High frequency bandwidth transition for HTCC hermetic packages

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***Abstract*—This paper presents simulation and measurement of large frequency bandwidth transitions up 100GHz, we introduce two different transitions using multi-layer high temperature cofired ceramic technology for optical hermetic package applications. Measurements results for the first transition show an overall bandwidth up to 50GHz, and simulation results for the second presents 100GHz bandwidth.**

Keywords—HTCC, package, HB-CDM package, high bandwidth transition

I. INTRODUCTION (*HEADING 1*)

During the last years, as consequence of the outbreak of but not limited to mobile internet-based applications, 4k/8K streaming platforms, and virtual reality, the data traffic of communication networks has risen sharply, hence the need for long distance high-bandwidth communication networks has become a major issue for telecom market. Coherent optical networks can provide larger transmission capacity and much distance up to 100 times mor than non-coherent optical networks (thousands Km for coherent versus tens Km for non-coherent). The main difference between coherent and non-coherent optical networks is the coherent modulation on transmitter side with heterodyne detection technology on receiver side, coherent modulators are therefore vital components for such high-speed coherent communication networks. Since these coherent modulators need to be hermetically packaged, the optical internetworking forum (OIF) has introduced the specifications of high-bandwidth coherent driver modulator (HB-CDM) package [1], radio frequency (RF) performance for such telecom packages, play a key role in the packed component performance.

Most kind of hermetic packages are surface-mount device's (SMD's), use surface-mount technology (SMT) to be mounted directly on the surface of printed circuit board (PCB). SMT packages are either lead frame packages (use lead frame), or leadless packages use flex PCB (F-PCB), ball grid array (BGA) instead of lead-frame as SMT. As HB-CDM package has been classified into three classes 40, 60, and 80[1], Aside from RF bandwidth, the difference between the packaging of HB-CDM classes was the PCB mounted method. Various designs and technologies for modulators with different bandwidths up to 63GHz have been reported, for example a HB-CDM has been improved by optimize the RF ground led-frame that reduce the crosstalk and achieve the 54GHz [2], in [3] they present a 56GHz of overall electro-optic (EO) bandwidth.

Hereafter, we present high temperature co-fired ceramic HTCC package with two different mounted method, and two different radio frequency (RF) transition.

II. PACKAGE AND TRANSITION

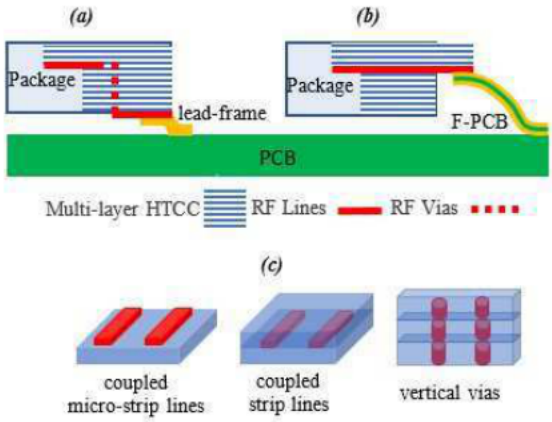

Fig.1 HTCC package. (a) lead-frame SMT (vertical transition)
(b) F-PCB SMT (straight transition)
(c) RF differential lines

Fig.1 presents standard RF HTCC package for optical telecommunication applications with two different SMT's Fig.1(a) lead frame, Fig.1(b) F-PCB, for lead frame case we need to drive the signal from the lead frame (top of package) into the package, so we use vertical vias, this transition (with vertical vias) can reach no more than 55GHz -3dB frequency bandwidth due to fabrication limits for vias diameter, ceramic sheet thickness, and lead-frame that produce impedance mismatch with HTCC package and create more losses.

To go further than 55GHz we need to overcome these parameters (lead frame, vias diameter and ceramic thickness), by reduce vias diameter below 80µm, consequently reduce ceramic thickness to be able to drill and fill these extra small vias, which is beyond actual fabrication limits.

As telecommunication network development require transmission bandwidth larger than 55GHz, package design engineers have turned to F-PCB Fig.1(b), which offer better impedance matching with HTCC package as direct result of absence of lead frame, and it doesn't need vertical vias to drive the signal into the package, where it can be brazed at the same ceramic sheet of interior RF traces, which means less changes in impedance and RF propagation modes than vertical transition for lead frame, so less losses and better transmission.

