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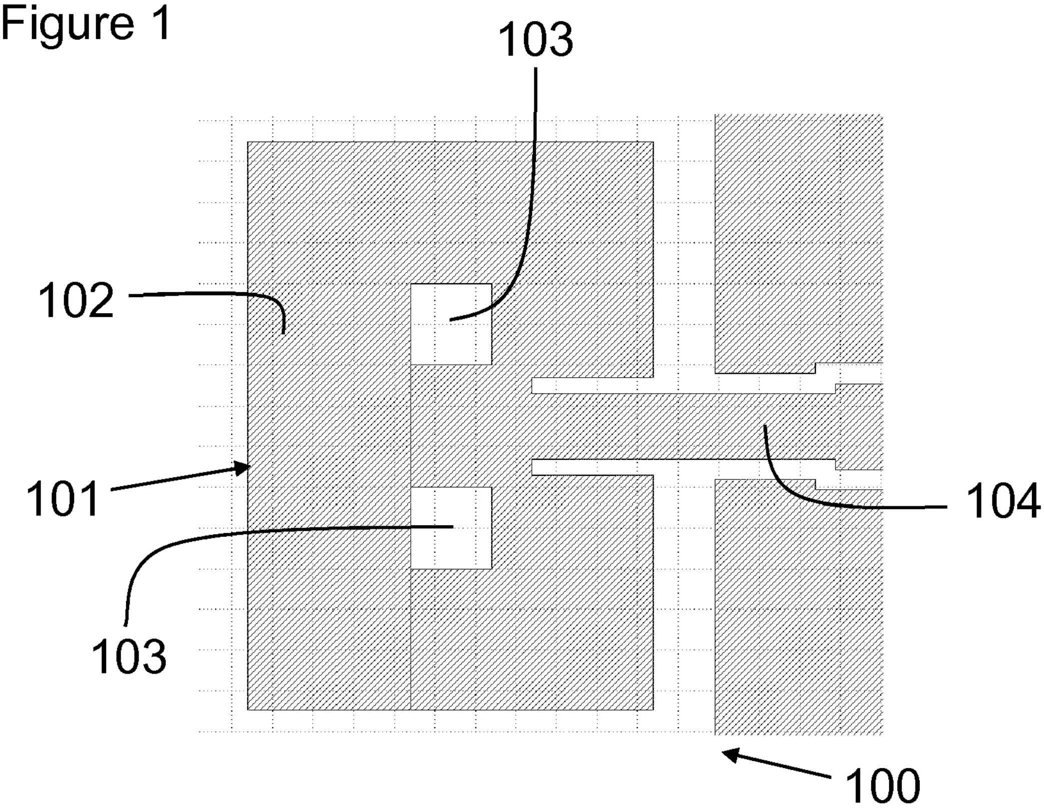
(54) AN INTEGRATED CIRCUIT PACKAGE AND METHOD OF MAKING THEREOF

(57) An integrated circuit package having an antenna therein, the antenna comprising a substantially laminar antenna section having a first major side and a second major side, the first major side opposite to the second major side, wherein the substantially laminar antenna section comprises at least one aperture extending from the first major side to the second major side.

Figure 1



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Description

[0001] The present disclosure relates to an integrated circuit package and a method of making thereof. In particular, the present disclosure relates to an integrated circuit package having an antenna-in-package and a method of making thereof.

[0002] According to a first aspect of the present disclosure there is provided an integrated circuit package having an antenna therein, the antenna comprising a substantially laminar antenna section having a first major side and a second major side, the first major side opposite to the second major side, wherein the substantially laminar antenna section comprises an aperture extending from the first major side to the second major side.

[0003] In one or more embodiments, the cross-sectional shape of the aperture may comprise one or more of: a circle, a square, a rectangle, a hexagon, a polygon or another shape. In one or more embodiments, the aperture may be a circle with a diameter greater than or less than or between any two of 100, 150, 200, 250 or 300 μm. In one or more embodiments, the apertures may be substantially rectangular with at least one or both of a width and length of greater than or less than or between any two of 100, 150, 200, 250 or 300 μm.

[0004] In one or more embodiments, the substantially laminar antenna section may be substantially rectangular.

[0005] In one or more embodiments, the area of the aperture or total area of a plurality of apertures comprises up to 20%, 25%, 30%, 35% or 40% of a total area of the antenna.

[0006] In one or more embodiments, the antenna may comprise a conductive material. In one or more embodiments, the substantially laminar antenna section may comprise a substantially laminar metal section. In one or more embodiments, the antenna may comprise a conductive non-metallic material.

[0007] In one or more embodiments, the integrated circuit package may comprise an outer encapsulation layer that encapsulates at least the substantially laminar antenna section.

[0008] In one or more embodiments, the aperture may be arranged in the antenna section at a position of low current density relative to a current density profile of the antenna, the current density profile defining current density as a function of position over the substantially laminar antenna section when in use. In one or more embodiments, the position of low current density comprises a position having less than the mean or median average current density. In one or more embodiments, the position of low current density comprises a current density less than 75%, 50% or 25% of the average current density.

