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(71) Applicant: **Nokia Solutions and Networks Oy**  
**02610 Espoo (FI)**

(72) Inventors:  
• **LIU, Gang**  
**Shanghai, 201199 (CN)**  
• **TIAN, Qi**  
**Shanghai, 201102 (CN)**  
• **ZHANG, Chengan**  
**Shanghai, 200120 (CN)**

(74) Representative: **DREISS Patentanwälte PartG**  
**mbB**  
**Friedrichstraße 6**  
**70174 Stuttgart (DE)**

(54) **ANTENNA STRUCTURE AND RADIO DEVICE**

(57) The present application provides an antenna structure and a radio device. The antenna structure comprises a first antenna and at least one second antenna. Said first antenna comprises a reflector and a feeder located at the focal point of said reflector. The main body structure of said reflector is a non-metal structure and is plated with a metal layer on its inner surface. Each second antenna is carried on said main body structure and co-sharing formed with said main body structure. According to the scheme of the present application, since the main body structure of the first antenna in the antenna structure adopts a non-metal structure with each second antenna being carried on said main body structure and co-sharing formed with said main body structure, co-sharing form between any of the antennas can be achieved with this antenna structure. Furthermore, this antenna structure is easy to manufacture, causes minimal interference to the reflector antenna, and is applicable to any radio device.

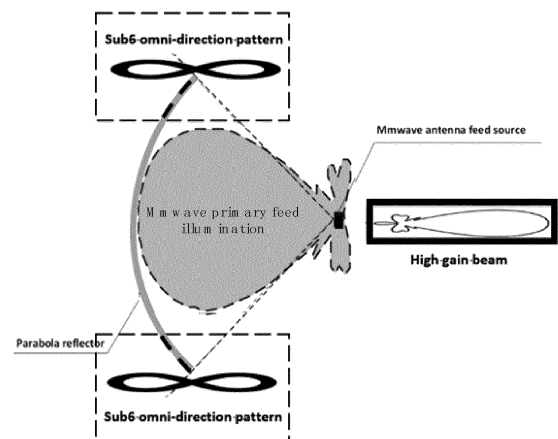


Fig. 1

## Description

### Technical Field

**[0001]** The present application relates to the field of antenna technology, in particular to an antenna structure with inter-antenna co-sharing form and a radio device.

### Background Art

**[0002]** With the advent of the era of fifth-generation (5G) broadband cellular network, fixed wireless access (FWA) has become one of the major use cases of 5G. The FWA product family is a kind of device that receives 4G/5G wireless signals by OTA (Over The Air) and converts them into Wi-Fi signals locally. FWA provides high-speed internet connection to residents and small enterprises. 5G Customer Premises Equipment (CPE) plays an important role in the FWA product family. The next evolution in 5G FWA is the introduction of mmWave (millimeter wave) spectrum (FR2). Current CPE deployments are mostly in sub-6 frequency bands and can only use a bandwidth of 100-200 MHz due to limited spectrum resources. On the other hand, a bandwidth of up to 800 MHz can be used with the mmWave frequency bands, which brings forth enormous incremental spectrum assets, thereby supporting faster data transmission and abundant video streaming.

**[0003]** 5G indoor mmWave CPE typically comprises a 5G UE (User Equipment) modem, a high-gain mmWave beamforming antenna assembly and an omni-directional sub-6 antenna. The device can be placed close to window or further inside the room while making the narrow high-gain mmWave beam align with the direction of arrival of the strongest radio signal. In addition, the device possesses broadband router functionality and provides connectivity to various UE over Wi-Fi or Ethernet. High-gain mmWave can be achieved by a reflector. By confining the initial emission from a radiating source (e.g., mmWave commercial module) into a narrow solid angle with use of a reflector antenna, higher gain can be achieved after reflection at the reflector, with the added reflector increasing the antenna system gain. Here, the wireless signal reaches the reflector through feeder radiation and then is reflected back in high-gain, narrow-beam transmission, where the larger the reflector size, the greater the gain is. The reflector type can be parabolic, Cassegrain or other types in antenna application.

**[0004]** Besides mmWave functionality, typical indoor CPE also includes sub-6 (4G/5G NR (New Radio)) functionality, examples of which include typical receiver antenna implementations of radio configurations such as DL (Downlink) 2×2 MIMO (Multiple Input Multiple Output) and DL 4×4 MIMO. In typical indoor environment there exists abundant multipath propagation, which is beneficial for high-order MIMO (rank 3/4) transmission and usually helps achieving associated throughput benefits. In the meanwhile, since the wide channel bandwidth ena-

bles Gbit/s speed, customers demand an increase in new available spectrum and wider channel bandwidths. Furthermore, LTE (Long Term Evolution), Wi-Fi, Bluetooth, GPS (Global Positioning System) and the like are also often required. In a word, CPE with more than a dozen antennas co-existed is very common.

**[0005]** Among various multi-antenna implementations for CPE in the prior art, generally known are separated sub-6 antenna and mmWave antenna, with each undertaking its own functions. Wherein, the mmWave implementation provides high equivalent isotropically radiated power (EIRP) through high-gain antenna, while the sub-6 implementation provides multi-band configuration (e.g., LTE/5G/NR/Wi-Fi/GPS/Bluetooth and the like) and MIMO configuration (such as 2×2 or 4×4 for the required band), which leads to a need for more same frequency band antennas. Accordingly, more space is needed for placement of sub-6 antenna based on performance consideration.