III. RESULS AND DISCUSSION

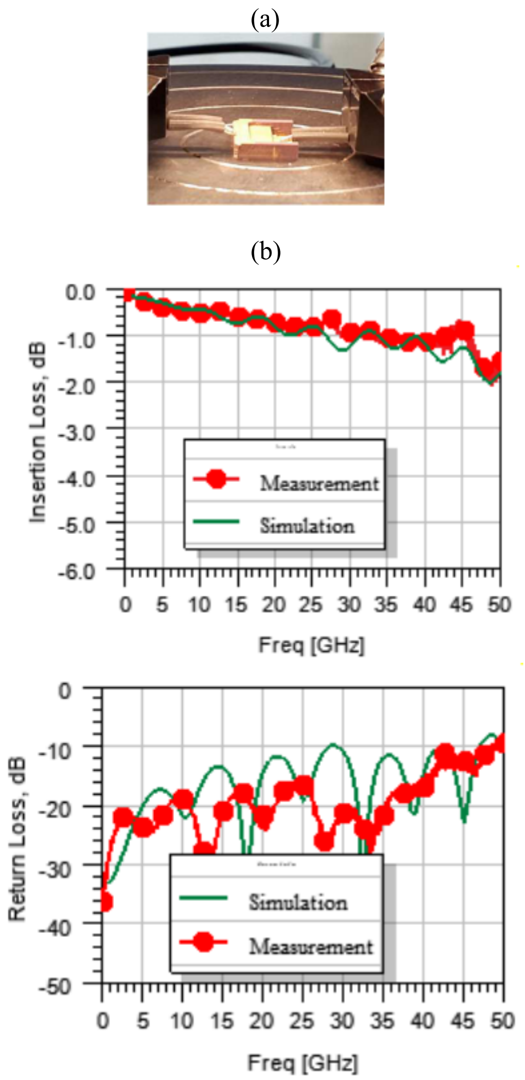

Fig.2 RF S-parameters results simulation Vs measurements for HTCC package with vertical transition befor lead frame brazing (a)measured structure (b)S-parameters results

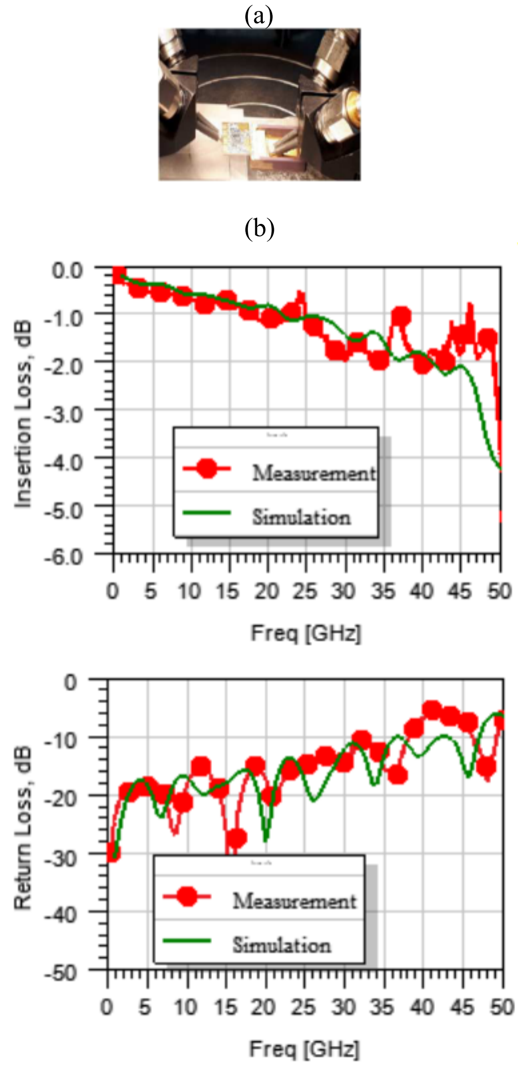

Fig.3 RF S-parameters results simulation Vs measurements for HTCC package (with vertical transition) +lead frame+PCB (a)measured structure (b)S-parameters results

Two packages for lead frame and F-PCB SMT's have been studied, Fig.2 presents s-parameters results of simulation and measurements for package with vertical transition (consist of coupled micro strip lines, coupled strip lines, and vertical vias) before brazing the lead frame, RF probes have been landed on the ceramic Fig.2(a), Fig.2(b) shows insertion and return loss results with -2dB insertion loss up to 50GHz and -10dB return loss up to 50GHz, also we can observe the accord the between simulation and measurement that confirm the simulation method.

