

An Antenna

FIELD OF THE INVENTION

5 The present invention relates to an antenna, particularly though not solely to a directional bond wire antenna.

BACKGROUND

 In most communications system the antenna is a very important part of
10 the design. In millimeter wave (MMW) communications systems, the antenna may be very small due to the short wavelength. For such a small size antenna, high radiation efficiency and high coupling efficiency may be important considerations.

 A MMW antenna is often made on a printed circuit board (PCB) or other
15 solid substrate. Prior art PCB substrates may have a high loss factor for MMW and hence the radiation efficiency of an antenna built on this kind of substrate may be less than optimal.

 One possible improvement is to use special processing on low loss
material such as MicroElectroMechanical Systems (MEMS) processing on glass
20 (alumina). However this may involve complex processing and high cost.

 The coupler from the IC die to the substrate where the antenna is, may also cause loss. Although the antenna may be located on the IC die (on-chip antenna) to avoid some coupling loss and reduce the size, the radiation

efficiency of an on-chip antenna may very low due to the high loss tangent of the IC die.

Another approach is using a bond wire on the signal port on the IC die and design the wire's length and shape so that the bond-wire works as an antenna. Because the bond wire is over air, the loss of the IC die and PCB substrate has little effect to the antenna. Such an antenna is called bond-wire antenna (BWA).

SUMMARY OF THE INVENTION

In general terms the invention proposes a circular polarisation (CP) BWA. This may have the advantage of:

1. Low cost;
2. Simple and very easy to implement;
3. CP for better signal transceiving;
4. wide signal bandwidth;
5. strong directivity; and/or
6. The best CP direction is the same as the maximum gain direction.

CP for an antenna may be beneficial in some complex blocking and reflection environments. This is because that CP has the effect of producing greater penetration into blocking and difficult reception areas than a signal with just one plane of polarisation.

In a first particular expression of the invention there is provided an antenna as claimed in Claim 1.

In a second particular expression of the invention there is provided a method as claimed in Claim 18.

BRIEF DESCRIPTION OF THE DRAWINGS

5 One or more example embodiments of the invention will now be described, with reference to the following figures, in which:

Fig. 1 is a schematic drawing of a single-ended CP BWA (dimensions are for 60Ghz of central frequency) according to a first example embodiment;

Fig.2 is a graph of the performance of the first example embodiment;

10 Fig.3 is a schematic of a wideband single-ended CP BWA (dimensions are for 60Ghz of central frequency) according to a second example embodiment;

Fig.4 is a graph of the performance of the second example embodiment;

15 Fig.5 is a schematic of a modified J-pole BWA (dimensions are for 60GHz of central frequency) according to a third example embodiment;

Fig.6 is a photo of a prototype of the second example embodiment; and

Fig.7 is a graph of the performance of the prototype in Figure 6;

Fig.8 is a photo of a prototype of the third example embodiment; and

Fig.9 is a graph of the performance of the prototype in Figure 8.

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DETAILED DESCRIPTION

The basic structure of a CP BWA 100 is shown in Figure 1 according to the first example embodiment. The CP BWA 100 is a single-ended feeding antenna, including a L-shape antenna 102 with slightly differential lengths for each arm bond-wire 104, 106 (each arm bond-wire is about half wavelength) and a pair of quarter-wavelength bond-wires 108, 110 working as a balun. One arm of the L-shape antenna 104 is bonded at signal pad 112 in IC die 114, the other arm 108 is bonded at one of two ground pads 116. The IC die 114 is bonded to a PCT substrate 117. To make the radiation more uniformly, the two quarter wavelength wires 108, 110 are bonded to two ground pads 116, 118 around the signal pad 112 on IC die 114. This may assist in forcing the current at the ground around the signal pad 112 on IC die 114 to zero. The other ends of each wire are bonded to pads 120, 122, 124 and 126 on the substrate 117.

The arm bond-wire 104 is slightly over half a wavelength, and the arm bond-wire 106 is slightly below half a wavelength 106. The arm bond-wires 104, 106 may be spread at an angle of between 30 to 120 degrees. The quarter wavelength wires 108, 110 may be spread at a wider angle. Each of the bond wires is oriented in generally a straight line.

Figure 2 shows the performance of the CP BWA 100. As seen in Figure 2a, this CP BWA 100 has about 10GHz of S11 ($S_{11} < -10\text{dB}$) bandwidth 200. In Figure 2d its axial ratio bandwidth (axial ratio $< 3\text{dB}$) 202 is about 4.5GHz. In Figure 2b the maximum gain direction 204 is not the same as the best CP direction 206 (smallest axial ratio direction). The maximum gain direction is generally aligned with the arm 104 bonded to the signal pad 112.

Figure 3 shows a modified CP BWA structure 300, in which another wire 302 is added between two arms 302, 304 of the L-shape antenna according to the second example embodiment. The additional wire 301 is bonded at a signal pad 312 on the IC die 314.