[0009] In one or more embodiments, the aperture may be located substantially at the centre of the antenna section.

[0010] In one or more embodiments, the antenna section may include a plurality of apertures. In one or more embodiments, each of the apertures of the plurality of apertures may be arranged in the substantially laminar antenna section spaced apart and substantially at the centre of the substantially laminar antenna section or at areas of low current density relative to a current distribution profile of the antenna.

[0011] In one or more embodiments, one or both of the first major side and the second major side may be at least partially covered by a dielectric material.

[0012] In one or more embodiments, the dielectric material may extend through the aperture or at least one of the plurality of apertures.

[0013] In one or more embodiments, the substantially laminar antenna section may comprise a patch antenna. In one or more embodiments, the substantially laminar antenna section may be a single-ended feed patch antenna or a differential feed patch antenna.

[0014] In one or more embodiments, the integrated circuit package includes a substrate having an integrated circuit formed therein and the antenna section is formed in a redistribution layer of said integrated circuit.

[0015] In one or more embodiments, the substantially laminar antenna section may comprise a width of greater than 400 μm or between 300 and 500 μm and a length of greater than 400 μm or between 300 and 500 μm. In one or more embodiments, the patch antenna may be sized suitably to couple to electromagnetic waves with frequencies between 60 - 90 GHz. In one or more embodiments, the patch antenna may be sized suitably to couple to electromagnetic waves with frequencies of substantially 77 GHz.

[0016] In one or more embodiments, the antenna may comprise a feed section configured to provide current to a main section, the main section configured to provide for emission of electromagnetic waves, the substantially laminar antenna section comprising the main section.

[0017] In one or more embodiment, the integrated circuit package may further comprise a reflector spaced from the antenna section configured to reflect electromagnetic waves emitted from the antenna section.

[0018] In one or more examples, the antenna section is formed in a redistribution layer. In one or more embodiments, the redistribution layer includes an arrangement of metal traces in the integrated circuit package that provide for routing of electrical connections over an active area or a region comprising an integrated circuit and which also provides the antenna section. In one or more examples, the redistribution layer provides for placement of solder bump pads over an active area of the integrated circuit region. In one or more examples, the redistribution layer and therefore the antenna section is provided on top of a passivation layer of an integrated circuit region of the integrated circuit package, the integrated circuit region comprising a region comprising one or more integrated circuits. In one or more examples, the passivation layer is typically of Silicon Oxide and/or Silicon Nitride. In one or more examples, the redistribution layer comprises a layer of metal, such as copper, traces and dielectric, such as an organic dielectric.

[0019] In one or more examples, the integrated circuit package includes a ground layer comprising a layer of metallization within the package arranged adjacent the antenna section and spaced therefrom, the ground layer having an electrical connection for connection to a reference voltage, such as ground, the ground layer configured to act as a reflector for reflecting electromagnetic waves emitted from the antenna section back towards the antenna section.

[0020] In one or more examples, the integrated circuit package is provided as an assembly with a printed circuit board (PCB), the integrated circuit package mounted to the PCB, and wherein the ground layer is arranged on the same side of the antenna section as the PCB, the assembly thereby configured to provide for emission of electromagnetic waves predominately away from said PCB.

[0021] In one or more examples, the integrated circuit package is provided as an assembly with a printed circuit board (PCB), the integrated circuit package mounted to the PCB, and wherein the PCB includes a hole aligned with the antenna section, the hole at least partially lined with a conductive material, the ground layer arranged on an opposite side of the antenna section to the hole, the assembly thereby configured to provide for emission of electromagnetic waves predominately through said hole in said PCB.

[0022] In one or more embodiments, the integrated circuit package may comprise a redistributed chip package (RCP).

[0023] According to a second aspect of the present disclosure, there is provided an electronic device comprising a receiver and/or transmitter connected to or comprising the integrated circuit package of the first aspect.

[0024] In one or more embodiments, the electronic device may comprise one or more of a mobile phone, a detection and ranging apparatus, an automated vehicle, a tablet computer or a wireless headphone device.

[0025] According to a third aspect of the present disclosure, there is provided a method of manufacturing the integrated circuit package of the first aspect comprising forming an antenna comprising a substantially laminar antenna section, wherein the antenna section comprises a first major side and a second major side, the first major side opposite to the second major side and wherein the substantially laminar antenna section comprises an aperture extending from the first major side to the second major side, and packaging at least the antenna to form the integrated circuit package having the antenna therein.

[0026] In one or more embodiments, the method of the third aspect of the disclosure may include the step of providing a layer of dielectric material, forming an antenna section as a layer in the dielectric material such that one of the first major side or the second major side of the antenna section is at least partially covered by the dielectric material, and providing a further dielectric material over the other of the first and second major side of the antenna section.

[0027] In one or more examples, the at least one aperture provides for degassing of a region between the substantially laminar antenna section and the dielectric material at least during manufacture. In one or more embodiments, the substantially laminar antenna section is formed in the integrated circuit package with the at least one aperture pre-formed therein.

[0028] While the disclosure is amenable to various modifications and alternative forms, specifics thereof have been shown by way of example in the drawings and will be described in detail.