### Summary of the Invention

**[0006]** The objective of the present application is to provide an antenna structure and a radio device.

**[0007]** In accordance with an aspect of the present application, an antenna structure is provided, wherein the antenna structure comprises a first antenna and at least one second antenna, said first antenna comprises a reflector and a feeder located at the focal point of said reflector, the main body structure of said reflector is a non-metal structure and is plated with a metal layer on its inner surface, and each second antenna is carried on said main body structure and co-sharing formed with said main body structure.

**[0008]** In accordance with an aspect of the present application, the main body structure of said reflector comprises but not limited to: parabolic body; spherical body; angular reflector; and Cassegrain body.

**[0009]** In accordance with an aspect of the present application, said at least one second antenna includes therein one or more omni-directional antennas, wherein for each omni-directional antenna of said one or more omni-directional antennas, that omni-directional antenna is placed on said inner surface in a co-sharing form, and there is a separating boundary between the metal layer on that omni-directional antenna and the metal layer on said inner surface.

**[0010]** In accordance with an aspect of the present application, said at least one second antenna includes therein one or more directional antennas, wherein for each directional antenna of said one or more directional antennas, that directional antenna comprises an antenna main body part that is placed on said inner surface in a co-sharing form, medium material, and a metal layer or metal cavity located on the back side of said main body structure, and there is a separating boundary between said antenna main body part and the metal layer on said inner surface.

**[0011]** In accordance with an aspect of the present application, the main body structure of said reflector is a plastic or other non-metal structure.

**[0012]** In accordance with an aspect of the present application, said antenna structure is manufactured by metal deposition (e.g., selective plating) on the surface of said non-metal structure with one-time forming.

**[0013]** In accordance with an aspect of the present application, said antenna structure is manufactured by laser engraving on the surface of said non-metal structure with one-time forming.

**[0014]** In accordance with an aspect of the present application, for a second antenna to be added, a cut-out is made on the metal layer plated on said inner surface, and the second antenna is placed on said cut-out in a co-sharing form. There is a separating boundary between the metal layer on the second antenna and the metal layer on said inner surface after the placement.

**[0015]** In accordance with an aspect of the present application, said first antenna is mmWave antenna while said second antenna is sub-6 antenna; alternatively, said first antenna is sub-6 antenna while said second antenna is mmWave antenna.

**[0016]** In accordance with an aspect of the present application, a radio device is provided, wherein said radio device comprises the antenna structure proposed in the present application.

**[0017]** In comparison with the prior art, the present application has the following advantages: since the main body structure of the first antenna in the antenna structure adopts a non-metal structure with each second antenna being carried on said main body structure and co-sharing formed with said main body structure, the co-sharing form between any of the antennas can be achieved with this antenna structure; this antenna structure is easy to manufacture and cost-effective without adding any extra expenses, and is applicable to any radio device; this antenna structure makes full use of the co-sharing form, meaning that no extra space is added for the second antenna, and the negative impact on the performance of the first antenna is minimal because the locations on the reflective surface where the second antennas are located still participate in reflection (the separating boundary for forming the second antenna is the only part that does not participate in reflection); this antenna structure can be manufactured with a one-time forming process and therefore is easy to manufacture and cost-effective.

#### Description of the Drawings

**[0018]** Through reading the detailed description of the non-limiting embodiments with reference to the following drawings, other features, objects and advantages of the present application will become more obvious:

Fig. 1 shows the schematic view of the design principle of the antenna structure of an embodiment of the present application;

Fig. 2a shows the front view of the antenna structure of an embodiment of the present application;

Fig. 2b shows the side view of the antenna structure shown in Fig. 2a;

Fig. 3a and Fig. 3b show the schematic views of the simulation results of performance based on the antenna structure shown in Fig. 2a;

Fig. 4 shows the co-existence of sub-6 antenna and mmWave antenna patterns in free space.

**[0019]** The same or similar reference numbers in the drawings represent the same or similar parts.

#### Detailed Description of the Embodiments

**[0020]** The specific structural and functional details disclosed herein are merely representative and serve the purpose of describing example embodiments of the present application. However, the present invention may be embodied in many alternative forms, and should not be construed as limited to only the embodiments set forth herein.

**[0021]** It will be understood that although the terms 'first', 'second', etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are used only to distinguish one element from another. For example, a first element could be termed a second element, and, similarly, a second element could be termed a first element, without departing from the scope of example embodiments. As used herein, the term 'and/or' includes any and all combinations of one or more of the associated items that are listed.

**[0022]** The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of example embodiments. As used herein, the singular forms 'a', 'an' and 'the' are intended to include the plural forms as well unless clearly indicated otherwise in the context. It will be further understood that the terms 'comprises', 'comprising', 'includes' and/or 'including', when used herein, specify the presence of the stated features, integers, steps, operations, elements and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components and/or combinations thereof.

