ICNSE -797
Novel Non-exchange Layer Structure Thru Kit of Double-sided Probing Calibration for SiP Measurement

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Abstract

SOLT is the calibration method in novel double-sided calibration and "thru" is a element about two-port calibration. So that is a reason about "thru" is a key element in novel double-sided calibration. In this paper, there is a novel double-sided right angle thru kit which can be used in multi-port novel double-sided calibration. By comparing different double-sided calibration, novel double-sided has better advantages. Therefore, novel double-sided calibration is used and researched in this paper. There is a design about it. Finally, non-exchanged layer structure to achieve the design in this paper.

Keyword: SOLT calibration, VNA measurement, double-sided calibration element, right angle double-sided thru kit, full 4-port calibration.

1. Introduction

Because of device is changed to faster and smaller, chip's structure transfer from two-dimensional to three-dimensional. Measurement and calibration are important on RF and microwave device. Input signal and output signal are not the same plane. Actually, one-sided calibration is not enough to measure RF and microwave device like system in package (SiP) or three-dimensional stacked integrated circuits (3DIC). In order to solve measurement after packaged and multi-layer stacking structure, new measure technique in RF and microwave device is needed. Therefore, double-sided measurement has been researched. There are three types in the development process of the double-sided measurement:

1) Test fixture included coplanar measurement.
2) Rotated probe arms measurement.
3) Novel double-side measurement.

There is Fig.1 shown about kinds of calibration method correspond to measurement method, and there is TABLE I shown about performance comparing of double-sided measurement and calibration. In SOLT(Short, Open, Load, Thru) [1][2] calibration, SOL elements are single-sided calibration so there is no problem about coplanar, but thru has the problem

because it is a two-port calibration element. As Fig.1(a) shown is test fixture included coplanar measurement, in this measurement method, it uses SOLT base on single-sided calibration each port to calibrate. And it adds the test fixture when measured. Discontinuous effects will happen between DUT and test fixture , finally caused inaccurate measurement. As Fig.1(b) shown is rotated probe arms measurement, this method uses SOLT base on single side calibration each port to calibrate, too. But when calibration done, the arms will rotate to another plane to measure. Each port in the measurement plane is different from the calibration plane, so it will cause inaccurate measurement, too. Both of the above-mentioned are used ISS(Impedance Standard Substrate)[3] kit in SOLT calibration and included error factors. Therefore, a better measurement should be researched.

As Fig.1(d) shown, novel double-sided measurement not only remove test fixture but also replace probe arms upside down for rotating probe arms. Therefore, probe tips are coplanar. With these changes, novel double-sided is feasible to multi-port measurement. And these make novel double-sided measurement has wider bandwidth than other type. In novel double-sided SOLT calibration, S-O-L element base on single sided for each port. And the thru element is based on double-sided for more than two ports.

