BGA Organic Module for 60 GHz LOS communications

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***Abstract* – In this paper, we present a 12x12x0.6mm^3 Ball Grid Array (BGA) organic module compatible with a Tx/Rx transceiver at 60 GHz, including a linearly polarized (LP) Tx antenna and a circularly polarized (CP) Rx antenna. Both antennas cover the 57-66 GHz band with a 5 dBi gain and higher than 50% total efficiency. The Rx CP antenna has an axial ratio lower than 3 dB on the same V-band. Each packaged antenna has an overall footprint of 4.8x4.8 mm^2. This BGA module is suitable for integration in WiGig certified wireless devices allowing short-range communications.**

***Index Terms* — 60 GHz, WiGig, Aperture-coupled Patch Antenna, Packaging, BGA module.**

1. Introduction

Recently, the broad and free bandwidth available around 60 GHz has been included into the WiFi/WiGig alliance (IEEE WLAN 802.11 ad amendment) in order to enable new WLAN usages like high-definition video transmission, wireless dock connections, kiosk file sharing, etc… [1]. Since these consumer applications target a large volume of devices, the pressure is on the cost of the whole communicating system including both the MilliMeter-Wave (MMW) transceiver with integrated chip (IC) and the associated antenna.

From the antenna side, the challenge concerns the development of a low-cost module with easy volume production while allowing acceptable antenna performance. For Line-Of-Sight (LOS) communications over a short distance (< 3m), the required antenna gain is at least 5 dBi. The main target specifications are summarized in Table 1. A previous Ball Grid Array (BGA) module integrating two linearly-polarized antennas in this technology already demonstrated promising performance at 60 GHz but this first attempt did not resulted in achieving 5 dBi gain over the whole 57-66 GHz [2].

In this paper, we present an enhanced version of the initial BGA organic module integrating a linearly-polarized (LP) for the transmit (Tx) path and a circularly-polarized (CP) for the receive (Rx) path, both working in the 57-66 GHz band and complying with the specifications given in Table 1. A CP antenna has been chosen for the Rx operation of the device to make the wireless link less more sensitive to possible device and antenna rotation and thus, enhance the robustness of the wireless transmission.

TABLE I
Specifications for short-range WiGig antennas

Frequency band	57-66 GHz
Reflection coefficient	< -10 dB
Polarization	Linear or Circular
Directivity	8 dBi
Minimum Gain	5 dBi
Co to cross-polar. ratio	20 dB
Radiation pattern Front-to-back ratio	15 dB

2. BGA Module Configuration

The BGA module was designed from the MMW High-density Interconnect (HDI) organic technology developed by STMicroelectronics. This technology is based on a low-cost organic build-up composed of one core and two prepreg substrates allowing more aggressive design rules than standard Printed Circuit Board (PCB) technologies. Thus, it is a good compromise for low-cost MMW applications. Moreover, the BGA modules are fabricated in strip format (Fig.1) allowing the assembly with the transceiver chip first and then PCB flip-chip integration to be entirely automated. The integration scheme of the BGA module (12×12×0.584mm^3) on the PCB is shown in Fig. 2. It can be seen that the antennas are radiating in the opposite direction of the PCB. Thus, the mutual coupling between the IC and the antenna is minimized.

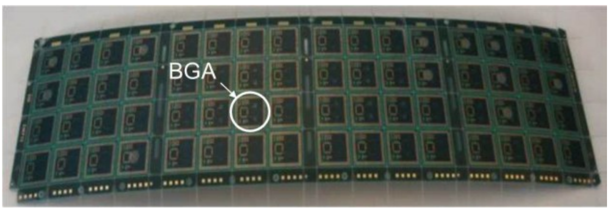

Fig. 1. Fabricated BGA modules in strip format.

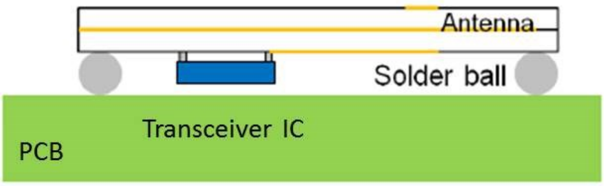

Fig. 2. Integration scheme of the BGA module on PCB.

The chosen build-up (Fig. 3) is made of four metal layers enclosing three substrates (one core and two prepregs). The metal layers can be connected together using µ-vias (in the prepreg substrate) or buried vias (in the core substrate).