**[0023]** It is found out by the applicant that mmWave antennas and sub-6 antennas are placed separately according to their respective functionality in prior art CPE devices, while reflector parts and accessories thereof take up a large proportion of space in compact CPE devices, which leads to the following problems: 1) there is not enough room for placement of sub-6 antennas, or there is a need for sacrificing sub-6 performance by weakening the antenna design or reducing the relative clearance between each antenna; 2) if mmWave antennas and sub-6 antennas are separated and if sub-6 probes are placed in front of the reflector or beside the

reflector, the radiation pattern will be only one side of the reflector and impacted more or less by the existence of the reflector.

**[0024]** Aiming at the technical problems mentioned above, the present application proposes an antenna structure with inter-antenna co-sharing form. With this antenna structure, the co-sharing form between any of the antennas can be achieved. Furthermore, this antenna structure is easy to manufacture, causes minimal interference to the reflector antenna, and is applicable to any radio device.

**[0025]** The present application will be described in more detail below in connection with the drawings.

**[0026]** The present application proposes an antenna structure, wherein the antenna structure comprises a first antenna and at least one second antenna, said first antenna comprises a reflector and a feeder located at the focal point of said reflector, the main body structure of said reflector is a non-metal structure and is plated with a metal layer on its inner surface, and each second antenna is carried on said main body structure and co-sharing formed with said main body structure. Wherein, said reflector and said feeder make up the first antenna, which may also be referred to as the reflector antenna. In some embodiments, a second antenna is co-sharing formed with the main body structure of the first antenna, meaning that this second antenna follows the same curvature as the main body structure of the first antenna. In some embodiments, the second antenna is carried on said main body structure and co-sharing formed with said main body structure. That is to say, the second antenna is attached to the inner surface of said main body structure and lies in the same plane as the inner reflective surface of the reflector (since the entirety of said main body structure, except for the area needed for placement of the second antenna, is plated with a metal layer to form the inner reflective surface, the second antenna may also be viewed as being integrated in the inner reflective surface of the reflector). In some embodiments, there is a separating boundary between each second antenna and the metal of the inner reflective surface of said first antenna. In some embodiments, since the entirety of said main body structure, except for the area needed for placement of the second antenna, is plated with a metal layer and said second antenna has also a metal layer thereon, the area for placement of the second antenna on said main body structure (including the actual placement area and the separating boundary formed around the actual placement area) may also be viewed as a cut-out on the inner reflective surface of the first antenna.

**[0027]** In some embodiments, said first antenna is mmWave antenna while said second antenna is sub-6 antenna; alternatively, said first antenna is sub-6 antenna while said second antenna is mmWave antenna. What needs to be explained is that the specific shapes, spectrums, types (such as directional antenna and omni-directional antenna) and the like are not limited by the present application. In some embodiments, the spectrum

ranges corresponding to the first antenna and the second antenna may be different (e.g., the first antenna is mmWave antenna while the second antenna is sub-6 antenna; for another example, the first antenna and the second antenna are both sub-6 antennas, but the spectrum ranges corresponding to the first antenna and the second antenna are different), or may be the same or partially the same. In some embodiments, when there are multiple second antennas, the spectrum range corresponding to each second antenna may be different or may be the same or partially the same, and the shape or type of each second antenna may be the same or may be different; in some embodiments, each second antenna can be of any possible shape or type. For example, the multiple second antennas in the antenna structure are sub-6 antennas used respectively for LTE, 5G NR, Wi-Fi, GPS and Bluetooth. For another example, the multiple second antennas in the antenna structure include at least one directional antenna and at least one omni-directional antenna. For yet another example, the multiple second antennas in the antenna structure include slot antennas, patch antennas and other antennas of various different shapes.

**[0028]** Wherein, the first antenna may be a reflector antenna of any structure, such as parabolic antenna, Cassegrain antenna and many other types of reflector antennas. In some embodiments, the main body structure of said reflector can be any possible structure. Preferably, said main body structure includes but not limited to: parabolic body, spherical reflector, angular reflector, Cassegrain body, etc. In some embodiments, the first antenna is a parabolic reflector antenna intended for mmWave functionality, while the second antenna is a sub-6 antenna. By integrating the second antenna in the inner reflective surface of the parabolic reflector antenna, the sub-6 antenna is co-sharing formed with the parabolic reflector antenna, meaning that the sub-6 antenna follows the same curvature as the parabola, and that the sub-6 antenna lies in the same plane as the inner reflective surface of the parabolic reflector. The inner reflective surface of the parabolic reflector and the second antenna are both covered with metal except at the separating boundary mentioned in the context.

**[0029]** In some embodiments, said at least one second antenna includes therein one or more omni-directional antennas, wherein for each omni-directional antenna of said one or more omni-directional antennas, that omni-directional antenna is placed on said inner surface in a co-sharing form, and there is a separating boundary between the metal layer on that omni-directional antenna and the metal layer on said inner surface. An omni-directional antenna is an antenna that exhibits uniform radiation of whole 360° in the horizontal pattern. The specific shape of the omni-directional antenna is not limited by the present application. In some embodiments, the length of the omni-directional antenna may be 1/4, 1/2 or full wavelength of the set wavelength.