5 This wire 301 may provide additional current flow to generate more resonant frequency points for enlarging the impedance matching bandwidth and also the CP bandwidth. Further wires may also be added to further improve antenna impedance matching and CP bandwidth. By control the length and direction of this additional wire 301, the bandwidth, the axial ratio of CP and the
10 direction can be adjusted.

The wire 301 may be located at angle to arm 302 to adjust the circular polarisation direction and/or the bandwidth. Typically the wire 301 is slightly longer than half a wavelength but shorter than the arm 302. The end of the arm 302 bonded to pad 312 is also raised 100 μm with respect to the wire 301.

15 Figure 4 shows the performance of this CP BWA 300. By adding this wire 301, the S11 signal bandwidth 400 is much wider. It is increased to >15GHz. The axial ratio bandwidth 402 is also increased to >15GHz. And its best axial ratio direction 404 matches the maximum gain direction 406

Figure 5 discloses another BWA 500 for the single-ended feeding case
20 according to the third example embodiment. Although it is not a CP antenna, it has simpler structure and good radiation performance. The two side bond wires 502, 504 have quarter wavelength connected to ground 506 in IC die 508 and

the central wire 510 having three quarters wavelength is bonded to the signal in IC die. It is modified structure from J-pole antenna.

The wideband CP BWA and modified J-pole antenna has been fabricated and tested. They have satisfied performance. Figure 6 shows a prototype wideband CP BWA 600 according to the second example embodiment. Figure 7 shows the performance 700 of the prototype 600 in Figure 6. Figure 8 shows a prototype modified J-pole antenna 800 according to the third example embodiment. Figure 9 shows the performance 900 of the prototype 800 in Figure 8.

According to the application it may be desirable to encapsulate the bond wires in mould resin. In this case the wavelength will be shorter according to the dielectric constant, and thus the wires will be correspondingly shorter.

While example embodiments of the invention have been described in detail, many variations are possible within the scope of the invention as will be clear to a skilled reader.

CLAIMS:

1. An antenna comprising:
a single end fed first wire including a first end attached to a signal pad on
5 an integrated circuit located on a substrate, and a second end attached to a first
pad on the substrate, the first wire being slightly longer than half a wavelength
at a central signal frequency.
2. An antenna as claimed in claim 1 further comprising a balun adjacent to
10 the first wire.
3. The antenna as claimed in claim 1 or 2 further comprising a second wire
including a first end attached to a ground pad on the integrated circuit and a
second end attached to a second pad on the substrate.
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4. The antenna as claimed in claim 3 further comprising a third wire
including a first end attached to the signal pad and a second end attached to a
third pad on the substrate.
- 20 5. The antenna as claimed in any one of claims 1 to 4 wherein the wire is a
bond-wire.

6. The antenna as claimed in claim 5 wherein the antenna is a bond-wire antenna (BWA).

7. The antenna as claimed in claim 3 or 4 wherein the first wire and the
5 second wire form a L-shape antenna, providing an angle of approximately 90 degrees therebetween.

8. The antenna as claimed in claim 7 wherein the second wire is slightly shorter than half a wavelength at the central signal frequency.

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9. The antenna as claimed in claim 4 wherein the third wire is slightly shorter than the wavelength at the central signal frequency.

10. The antenna as claimed in claim 9 when dependant on claim 4 wherein
15 the third wire approximately bisects the angle.

11. The antenna as claimed in claim 2 wherein the balun comprises a pair of wires, each of the pair of about a quarter-wavelength in length at the central signal frequency, each of the pair of wires being attached to a ground pad on
20 the integrated circuit and a pad on the substrate respectively.

12. The antenna as claimed in claim 11 wherein the pair of wires provide an angle of approximately 135 degrees therebetween.

13. The antenna as claimed in claims 1 to 12 wherein a direction of best gain is substantially similar to a direction of best circular polarisation.
- 5 14. The antenna as claimed in claim 1 wherein the first wire is a modified J-pole BWA antenna.
15. The antenna as claimed in claim 14 further comprising a balun adjacent to the first wire.
- 10 16. The antenna as claimed in claim 15 wherein the balun comprising a pair of wires, each of the pair of wires about a quarter-wavelength in length at the central signal frequency, each of the pair of wires attached to a ground pad on the integrated circuit and a pad on the substrate respectively.
- 15 17. The antenna as claimed in claim 16 wherein the pair of wires are parallel and spaced from the first wire.
18. A method of manufacturing an antenna comprising:
- 20 providing an integrated circuit on a substrate,
providing a bond-wire slightly longer than half a wavelength at a central signal frequency.

attaching a first end of the bond-wire to a signal pad on the integrated circuit, and

attaching a second end of the bond-wire to a pad on the substrate.