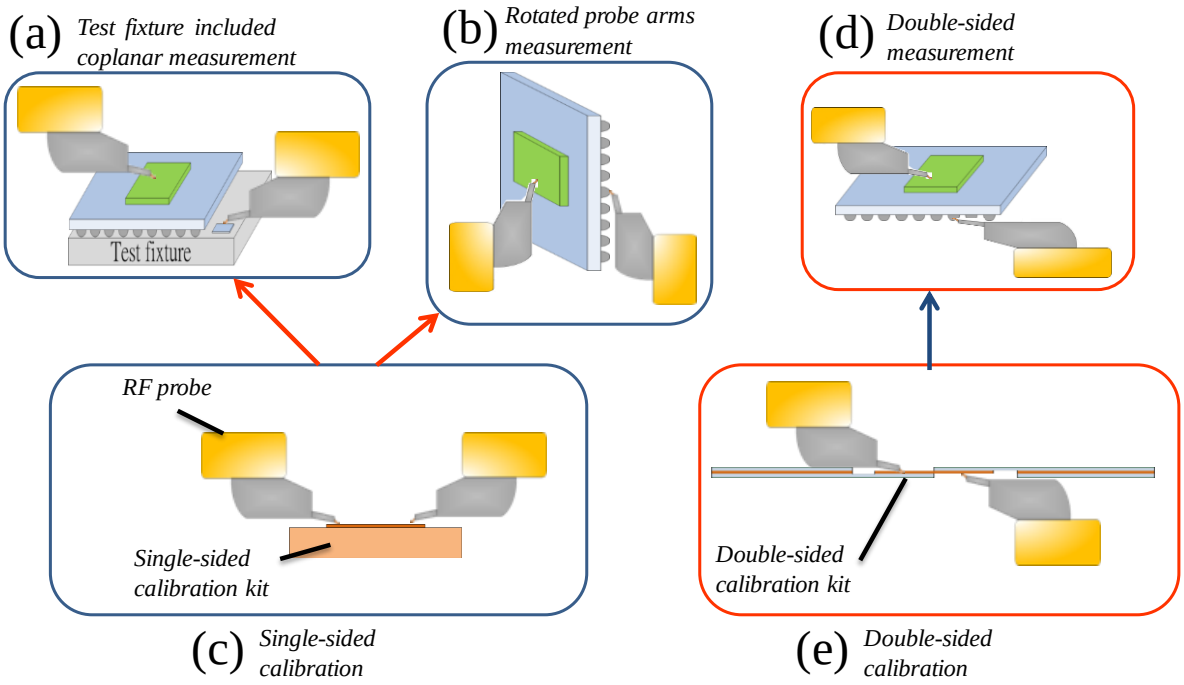


Figure.1 Calibration kit and measurement

Thru element is the key part for novel double-sided SOLT calibration [4]. However existing novel double-sided direct thru kit is applied in two ports. Novel double-sided right angle thru kit applied in multi-port is needed [5] [6].

In this paper, the research is based on full 4-port calibration. There ia a type about double-sided right angle thru kit.

TABLE. I
Performance comparing of double-sided measurement and calibration

Method of measurement	*Test fixture included coplanar measurement*	*Rotated probe arms measurement*	*Novel double-side measurement*
Method of calibration	Single-side calibration	Single-side calibration	Double-side calibration
Advantage	1. Single-side calibration has been developed. 2. ISS kit for calibration has been commercialized 3. Probe tips are coplanar	1. Single-side calibration is much riper 2. ISS kit for single-side calibration has been developed 3. Without path error from fixture 4. Measuring packaged product is feasible	1. Without path error from fixture 2. Reference plan do not be moved 3. Measuring packaged product is feasible. 4.Probe tips are coplanar 5.Multi-port has higher feasibility.
Disadvantage	1. De-embedding is required to remove path error 2. Multi-port measurement is not easy	1. Reference plan is moved 2. Probe tips are not coplanar 3. Multi-port measurement and calibration is hard to realize	1. Double-side calibration is not ripe enough. 2. Thru kit and line kit for double-side calibration is developing.

2. Design And Structure

In this paper, both of the novel double-sided right angle and differential thru kit are composed of single-metal-layer PCB(Printed Circuit Board). Laminated structure of thru element is shown as Fig.2.

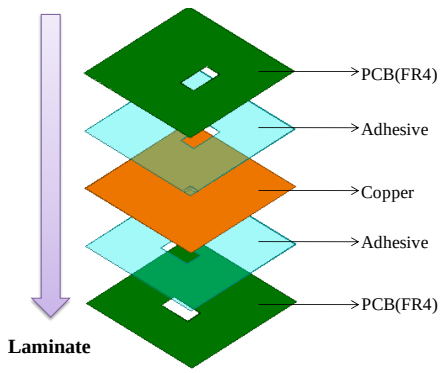


Figure.2 Laminate structure of thru element

To calibrate successfully, the impedance where probe contact is needed to be set at 50**Ω** between calibration kit and port of vector network analyzer (VNA) for impedance matching. Double-sided right angle thru kit is divided into three parts. As Figure.3 shown, the structure contains two parts and each of part is coplanar wave guide. Part A is different from part B because of the dielectric. Part A has one side with dielectric, but part B has two sides with dielectric. So part A and part B will have different impedance if their line width are the same.