**[0030]** In some embodiments, said at least one second

antenna includes therein one or more directional antennas, wherein for each directional antenna of said one or more directional antennas, that directional antenna comprises an antenna main body part that is placed on said inner surface in a co-sharing form, non-metal medium material (e.g., plastic) of said main body structure, and a metal layer or metal cavity located on the back side of said main body structure, and there is a separating boundary between said antenna main body part and the metal layer on said inner surface. A directional antenna is an antenna that exhibits radiation in a certain angular range in the horizontal pattern, such as a slot antenna. The specific shape of the directional antenna is not limited by the present application. In some embodiments, the length of the directional antenna may be 1/2 or full wavelength of the set wavelength. In some embodiments, the distance between said metal layer or metal cavity and said antenna main body part is approximately 1/4 of the set wavelength. In some embodiments, the medium material of a directional antenna is the material of the main body structure that lies between its antenna main body part and the metal layer/metal cavity. For example, when the main body structure of the first antenna is a plastic structure, the medium material between the antenna main body part of the directional antenna and the metal reflective layer on the back side is the plastic of the main body structure of the first antenna. In some embodiments, the second antenna is a slot antenna. A cross slot is placed on the inner surface of the main body structure of the first antenna and is co-sharing formed with the inner surface. Said main body structure has a metal cavity on its back side, and the depth of said metal cavity is 1/4 of the set wavelength. Furthermore, the metal cavity is open at one end, and the inside of the metal cavity may be a cavity that is constructed entirely or partially utilizing the structure of the first antenna. In some embodiments, the antenna main body part of the directional antenna is placed on the inner surface of the main body structure of the first antenna and is co-sharing formed with the inner surface. Said main body structure has a metal layer on its back side, and the area of said metal layer is larger than that of said main body part. The distance between said antenna main body part and said metal layer is approximately 1/4 of the set wavelength. What lies between said antenna main body part and said metal layer is the plastic of the main body structure of the first antenna.

**[0031]** In some embodiments, said antenna structure comprises a first antenna and multiple second antennas, wherein the second antennas include therein at least one directional antenna and at least one omni-directional antenna.

**[0032]** What needs to be explained is that regardless of the type of the second antenna, although the performance of the first antenna might be affected with the antenna structure of this scheme, however, if the amount or size of the second antenna is completely controllable and if the specific location of the second antenna is optimized, the negative impact on the first antenna is min-

imized. This is because the second antenna is also plated with metal thereon, i.e., the second antenna still participates in reflection. Therefore, the final hollowing of the metal on the inner surface of the main body structure of the first antenna can be converted to a smaller proportion.

**[0033]** In some embodiments, said non-metal structure is plastic. For example, the main body structure of the first antenna is a parabolic body which adopts a plastic structure. The second antennas are all carried on the inner surface of the parabolic body, wherein the second antennas and the inner surface of the parabolic body are plated with metal in all areas except at the separating boundaries (if there exist directional antennas as the second antennas, there are also corresponding areas on the back side of the parabolic body that are plated with metal). What needs to be explained is that said main body structure may also adopt other non-metal structures than a plastic one.

**[0034]** The antenna structure of the present application can be manufactured from a one-time forming process. In some embodiments, said antenna structure is manufactured by metal deposition on the surface of said non-metal structure with one-time forming. For example, if the main body structure of the first antenna adopts a plastic structure, the antenna structure can be manufactured by metal deposition (e.g., selective plating) on the plastic surface with one-time forming. That is, metal plating of the inner reflective surface of the first antenna and the main body part of the second antenna can be achieved directly by metal deposition on the plastic surface with one-time forming, wherein metal plating is not needed at the separating boundary corresponding to each second antenna on the plastic inner surface. In some embodiments, said antenna structure is manufactured by using laser direct structuring (LDS) on the surface of the non-metal structure. For example, if the main body structure of the first antenna adopts a plastic structure added with LDS active agent, the antenna structure can be manufactured by using laser direct structuring (i.e., laser engraving) on the plastic surface.

**[0035]** In some embodiments, for a second antenna to be added, a cut-out is made on the metal layer plated on said inner surface, and the second antenna is placed on said cut-out in a co-sharing form (i.e., placed directly on the inner surface of the main body structure that adopts a non-metal structure). There is a separating boundary between the metal layer on the second antenna and the metal layer on said inner surface after the placement. In some embodiments, the cut-out made on the metal layer plated on said inner surface is slightly larger than the to-be-added second antenna to make sure that there is a separating boundary between the metal on the second antenna and on the inner surface. In some embodiments, a second antenna that is co-sharing formed with the first antenna can be added by making a cut-out on the metal layer plated on the inner surface, so that new second antennas can be added conveniently and swiftly on the existing antenna structure.

**[0036]** Fig. 1 shows the schematic view of the design principle of the antenna structure of an embodiment of the present application. The antenna structure comprises a first antenna and multiple second antennas. The first antenna is a mmWave antenna that comprises a parabolic reflector and a mmWave antenna feeder located at the focal point of the parabolic reflector. The second antennas are sub-6 antennas, and there are multiple sub-6 antennas that are co-sharing formed on the inner surface of the parabolic reflector. Fig. 1 shows the omnidirectional radiation produced by the sub-6 antennas that are embedded in the mmWave reflector antenna (such as the Sub6 omni-directional pattern shown in Fig. 1). The mmWave signal is radiated from the feeder to the parabolic reflector, such as the mmWave primary feed illumination shown in Fig. 1, and is reflected back in high-gain, narrow-beam transmission after reflection at the parabolic reflector, such as the high-gain beam shown in Fig. 1.