[0029] It should be understood, however, that other embodiments, beyond the particular embodiments described, are possible as well. All modifications, equivalents, and alternative embodiments falling within the spirit and scope of the appended claims are covered as well.

[0030] The above discussion is not intended to represent every example embodiment or every implementation within the scope of the current or future Claim sets. The figures and Detailed Description that follow also exemplify various example embodiments. Various example embodiments may be more completely understood in consideration of the following Detailed Description in connection with the accompanying Drawings.

[0031] One or more embodiments will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 shows an example embodiment of a single-ended feed patch antenna;

Figure 2 shows an example embodiment of a differential feed patch antenna;

Figure 3 shows an example embodiment of the cross section of an integrated circuit package having a single-ended feed patch antenna therein, the package mounted on a PCB;

Figure 4 shows a second example embodiment of an integrated circuit package having an antenna therein, the package mounted on a PCB;

Figure 5 shows an example electronic device comprising an integrated circuit package; and

Figure 6 shows an example embodiment of a method of manufacturing an integrated circuit package.

[0032] Antennas are a common feature of many electronic devices to allow for the transmission and/or reception of electromagnetic waves between electronic devices, thereby allowing for information to be passed between. Antennas are used in fields of technology as diverse as telecommunications, autonomous vehicles ranging and detection systems, wireless headphone technology and more besides.

[0033] Antennas may be integrated into integrated circuit packages, referred to as antenna-in-package in the art. Antenna-in-package solutions are becoming more and more attractive for millimetre wave applications, such as mobile phone transceivers and automotive radar systems. Improving the mechanical performance of these antenna-in-package solutions is a key step towards enhancing the operation and reliability of these devices. The antenna may comprise a conductor, such as a metal layer on a substrate within the package. In some examples, where the size of the antenna exceeds particular dimensions, such as a particular area, it has been found that delamination or partial delamination of the antenna from the substrate may occur during manufacture. Delamination can lead to mechanical faults or imperfections which negatively impact the operation or performance of the antenna. Without wishing to be bound by theory, it is suspected that delamination may be at least partially a result of trapped gasses, such as air, under the antenna during manufacture. In addition, designers may need to satisfy particular matter (e.g. copper) density requirements. It has been found that the incorporation of apertures in the antenna may allow the gasses to escape during manufacture and thereby reduces delamination of the antenna. While the use of apertures may have advantages, care must be taken in order to minimise reductions to the coupling efficiency of the device.

[0034] Figure 1 shows a plan view of an example antenna 100, for incorporation within a package (not shown), comprising a substantially laminar antenna section 101 having a first major side 102, and a second major side (opposite side to the first major side) connected by an edge. In this example, the antenna 100 is a patch antenna and, specifically, a single-ended feed patch antenna. The first major side 102 is opposite the second major side and, in this example, the substantially laminar antenna section 101 comprises two apertures 103 with square cross-sections. In other embodiments, the substantially laminar antenna section may only comprise a single aperture. Figure 1 also shows a feed section or transmission line 104 which is configured to be capacitively coupled to another portion of the integrated circuit package. The transmission line 104, in this example, is configured to provide current to the antenna section 101. Thus, in other words, the antenna section 101 comprises a substantially flat layer having two faces comprising the first and second major sides 101, 102 (and an edge therebetween) with the aperture(s) 103 extending through the layer between the faces.

[0035] Figure 2 shows a plan view of an example antenna 200 comprising a substantially laminar antenna section 201 having a first major side 202, and a second major side (opposite side to the first major side) and comprising a first antenna section 205 and a second antenna section 206. In this example, the antenna 200 is a patch antenna and, specifically, a differential feed patch antenna. The first major side 202 is opposite the second major side. In this example, the first antenna section 205 comprises a transmission line 204 which is configured to be capacitively coupled to another portion of the integrated circuit package. The first antenna section 205 comprises four apertures 203 with circular cross-sections and the second antenna section 206 comprises two apertures 203 with circular cross-sections. In other embodiments, the substantially laminar antenna section 201 may comprise one or more apertures 203 only in one of the first antenna section 205 or the second antenna section 206. The first substantially laminar antenna section 205 and the second substantially laminar antenna section 206 may have different shapes, as shown in the example of figure 2. Alternatively, the shape of the substantially laminar antenna sections 205, 206 may be the same.

[0036] In the examples of both of figure 1 and figure 2, the first major side 102, 202 and the second major side of the substantially laminar antenna section 101, 201 comprise those sides with the largest surface areas. Antennas 100, 200 which are designed for millimetre wave operation tend to comprise a laminar shape. In this instance, the antennas 100, 200 of the examples are substantially laminar, meaning that they each comprise a substantially flat layer. The layers may be configured in terms of their dimensions and/or shape such that it is capable of coupling to the desired frequency of electromagnetic waves in order to either receive waves or to emit waves of such a frequency.

[0037] In some examples the substantially laminar antenna section 101, 201 comprises a layer of conductive material. The conductive material may be, for example, a metallic material such as silver, copper, annealed copper, gold or others. Alternatively, the substantially laminar antenna section 101, 201 may be a non-metallic conductive material such as one or more layers of graphene. The dimensions above which delamination of a substantially laminar antenna section 101, 201 occurs may be dependent on the material used to form the antenna 100, 200.