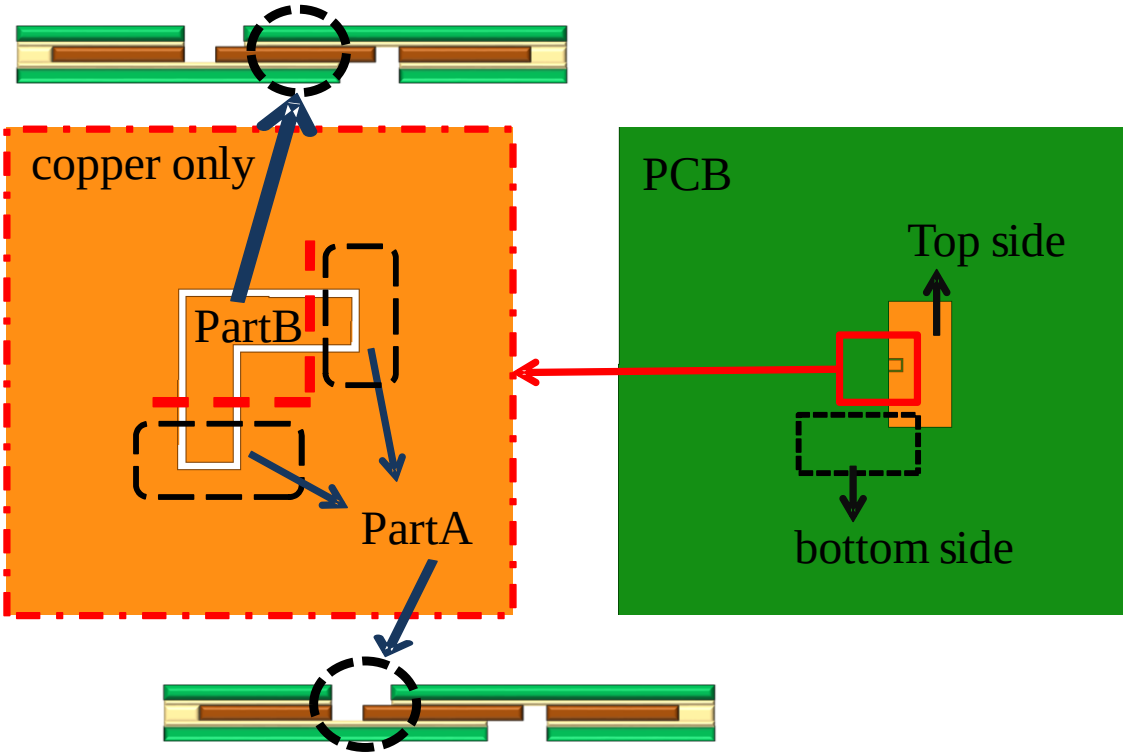


Figure.3 Top and cross-section view about novel double-sided right angle thru kit

As Fig.4 shown is double-sided right angle thru kit.