**[0037]** The second antenna in the present application can be of any form, that is, any form of co-sharing form with the first antenna of the second antenna is supported. For example, the second antenna can be a slot antenna, patch antenna or any other antenna design for wireless communication, and can also be designed as a single antenna or multiple antennas in MIMO application. For any antenna design, electro-magnetic simulation needs to be carried out in the first place. The examples of simulation results of the present application are given below based on Fig. 2a, Fig. 2b, Fig. 3a, Fig. 3b and Fig. 4. Wherein, Fig. 2a shows the front view of the antenna structure of an example of the present application, Fig. 2b shows the side view of the antenna structure shown in Fig. 2a, and Fig. 3a and Fig. 3b show the schematic views of the simulation results of performance based on the antenna structure shown in Fig. 2a. In this example, the antenna structure comprises a parabolic reflector antenna (mmWave antenna) and 4 sub-6 antennas. The 4 sub-6 antennas are engraved on the surface of the parabolic body of the parabolic reflector antenna (in which one sub-6 antenna is for Wi-Fi, one sub-6 antenna is for LTE, and two sub-6 antennas are for 5G/NR according to different frequency bands), and there are separating boundaries between the metal on the sub-6 antennas and on the surface of the parabolic body. As can be seen in Figs. 3a and 3b, the impact of the introduction of sub-6 antennas on the performance of the parabolic reflector antenna is a 0.22dB decrease in gain, which is a minor and acceptable impact considering the antenna gain level in the actual application is 27dB. On the other hand, the co-sharing form with the parabolic reflector antenna proposed by the present application brings the benefits of the 4 sub-6 antennas. Fig. 4 shows the co-existence of sub-6 antenna and mmWave antenna patterns in free space, with the solid box representing the sub-6 antenna pattern and the dashed box representing the mmWave antenna pattern.

**[0038]** According to the scheme of the present appli-

cation, since the main body structure of the first antenna in the antenna structure adopts a non-metal structure with each second antenna being carried on said main body structure and co-sharing formed with said main body structure, the co-sharing form between any of the antennas can be achieved with this antenna structure. Furthermore, this antenna structure is easy to manufacture, causes little interference to the reflector antenna, and is applicable to any radio device.

**[0039]** The present application also proposes a radio device, wherein the radio device comprises the antenna structure proposed by the present application.

**[0040]** To those skilled in the art, it is apparent that the present application is not limited to the details of the illustrative embodiments mentioned above, and can be implemented in other specific forms without departing from the spirit or basic features of the present application. Therefore, from any perspective, the embodiments should be regarded as illustrative and not restrictive. The scope of the present application is defined by the appended claims and not the depiction above. Therefore, all variations within the meaning and scope of equivalent elements of the claims are intended to be encompassed within the present application. No reference numerals in the claims should be regarded as limiting the involved claims. In addition, it is apparent that the word 'comprise' or 'include' does not exclude other units or steps, and singularity does not exclude plurality. A plurality of units or apparatuses stated in a system claim may also be implemented by a single unit or apparatus through software or hardware. Words like 'first' and 'second' are used to indicate names and not to indicate any specific order.

## Claims

1. An antenna structure, wherein the antenna structure comprises a first antenna and at least one second antenna, said first antenna comprises a reflector and a feeder located at the focal point of said reflector, the main body structure of said reflector is a non-metal structure and is plated with a metal layer on its inner surface, and each second antenna is carried on said main body structure and co-sharing formed with said main body structure.
2. The antenna structure according to Claim 1, wherein said main body structure comprises any of the following:
  - parabolic body;
  - spherical body;
  - angular reflector; and
  - Cassegrain body.
3. The antenna structure according to Claim 1, wherein said at least one second antenna includes therein one or more omni-directional antennas, for each om-

ni-directional antenna of said one or more omni-directional antennas, that omni-directional antenna is placed on said inner surface in a co-sharing form, and there is a separating boundary between the metal layer on that omni-directional antenna and the metal layer on said inner surface. 5

4. The antenna structure according to any of Claims 1 to 3, wherein said at least one second antenna includes therein one or more directional antennas, for each directional antenna of said one or more directional antennas, that directional antenna comprises an antenna main body part that is placed on said inner surface in a co-sharing form, non-metal medium material of said main body structure, and a metal layer or metal cavity located on the back side of said main body structure, and there is a separating boundary between said antenna main body part and the metal layer on said inner surface. 10  
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5. The antenna structure according to any of Claims 1 to 4, wherein said non-metal structure is plastic.
6. The antenna structure according to any of Claims 1 to 5, wherein said antenna structure is manufactured by metal deposition on the surface of the non-metal structure with one-time forming. 25
7. The antenna structure according to any of Claims 1 to 5, wherein said antenna structure is manufactured by using laser direct structuring on the surface of the non-metal structure. 30
8. The antenna structure according to any of Claims 1 to 5, wherein for a second antenna to be added, a cut-out is made on the metal layer plated on said inner surface, and the second antenna is placed on said cut-out in a co-sharing form, and there is a separating boundary between the metal layer on the second antenna and the metal layer on said inner surface after the placement. 35  
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9. The antenna structure according to any of Claims 1 to 8, wherein said first antenna is mmWave antenna while said second antenna is sub-6 antenna; alternatively, said first antenna is sub-6 antenna while said second antenna is mmWave antenna. 45
10. A radio device, wherein said radio device comprises the antenna structure according to any of Claims 1 to 9. 50