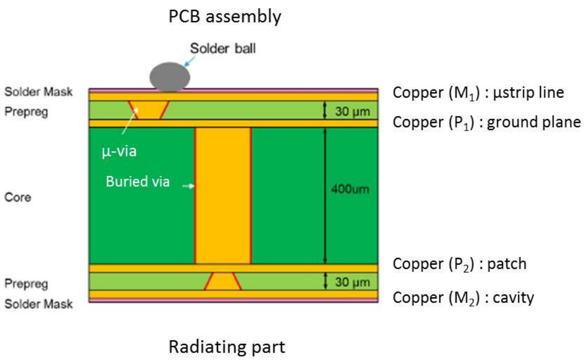

Fig. 3. Build-up HDI of the BGA module.

3. Antenna Design and Performance

Given the simplicity of the build-up (4 metal layers), the position of the signal line (M_1) and the chosen direction of radiation (opposite of the IC), we investigated an Aperture-Coupled Antenna (ACP) topology, known for quite wideband performance. We decided to use two antennas (one for Rx and one for Tx) instead of a single antenna in order to avoid a high insertion loss 60 GHz switch between the antenna and the transceiver. The module footprint with both antennas is shown in Fig. 4.

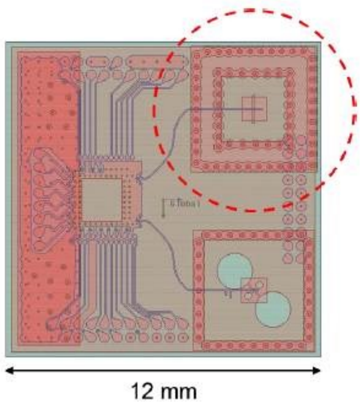

Fig. 4. BGA module footprint.

(1) Tx LP Antenna

The Tx LP antenna is circled in red in Fig. 4. The signal line is etched on M_1, the ground plane with the slot is set on P_1 and the patch on P_2. The antenna is surrounded by a metal cavity made of buried vias between P_1 and P_2 and µ-vias between P_2 and M_2. This cavity is essential as the slot excites a TM surface mode in the core substrate. The footprint of this antenna is 4.8×4.8mm^2.

The LP antenna has a reflection coefficient below -10 dB on the 57-66 GHz band. The measured co-polarization gain is higher than 5dBi from 58 to 66 GHz. This antenna respects the specifications given in Table I.

(2) Rx CP Antenna

For simplicity in the design and integration in the module, we investigated a single feed solution for the CP antenna with a targeted 3-dB axial ratio bandwidth covering the whole 57-66 GHz band. For that purpose, the slot in the ground plane is modified to excite two orthogonal modes on the patch (Fig. 4). The footprint of this antenna is 4.6×4.6mm^2.

The antenna has a reflection coefficient below -10 dB on the 57-66 GHz band. The measured axial ratio is below 3 dB from 55 to 64 GHz (Fig. 5), which is quite close to the expected performance.

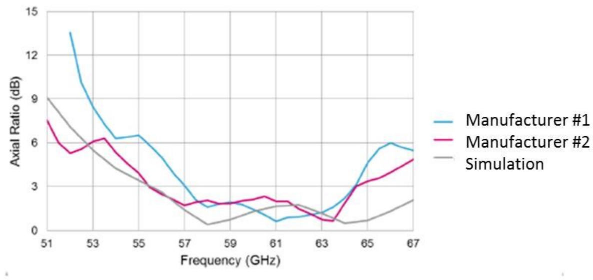

Fig. 5. Axial Ratio in the broadside direction for the Rx CP antenna.

4. Conclusion

In this paper, we presented a BGA organic module for WiGig LOS applications including two antennas, a Tx LP antenna and a Rx CP antenna. Detailed analysis of each antenna and completed measurements will be presented at the conference.

Acknowledgment

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References

[1] www.wigig.org

[2] R. Pilard, D. Titz, F. Gianesello, P. Clascibetta, J.M. Riviere, J. Lopez, R. Coffy, E. Saugier, A. Poulain, F. Ferrero, C. Luxey, P. Brachat, G. Jacquemod, D. Gloria, “HDI organic technology integrating built-in antennas dedicated to 60 GHz SiP solution”, IEEE Antennas & Propagation Soc. Int. Symp. 2012 (AP-S 2012), Chicago, USA, 2012.