[0038] The apertures 103,203 may be incorporated into the substantially laminar antenna section 101, 201 at positions, sizes and with cross-sectional shapes which reduce the possible impact on the performance of the antenna. In the example of figure 1, the cross-sections of the apertures 103 are squares, however, it will be appreciated that any shape may be used and that different shapes may be particularly advantageous depending on the overall shape of the substantially laminar antenna section 101, 201. The size, shape and position of the apertures 103, 203 may be determined by modelling the current density of a substantially laminar antenna section 101, 201 into which apertures 103, 203 are to be incorporated. The current density may be modelled, based on receipt of a desired frequency of electromagnetic wave, as a function of position over the area/volume of the substantially laminar antenna section 101, 201. From the resultant current density profile obtained from modelling the substantially laminar antenna section 101, 201, a desirable or optimum number of apertures 103, 203 and their positions, shapes and sizes may be determined. The position of the one or more apertures may be chosen to be those positions with the lowest current densities during the receipt of the desired frequency of electromagnetic wave. By selecting the areas with the lowest current densities any impact on the coupling of the antenna 100, 200 to the electromagnetic waves may be reduced. The areas of low current density may be determined by calculating or measuring the current density profile of the substantially laminar antenna section and subsequently determining one or both of the mean current density across the substantially laminar antenna patch or the median average current density. An area may be considered to have a low current density at positions where the current density is less than average current density or where the current density is less than 75%, 50% or 25% of the average current density.

[0039] Many antenna materials have low skin depths, meaning that any current which flows therethrough flows close to the surface of the material when excited by radio frequency electromagnetic waves. For example, the skin depth of copper at 2.4 GHz is about one micrometre. As a result of this, the apertures 103,203 may be placed away from the edges of the substantially laminar antenna section 101, 201, such as shown in the examples of figures 1 and 2. This position may be substantially at or towards the centre of the antenna section. In some examples, it may not be necessary to generate a current density profile of an antenna 100, 200, but instead, it may be possible to determine the positions furthest from the edges of the substantially laminar antenna sections 101, 201 and choose these locations for the apertures 103, 203.

[0040] The antenna 100, 200 may comprise suitable dimensions (length and width) in order to couple to electromagnetic waves with frequencies between 60 - 90 GHz. Preferably, the antenna 100, 200 is sized in order to couple with electromagnetic waves with a frequency of substantially 77 GHz. In general, the substantially laminar antenna section 101, 201 of the patch antenna may comprise a width of between 300 and 1000 and a length of between 300 and 1000 μm. For example, the substantially laminar antenna section 201, 201 may comprise a width of 400 μm and a length of 400 μm. In other examples, the substantially laminar antenna section may comprise a width of 1 mm and a length of 1 mm.

[0041] Figure 3 shows a cross section of an integrated circuit package 300 comprising the substantially laminar antenna section 301 having a first major surface 302 and a second major surface 307 and an aperture 303 (the position marked by dashed lines) therein. In one or more embodiments, a dielectric material 308 covers both the first major side 302 and the second major side 307 of the substantially laminar antenna section 301.

[0042] It will be appreciated that in some embodiments, the dielectric material 308 may only extend over one side of the substantially laminar antenna section 301 or the antenna may be otherwise mounted in the integrated circuit package 300. Alternatively, the dielectric material 308 may not extend over the entirety of one or both sides of the substantially laminar antenna section 301. In this embodiment, the dielectric material 308 extends through the aperture 303, however, it will be appreciated that the dielectric material 308 may not extend through the aperture 303, or it may not fill the aperture 303 entirely.

[0043] The package 300 may be connected to a printed circuit board 312 by way of one or more solder balls 309 and associated contact pads 310. The solder balls 309 may provide for capacitive communication between the printed circuit board 312 and the substantially laminar antenna section 301.

[0044] The dielectric material 308 may be formed on a substrate 314. The substrate 314, in this example, includes a monolithic microwave integrated circuit (MMIC) 314 formed therein. It will be appreciated that the substrate may be considered more generally as having any sort of integrated circuit formed therein. The MMIC 314 may comprise an integrated circuit which may perform operations such as signal mixing, power amplification, low-noise amplification and high frequency switching. The MMIC 314 may provide for the provision of signalling to the antenna for emission or receipt of signals from the antenna or perform a specific function in order to improve the performance of the antenna.

[0045] The integrated circuit package 300 may include a redistribution layer 313. The redistribution layer may comprise a layer of metallization on the substrate 314 to provide for redistribution or repositioning of input/output pads of an integrated circuit, such as MMIC 314 (or more generally any integrated circuit formed in a substrate 314) within the package for connection to external circuitry. In this example, the antenna section 301 is formed in the redistribution layer, i.e. in the same plane and therefore, potentially, in the same manufacturing step. The antenna section may thus comprise a layer of metallization in said redistribution layer 313 of said integrated circuit of the substrate 314.

