capacitive effect in the transition region [3] or the inductive effect of vertical vias [2], F. J. Schmuckle et al. [3] designed the critical ground part moved



(a)



(b)

Fig. 1 Perspective view (a) of the designed vertical via transition using a coaxial line and its layout (b).

down beneath the lower ground of the SL. Shuo Lei et al. [2] proposed additional pads in the vertical vias to reduce the inductive effect at the transition. In addition, for suppression of unwanted resonance modes, PBG structure in the cavity was designed, forming a kind of bandstop filter at the operation frequency [6]. In this paper, using a coaxial like vertical via transition the SMT pad is implemented for the PCB-to-LTCC interface. Using 9-layerLTCC substrate, CPW-to-Coaxial line-to-SMT pad transition is designed and fabricated. A part of outer conductor of the coaxial line is cut off due to overlap between a CPW on PCB and transition. For reduction of radiation and return path, a cap is designed on the top layer. Transition is designed and analysed using a 3-D Finite Integration Technique (FIT) simulator [7] and they are implemented using a 9-layer LTCC dielectric.

II. Design and Fabrication

Fig. 1 (a) illustrates the 3D structure of the CPW-to-coaxial line-to-SMT pad transition in a 9-layer LTCC substrate. Relative dielectric constant of the LTCC substrate is 7.0 at 60GHz. The total height of the vertical vias in the transition region is 700 μm. The size of the pad on the PCB is 560 x 560 μm^2. The inner and outer diameters of the coaxial line are 135 and 695 μm, respectively. The size of the inner conductor (via), which is used for the signal via, is fixed. For 50 Ω impedance the outer diameter of 1,226 μm is required. However, it leads to a bulky SMT pad structure. Through the size optimization of coaxial line in terms of transition loss and size, the outer diameter is determined and at this time the impedance of the coaxial line is 37 Ω. The cap on the 9 layer of the LTCC substrate is designed for reduction of radiation due to via discontinuities. It radius is 928 μm. A part of outer conductor of the coaxial line is cut off due to overlap between a CPW on PCB and the outer conductor used as the ground. The CPW on the seventh layer is designed for interconnection with other devices or measurement. Fig. 1 (b) shows the layout of the transition. The width of the CPW and embedded CPW is 144 and 90 μm, respectively. Their gaps are 83 and 95 μm, respectively. Their height of the substrate is 100 μm.

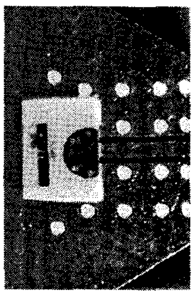


Fig. 2 Fabricated SMT pad transition on the PCB board

The designed coaxial line transition was implemented using seven LTCC dielectric layers with a dielectric constant of 7.0 and its thickness between the metal layers is 100 μm. The Ag and Ag/Pd conductors were screen-printed on the unfired layers for internal and external conductors respectively.Signal vias 150 μm in diameter was formed through the standard mechanical punching process. Fig.2 shows the fabricated CPW-to-coaxial line-to-SMT pad transition on the PCB board.

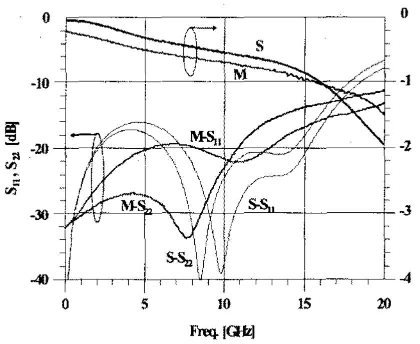


Fig. 3 Simulated and measured results [S: simulation and M: measurement].

III. Measurements

Using probing method on the probe station, the fabricated transition for SMT pad applications was characterized. Fig. 3 shows the designed and measured results. Poles of both return (S11 and S22) and insertion loss (S21) make a difference between the simulated and measured results. This difference comes from parasitics due to soldering works. The measured insertion loss of 0.9dB is achieved at 15 GHz. The return losses of S11 and S22 are below -14 dB at the same frequency.

IV. Conclusion

In this paper, a CPW-to-coaxial line-to-SMT pad transition is presented for LTCC SMT package applications. 7-layer vertical via transition is designed using a coaxial line. A part of outer conductor is removed due to overlap between a CPW on PCB and coaxial ground. For reduction of radiation and return path, a cap is designed on the top layer. The measured S11 and S21 are −14 and 0.9 dB, respectively at 15 GHz.

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