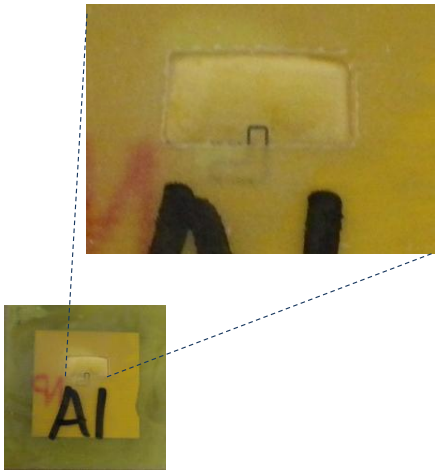
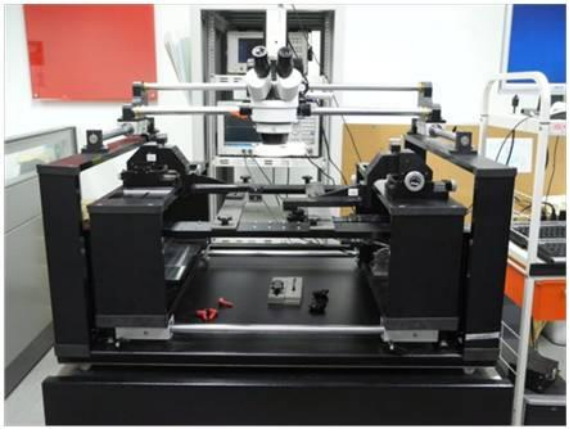


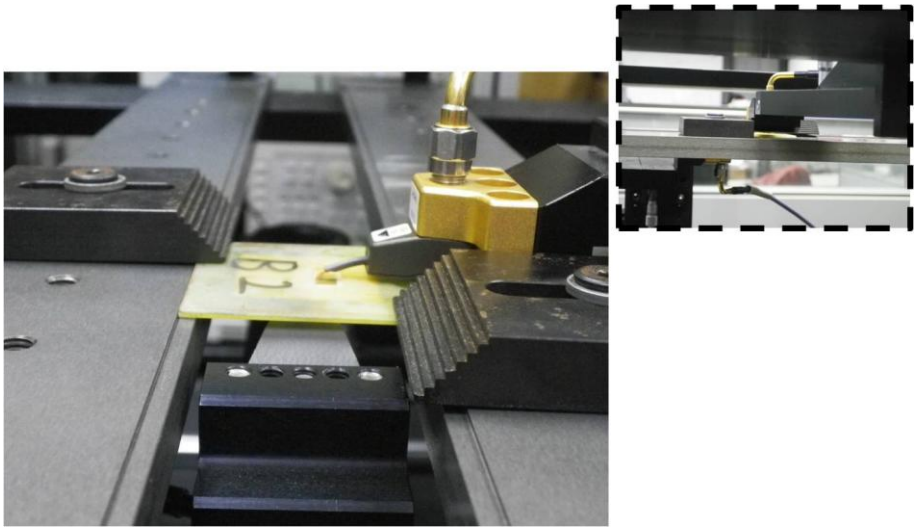
Figure.4 Double-sided right angle thru kit

3. Simulation and Measurement

In this paper, Novel double-sided right angle thru kit is simulated by HFSS, and measured by VNA Agilent E5701C to measure. And it should have a novel double-sided probe station. As Fig.5 shown, there is novel double-sided probe station and measurement situation.



(a)



(b)

Figure.5 (a) Novel double-sided probe station and (b) measurement situation

When a new kit has been made, there is some steps should be done so that can be used in calibration. First, use novel double-sided thru kit to calibrate, and let the new kit be a DUT. It will get a result, in this paper calls it Type B. Second, let Type B be standard definition. Finally, use new kit to calibrate, and let itself be a DUT. And it will get a result, in this paper calls it Type A. By comparing Type A and Type B can know that new kit is too good to be used in calibration.

An available thru kit's insertion loss should be above -0.02 dB in bandwidth. As Fig.6 shown, there are simulation and Type A and Type B results. Type A and B are above -0.02 dB in 20 GHz bandwidth.