[0046] The integrated circuit package 300 includes a ground layer 311 comprising a layer of metallization within the package 300 arranged adjacent the antenna section 301 and spaced therefrom. The ground layer 311 is configured to be connected to a reference voltage, such as ground. The ground layer 311 may act as a reflector for reflecting electromagnetic waves emitted from the first major side 302 (upwards in the figure) back towards the antenna section 301.

[0047] In one or more examples, the integrated circuit package 300 and printed circuit board (PCB) 312 form an assembly. The PCB 312 in this example includes a hole 315 aligned with the antenna section 301. The hole may be at least partially or wholly lined with a conductive material such as a metal 316. Accordingly, the lined hole 315 may act as a waveguide. The ground layer 311 is arranged on an opposite side of the antenna section 301 to the hole 315 and thus the assembly is configured to provide for emission of electromagnetic waves 317 predominately through said hole 315 in said PCB 312. The ground layer 311 acts to reflect electromagnetic waves emitted from the first major side 301 back and through the hole 315.

[0048] Figure 4 shows a second example embodiment similar to that shown in figure 3. The same reference numerals have been used. In this example the package 300 is arranged the other way up and connects to the PCB 312 by connections on the substrate 314 rather than via the redistribution layer 313. Further, no hole 315 is provided in the PCB 312. In this example, the ground layer 311 is arranged on the same side of the antenna section 301 as the PCB 312. Accordingly, the assembly is thereby configured to provide for emission of electromagnetic waves 317 predominately away from said PCB as shown in the figure. The ground layer 311 acts to reflect electromagnetic waves emitted from the second major side 307 back and in the direction 317.

[0049] Figure 5 shows an electronic device 501 comprising the integrated circuit package 500 similar to package 300 of figures 3 and 4. The electronic device 501 may be any device which requires an antenna. For example, the electronic device 501 may be a mobile phone, a detection and ranging apparatus, an automated vehicle, a tablet computer or a wireless headphone device.

[0050] Figure 6 shows the steps for an example method of manufacturing the integrated circuit package of figures 3 or 4. Figure 6 shows the step 502 of forming a substantially laminar antenna section, wherein the antenna section comprises a first major side and a second major side, the first major side opposite to the second major side and wherein the substantially laminar antenna section comprises an aperture extending from the first major side to the second major side, packaging at least the antenna to form the integrated circuit package.

[0051] The method includes the optional step of applying 501 a first layer of dielectric material, the forming step 502, and applying 503 a second layer of dielectric material to the substantially laminar antenna section. The first layer of dielectric material may be applied to a semiconductor substrate. The first layer of dielectric material may comprise a passivation layer of an integrated circuit, such as MMIC 314. The forming step 502 may comprise applying the antenna section to the surface of the first layer dielectric material or a substrate. The apertures may be formed into the substantially laminar antenna section before or as it is formed on the first layer of dielectric material. Alternatively, the apertures may be cut into the substantially laminar antenna section after the antenna has been applied to the first dielectric material.

[0052] Thus, in one or more embodiments, the method may further include the step of providing a first layer of dielectric material, forming the antenna section on said first layer of dielectric material such that one of the first major side or the second major side of the antenna section is at least partially covered by the dielectric material, and providing a second layer of dielectric material over the other of the first and second major side of the antenna section.

[0053] The instructions and/or flowchart steps in the above figures can be executed in any order, unless a specific order is explicitly stated. Also, those skilled in the art will recognize that while one example set of instructions/method has been discussed, the material in this specification can be combined in a variety of ways to yield other examples as well, and are to be understood within a context provided by this detailed description.

[0054] In one example, one or more instructions or steps discussed herein are automated. The terms automated or automatically (and like variations thereof) mean controlled operation of an apparatus, system, and/or process using computers and/or mechanical/electrical devices without the necessity of human intervention, observation, effort and/or decision.

[0055] It will be appreciated that any components said to be coupled may be coupled or connected either directly or indirectly. In the case of indirect coupling, additional components may be located between the two components that are said to be coupled.

[0056] In this specification, example embodiments have been presented in terms of a selected set of details. However, a person of ordinary skill in the art would understand that many other example embodiments may be practiced which include a different selected set of these details. It is intended that the following claims cover all possible example embodiments.

Claims

1. An integrated circuit package having an antenna therein, the antenna comprising a substantially laminar antenna section having a first major side and a second major side, the first major side opposite to the second major side, wherein the substantially laminar antenna section comprises at least one aperture extending from the first major side to the second major side.

2. The integrated circuit package of claim 1, wherein the substantially laminar antenna section comprises a substantially laminar metal section.

3. The integrated circuit package of any preceding claim, wherein the aperture is located substantially at the centre of the substantially laminar antenna section.

4. The integrated circuit package of any preceding claim, wherein the antenna section includes a plurality of apertures.

5. The integrated circuit package of any preceding claim, wherein one or more of the first major side and the second major side is at least partially covered by a dielectric material.

6. The integrated circuit package of any preceding claim, wherein a dielectric material extends through

the aperture or at least one of a plurality of apertures.