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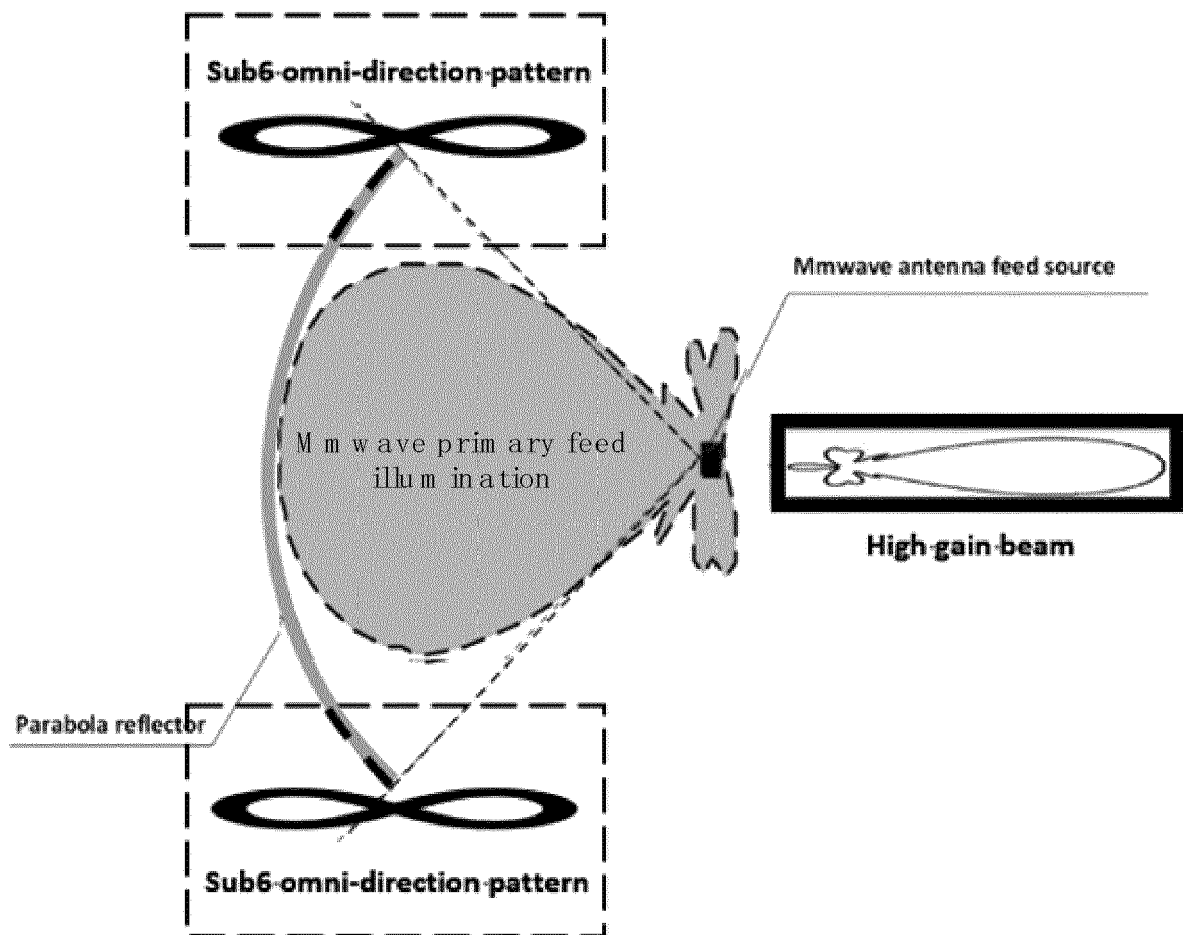