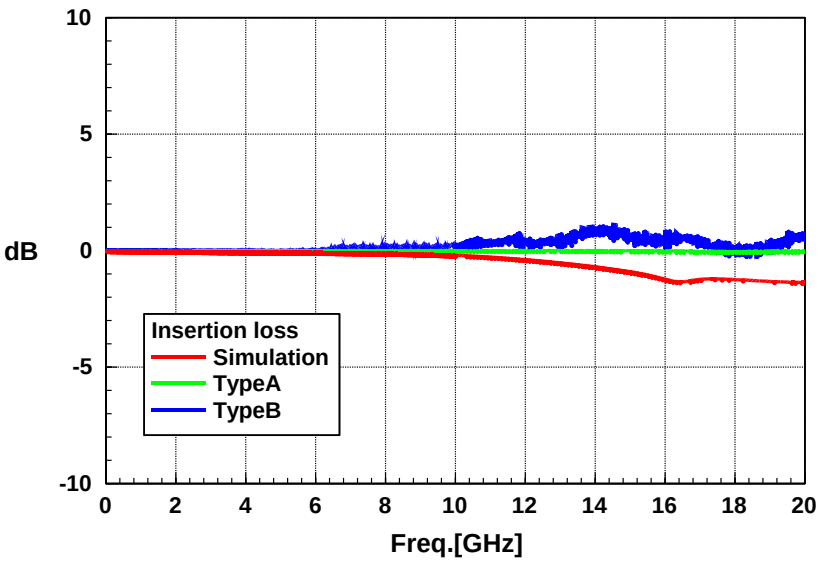


Figure.6 Insertion loss of simulated and measurement result

Phase for thru kit is shown Fig.7. The delay time is the key part of thru kit. The expression of calculating delay time is from Eq.(1).[7]\

$$\theta = \beta \ell \tag{1}$$

And

$$\beta = \frac{\omega}{v_p} \tag{2}$$

Equation of delay time by using Eq. (1) and (2) leads to the following Eq. (3).

$$Delay = \frac{\arg(S_{21}(f)) - \arg(S_{21}(0))}{2\pi f} \tag{3}$$

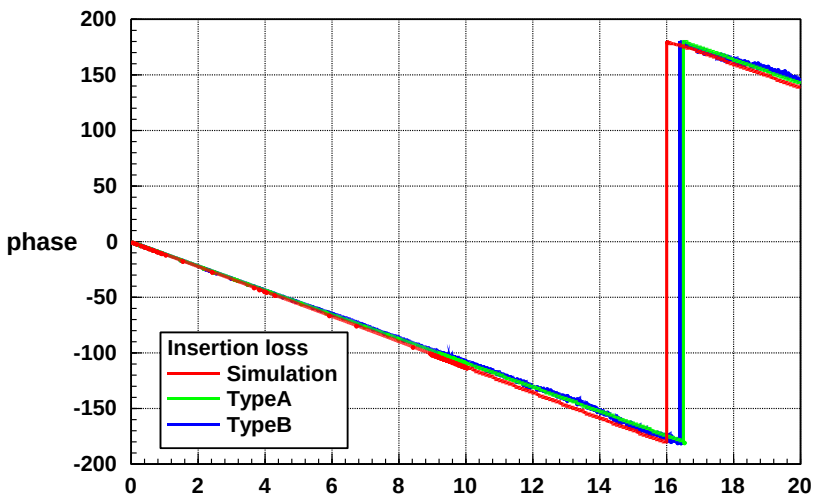


Figure.6 Phase of simulated and measurement result

4. Conclusion

From summing up information above of all, the standard definition for novel double-sided right angle thru kit with non-exchange layer structure is shown in TABLE II.

TABLE. II

Standard definition for novel double-sided thru kit with non-exchange layer structure

Type	*Delay Time(ps)*	Z_0 *(Ω)*	*Structure*	*Bandwidth*
Right angle	*30.2*	*50*	*waveguide*	*20 GHz*

In this design, novel double-sided right angle thru kit follows the existing process of PCB manufacture. For the reason, the kit can be realized. Insertion loss of the thru kit reaches -0.02 dB. In addition, right angle thru kit can use upon 20 GHz. The delay time which generated from length is 30.2 ps. With the double-sided thru kit, it makes measurement of TSV in SiP and 3DIC be more possible. The thru kit applies to GS to SG in right angle To realize the measurement between chip and package, the thru kit of design for different pitch and type of probe is the next target.

5. Reference

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