7. The integrated circuit package of any preceding claim, wherein the integrated circuit package includes a substrate having an integrated circuit formed therein and the antenna section is formed in a redistribution layer of said integrated circuit.

8. The integrated circuit package of claim 7, wherein the substantially laminar antenna section is one of:

   i) a single-ended feed patch antenna; and
   ii) a differential feed patch antenna.

9. The integrated circuit package of any preceding claim, wherein the antenna comprises a feed section configured to connect the substantially laminar antenna section to further circuitry for providing current to the substantially laminar antenna section for the emission of electromagnetic waves.

10. The integrated circuit package of claim 9, wherein the feed section is narrower in width than a width of the substantially laminar antenna section

11. The integrated circuit package of any preceding claim further comprising a reflector spaced from the antenna section configured to reflect electromagnetic waves generated by the substantially laminar antenna section.

12. An electronic device comprising a receiver and/or a transmitter connected to or comprising the integrated circuit package of any of claims 1 - 11.

13. The electronic device of claim 12, wherein the electronic device comprises at least one of: a mobile phone, a detection and ranging apparatus, an automated vehicle, a tablet computer or a wireless headphone.

14. A method of manufacturing the integrated circuit package of any of claims 1 - 13 comprising forming an antenna comprising a substantially laminar antenna section, wherein the antenna section comprises a first major side and a second major side, the first major side opposite to the second major side and wherein the substantially laminar antenna section comprises an aperture extending from the first major side to the second major side, and packaging at least the antenna to form the integrated circuit package having the antenna therein.

15. The method of claim 14 including the step of providing a first layer of dielectric material, forming the antenna section as said first layer of the dielectric material such that one of the first major side or the second major side of the antenna section is at least partially covered by the dielectric material, and providing a second layer of dielectric material over the other of the first and second major side of the antenna section.