In Fig.3 we present s-parameters results of simulation and measurements for the package with vertical transition after brazing lead frame and PCB, so RF probes have been landed on the ceramic of interior package and on the PCB that has been soldered with lead frame on the other side Fig.3(a), for this configuration we notice 1 dB degradation for insertion loss with -3dB up to 50GHzs Fig.3(b), we observe the degradation also in return loss results, as return loss > -10dB from 38GHz, this degradation explained by the mismatch impedance due to lead frame air gap with PCB and brazing.

As explained earlier, to extend the bandwidth further than 50GHz we replaced the lead frame SMT by F-PCB SMT, for F-PCB SMT the package transition consist of coupled micro strip line and coupled strip line without vertical vias, Fig.4 presents the simulated structure with s-parameters simulation results for HTCC package with F-PCB.

The HTCC package for F-PCB SMT has kept the transition principal dimensions as pitch between channels 2.4mm, but we had more flexibility on terms of RF traces dimensions of brazing zone, as we were committed to width minimum limits for package with lead frame SMT to be able to solder the lead frame. 7.6mm F-PCB length has been added with solder material to the HTCC package for simulation Fig.4(a). Fig.4(b) shows insertion loss and return loss simulation results, smooth insertion loss curve with -3dB up to 80GHz and -4dB at 100GHz, matched impedance between package and F-PCB can be clearly seen with return loss results where we are adapted around -15dB up to 100GHz.

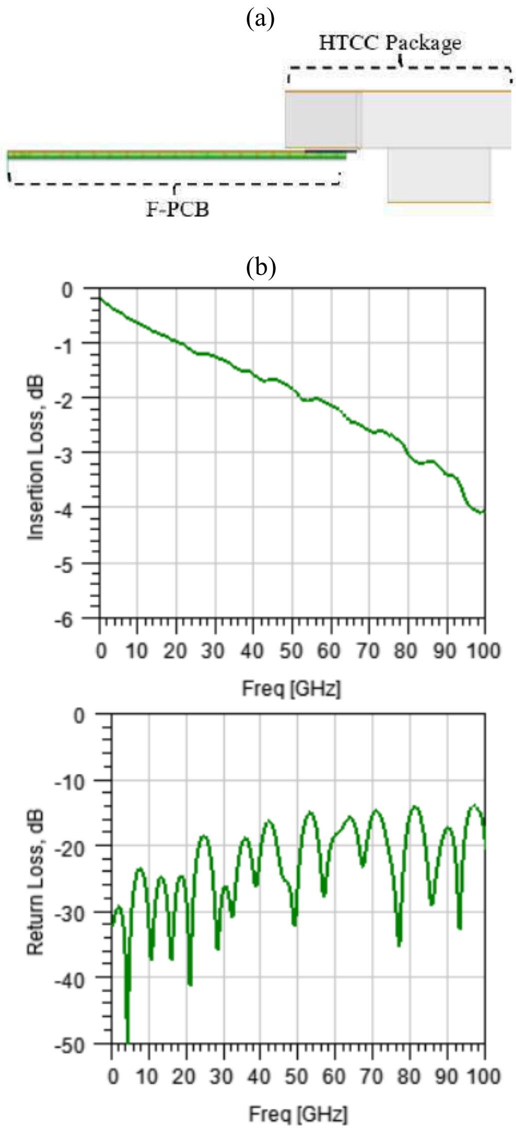

Fig.4 RF simulation results for package with F-PCB SMT. (a) simulated structure. (b) insertion and return loss results

RF bandwidth enlargement is clear between the two different mounted methods (lead frame and F-PCB), in fact using F-PCB as SMT gave us more flexibility in terms of design, the transition has no more vertical vias, and we can simulate and adapt the RF transition of package with F-PCB as one structure, using time domain reflectometry (TDR) simulation for such complicated structure with several changes in RF line modes was a good optimisation technique, as it enable us to identify the design problem by detecting mismatching impedance points along RF traces.

We are confident of our simulation methods and results for package with F-PCB mounted technology, also the accord between measurements and simulation for package with lead frame Fig.2(b) make us more confident, in the meantime we are working on developing the bandwidth beyond 100GHz, then fabrication and measurement.

IV. Conclusion

We presented and compared between two SMT methods for HTCC package (lead frame and F-PCB), 50GHZ bandwidth for lead frame, and an extended bandwidth up to 100GHz for F-PCB, these transition designs can be used for HTCC packages for optical telecom applications including the three classes of HB-CDM.

Acknowledgment

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