Fig. 1

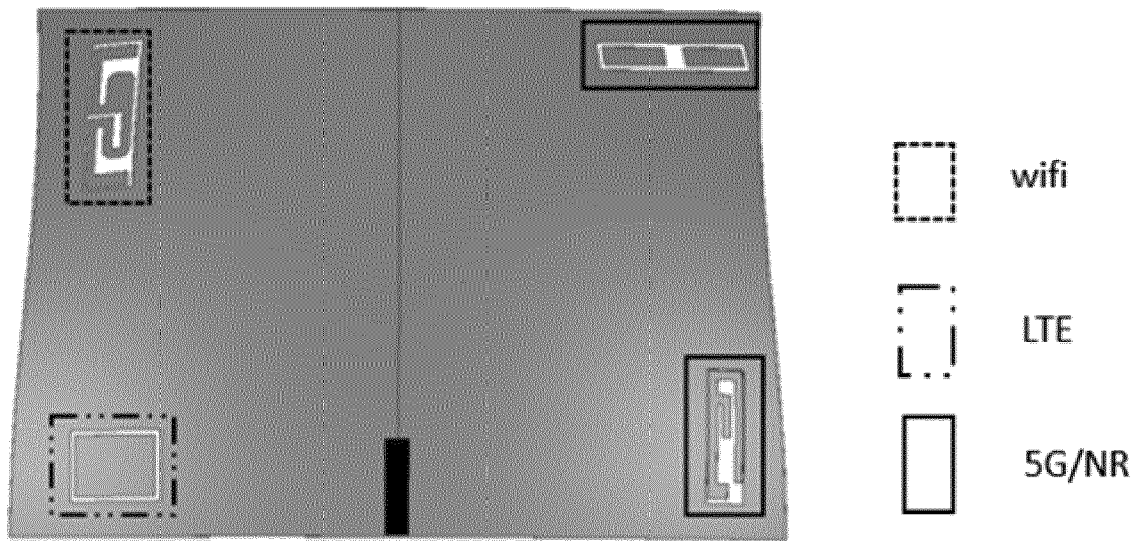


Fig. 2a

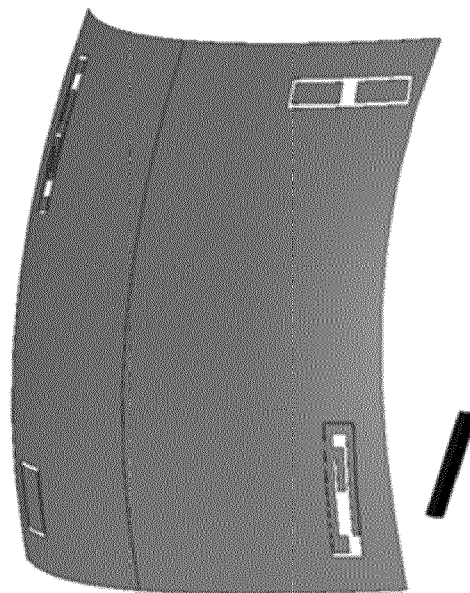


Fig. 2b

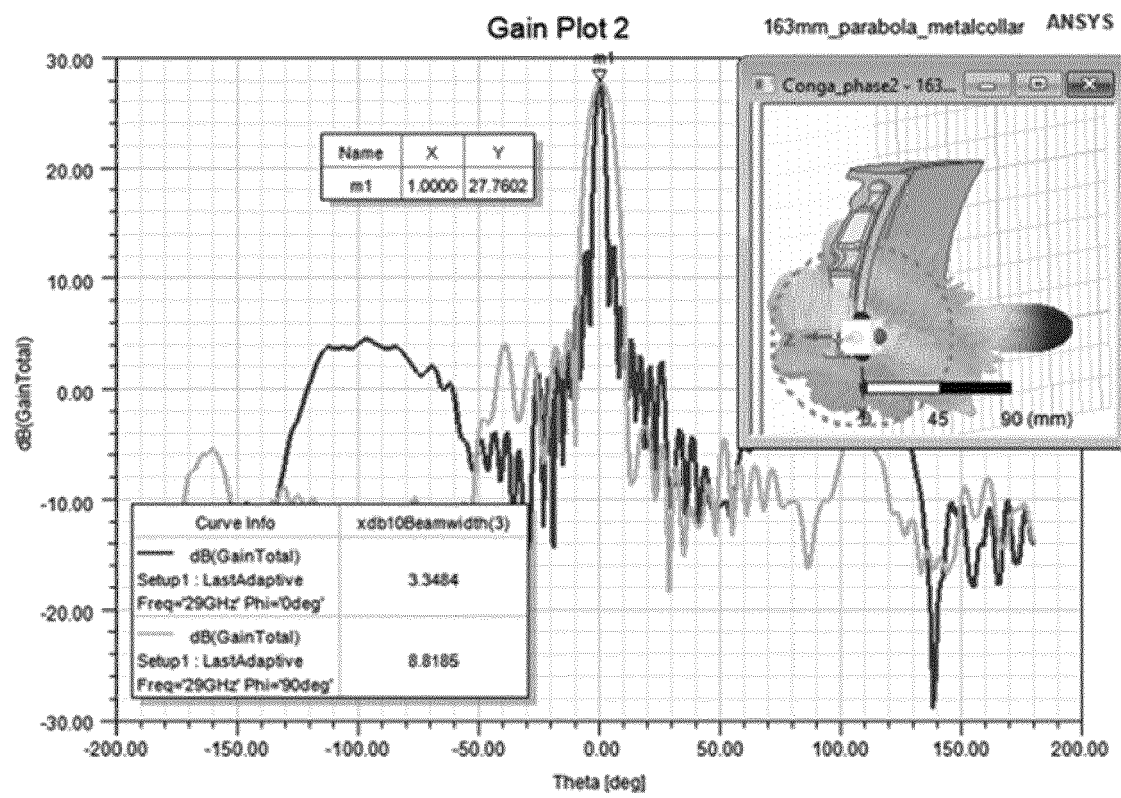


Fig. 3a

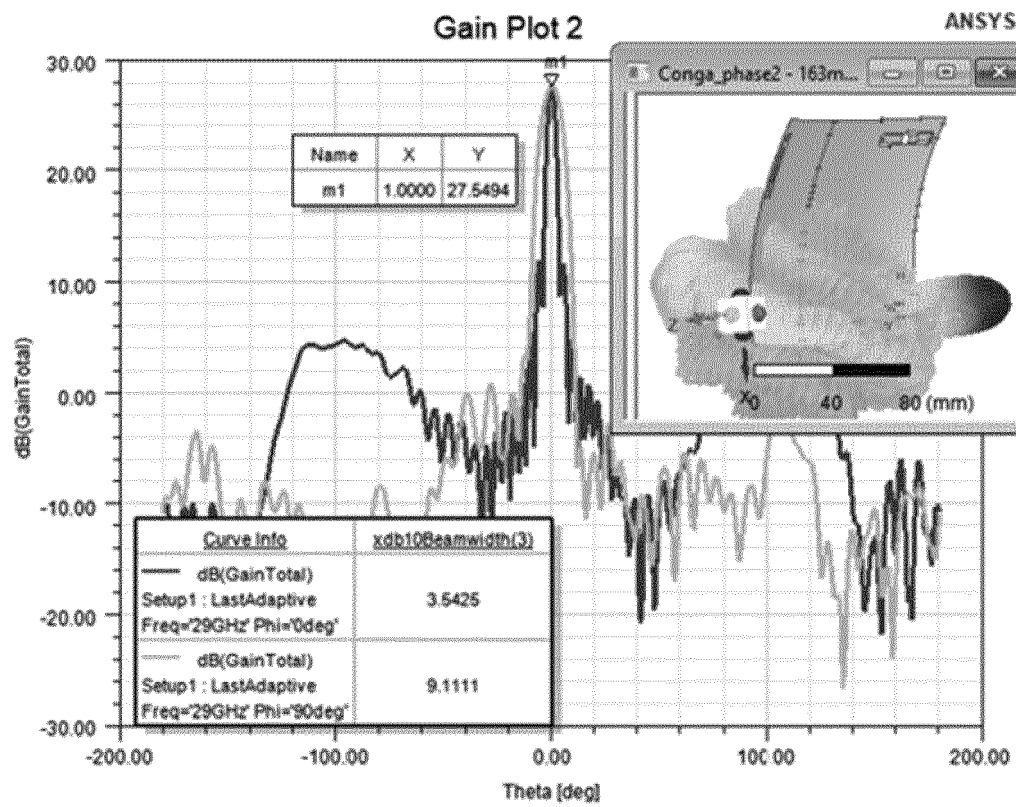


Fig. 3b

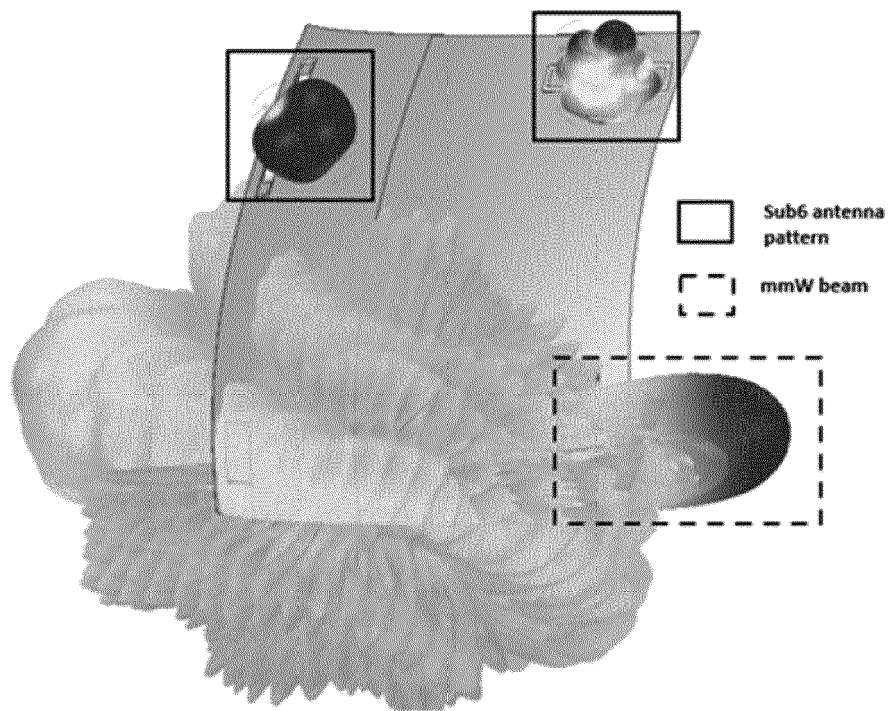


Fig. 4



## EUROPEAN SEARCH REPORT

Application Number

EP 22 21 1877

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EPO FORM 1503 03.82 (P04C01)

| DOCUMENTS CONSIDERED TO BE RELEVANT                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                          |                                                         |                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------|
| Category                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Citation of document with indication, where appropriate, of relevant passages                                                                                                                                                                                            | Relevant to claim                                       | CLASSIFICATION OF THE APPLICATION (IPC)                             |
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| The present search report has been drawn up for all claims                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                                                                                                                                                                                                                                          |                                                         |                                                                     |
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| CATEGORY OF CITED DOCUMENTS<br>X : particularly relevant if taken alone<br>Y : particularly relevant if combined with another document of the same category<br>A : technological background<br>O : non-written disclosure<br>P : intermediate document<br>T : theory or principle underlying the invention<br>E : earlier patent document, but published on, or after the filing date<br>D : document cited in the application<br>L : document cited for other reasons<br>.....<br>& : member of the same patent family, corresponding document |                                                                                                                                                                                                                                                                          |                                                         |                                                                     |

**ANNEX TO THE EUROPEAN SEARCH REPORT  
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