Figure 1

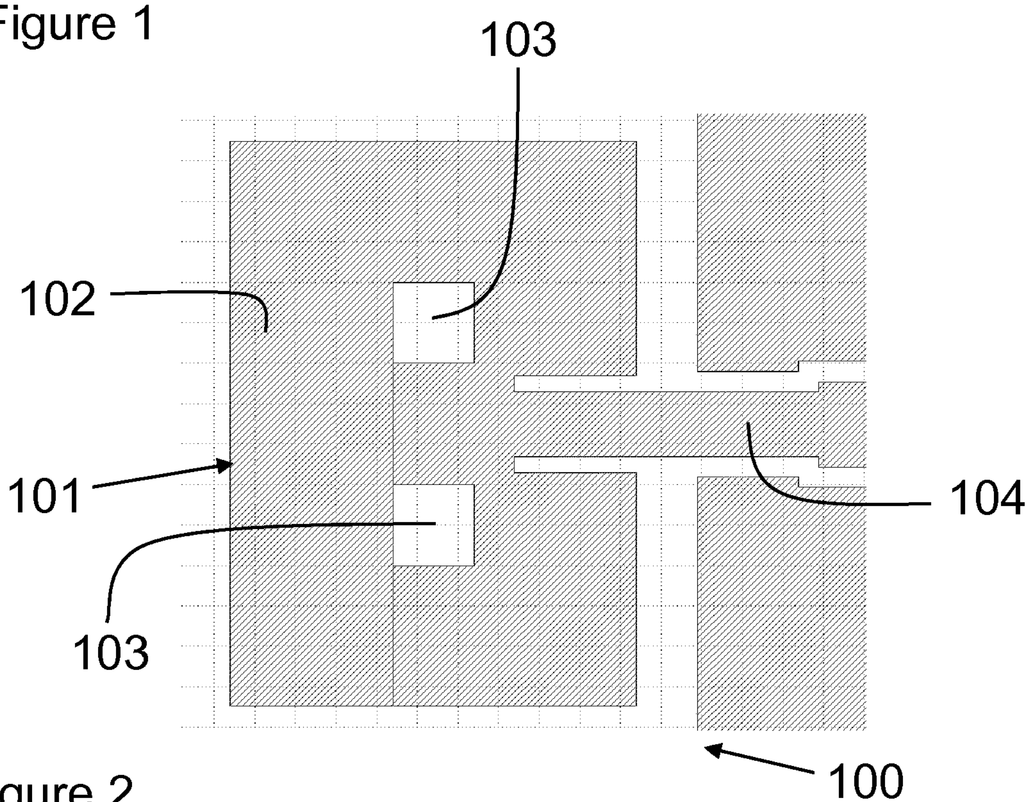


Figure 2

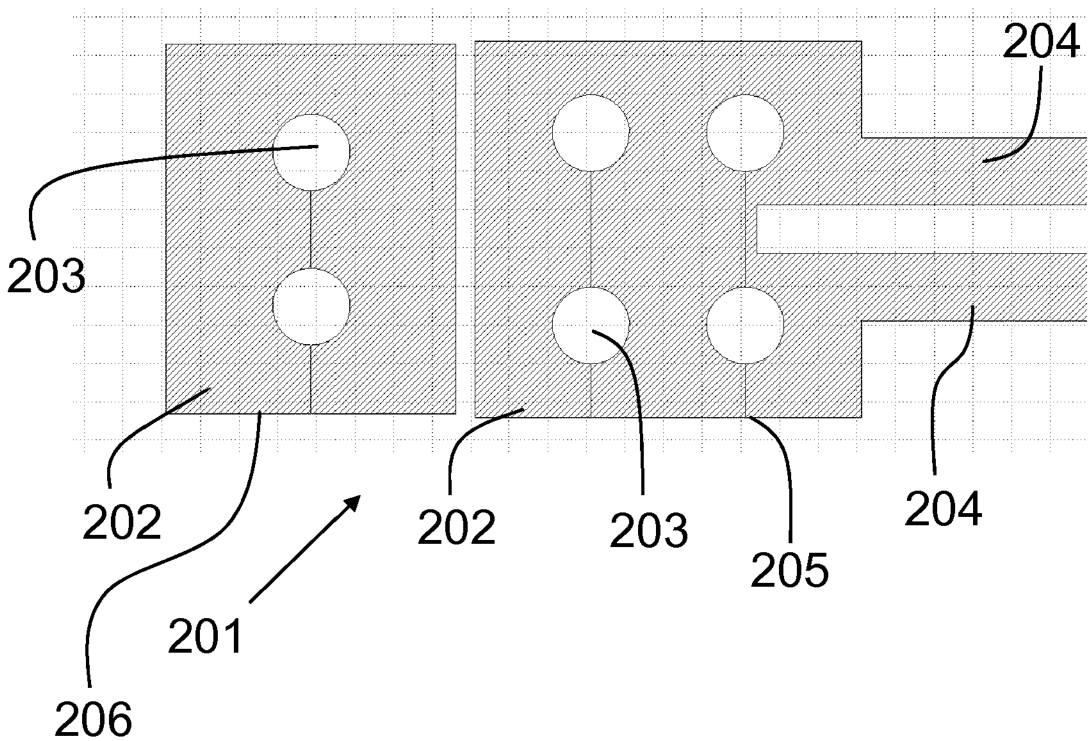


Figure 3

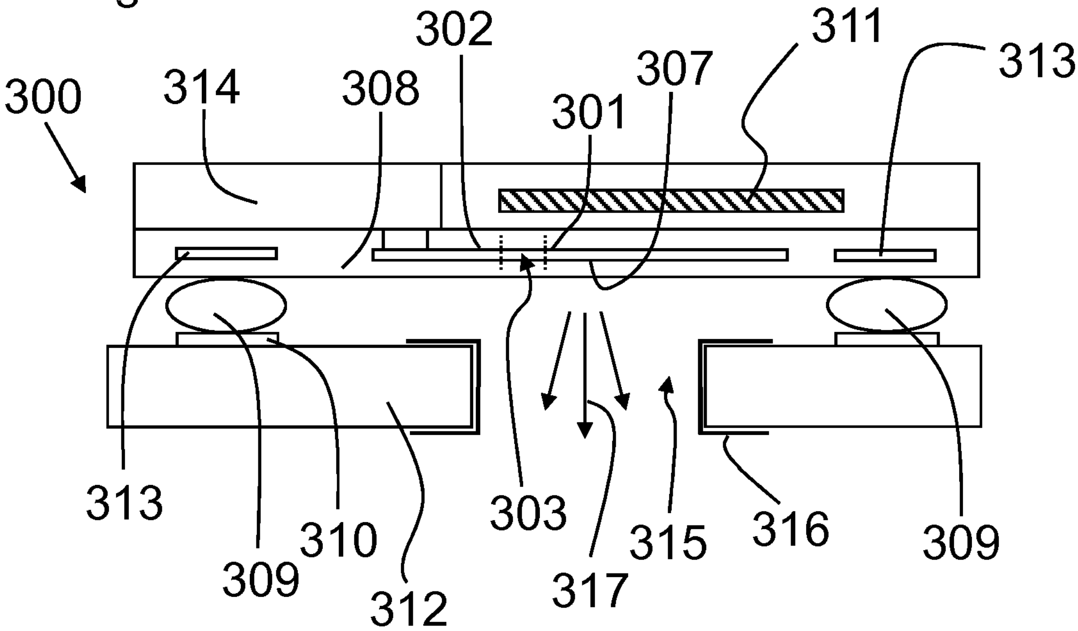


Figure 4

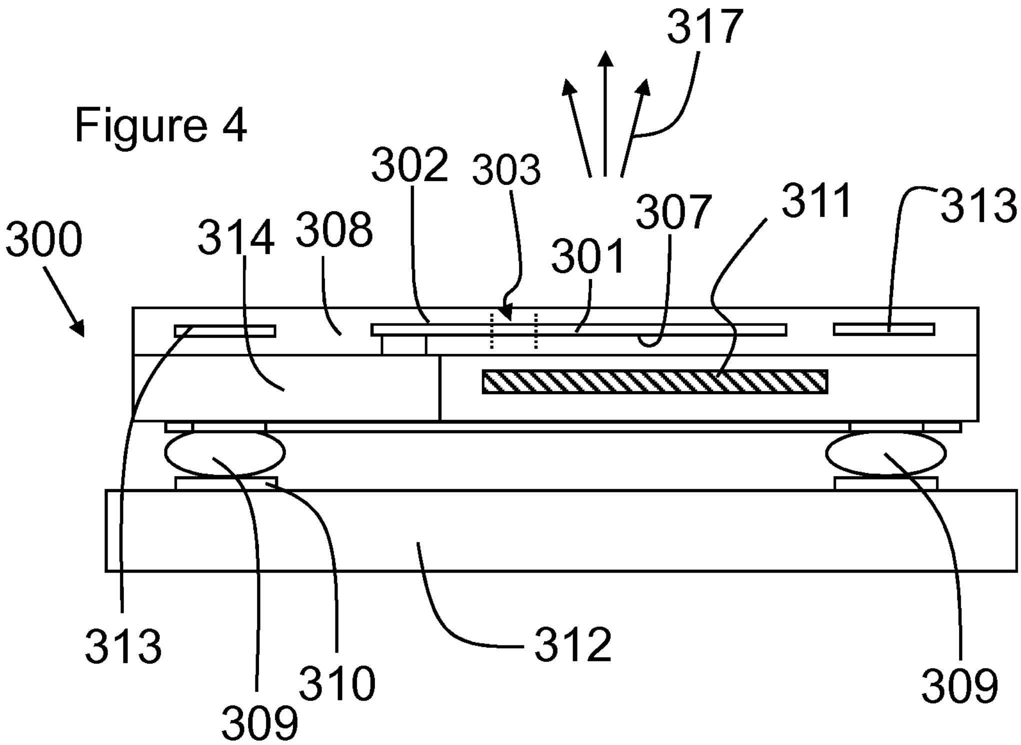


Figure 5

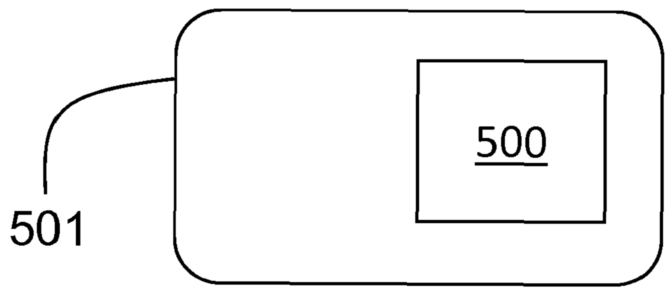
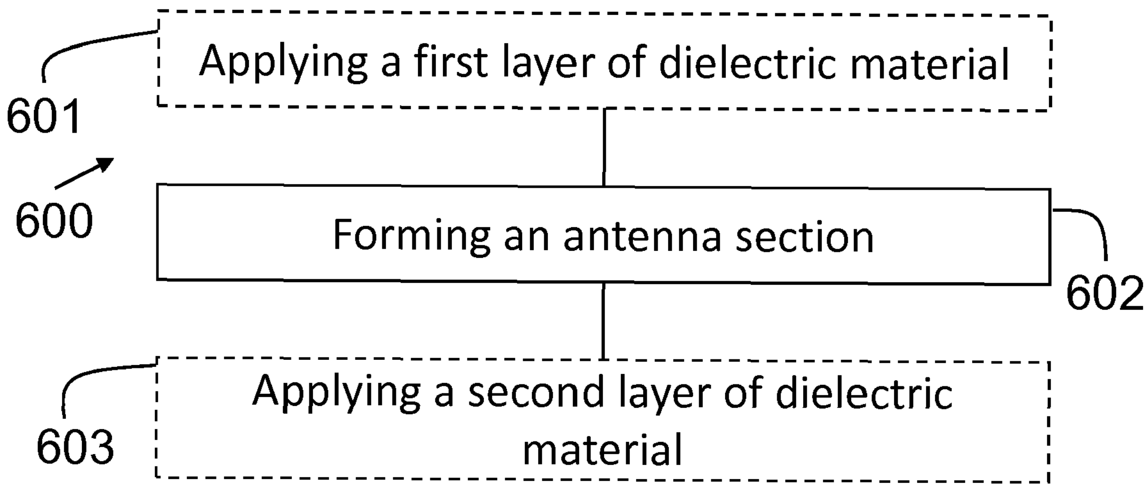


Figure 6



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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 0586

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2014/145884 A1 (DANG BING [US] ET AL) 29 May 2014 (2014-05-29) * paragraphs [0015] - [0021] * * paragraph [0027] * * paragraph [0035] * * figures 1, 2, 4A * -----	1-15	INV. H01Q1/22 H01Q1/38 H01Q9/04
X	US 2010/193935 A1 (LACHNER RUDOLF [DE] ET AL) 5 August 2010 (2010-08-05) * paragraphs [0018] - [0035] * * figures 1a-1d * * figures 3b-3f * * paragraphs [0048] - [0050] * * figure 5 * -----	1-3,5-15	
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TECHNICAL FIELDS SEARCHED (IPC)

H01Q

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	9 January 2018	Culhaoglu, Ali

CATEGORY OF CITED DOCUMENTS

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