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(71) Applicant: **HUAWEI TECHNOLOGIES CO., LTD.**
[CN/CN]; Huawei Administration Building, Bantian, Longgang District, Shenzhen, Guangdong 518129 (CN).

(72) Inventors: **GUNTUPALLI, Ajay Babu**; Huawei Technologies Duesseldorf GmbH, Riesstr. 25, 80992 (DE). **MURILLO BARRERA, Alejandro**; Huawei Technologies Duesseldorf GmbH, Riesstr. 25, 80992 (DE). **REBEGEA, Serban**; Huawei Technologies Duesseldorf GmbH, Riesstr. 25, 80992 (DE). **GONZALEZ, Ignacio**; Huawei Technologies Duesseldorf GmbH, Riesstr. 25, 80992 (DE). **GONG, Zhi**; Huawei Administration Building, Bantian, Longgang District, Shenzhen, Guangdong 518129 (CN). **BISCONTINI, Bruno**; Huawei Technologies Duesseldorf GmbH, Riesstr. 25, 80992 (DE).

OBERMAIER, Johann Baptist; Huawei Technologies Duesseldorf GmbH, Riesstr. 25, 80992 (DE).

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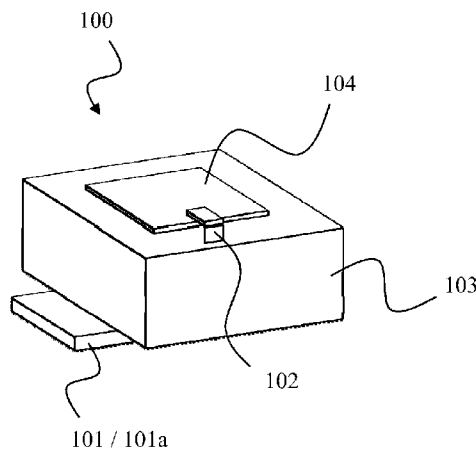


FIG. 1

(57) Abstract: This disclosure relates to a radio frequency (RF) device, which comprises radiators and a distribution network (DN). The DN comprises one or more DN layers. Each DN layer comprises RF circuitry designed to feed at least one radiator or to connect to another DN layer. Each DN layer further comprises one or more bendable feeding probes, each protruding from the DN layer and being connected to the RF circuitry of the DN layer. The RF device also comprises a planar dielectric structure arranged on the DN. The one or more feeding probes extend through one or more gaps in the dielectric structure, and each feeding probe is bent onto and attached to a surface of the dielectric structure. The RF device further comprises a planar array of one or more radiators arranged on the surface of the dielectric structure. Each radiator is coupled to one or two of the feeding probes.



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A DIELECTRIC AND CONDUCTIVE FOIL BASED DISTRIBUTION NETWORK WITH BENDABLE FEEDING PROBES

5 TECHNICAL FIELD

The present disclosure relates to a radio frequency (RF) device, for instance, an antenna device. The disclosure particularly relates to a distribution network (DN) of the RF device. The RF device comprises one or more radiators and the DN. The RF device, and specifically the DN, can be assembled using dielectrics and conductive foils. The DN has bendable feeding probes, which allow the feeding of the radiators of the RF device.

BACKGROUND

15 Within a social and technological context that prioritizes efficiency, high-performance and low-loss equipment is key. For example, regarding antenna devices for cellular communications, the pursuit of efficiency is performed at several levels. On the one hand, advanced radiation features adapted to the service environment are fundamental. On the other hand, low losses at the different stages of the communication signal path should
20 also be optimized.

Within a typical antenna device, the signals are conducted through a DN, which distributes the signals to available radiators of a radiating structure. The radiators are the interfaces between the distribution network and the propagation environment (the air).
25 The DN may be implemented as transmission lines, and possibly other components. Examples of transmission are microstrip, stripline, or waveguides. Losses along these transmission lines occur both in the conductors and in dielectric materials embedding the conductors. High conductivity materials are thus beneficial for implementing the conductors. Moreover, materials with a low dielectric constant may reduce the electrical
30 length of the transmission lines, and may thus lead to lower losses due to less friction with atoms of the material. However, such low dielectric constant materials usually results in a more complex design of the antenna device. Finally, the radiators are typically implemented as flat conductive patterns, which are also subject to losses at the conductors and the surrounding dielectrics.

In addition to the above-described loss issues, the assembly of the typical antenna device is often complicated, and requires specific machines. In particular, the construction of the DN and the coupling of the DN and radiators of the antenna device may be complex.

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SUMMARY

In view of the above, an objective of this disclosure is to provide an easy, e.g., manual, way to assemble an RF device, for example an antenna device, including a DN. Another objective is to reduce the losses in the DN and the RF device. Another objective is to achieve a simplified feed architecture for feeding one or more radiators of the RF device with the DN. Another objective is to ensure an efficient transfer of energy from the DN to the radiators. Another objective is to provide a mechanically stable RF device, which is of low weight at the same time

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These and other objectives are achieved by the solutions described in the independent claims. Advantageous implementations of are described in the dependent claims.

A first aspect of this disclosure provides a RF device comprising: a DN, which comprises one or more DN layers, each DN layer comprising RF circuitry designed to feed at least one radiator or to connect to another DN layer; wherein each DN layer further comprises one or more bendable feeding probes, each feeding probe protruding from the DN layer and being connected to the RF circuitry of the DN layer; a planar dielectric structure arranged on the DN; wherein the one or more feeding probes extend through one or more gaps in the dielectric structure, and each feeding probe is bent onto and attached to a surface of the dielectric structure; and a planar array of one or more radiators arranged on the surface of the dielectric structure; wherein each radiator is coupled to one or two of the feeding probes.

Due to the bendable feeding probes, the DN can be easily connected to the radiators of the RF device, for example, manually or with simple automatization. The feeding probes allow to efficiently transfer energy from the DN to the radiators. The RF device of the first aspect may show low losses and good performance. Due to the used materials, the RF device can be stable while light of weight.

In an implementation form of the first aspect, the radiators are single-polarization radiators; and each radiator is coupled to one of the feeding probes.

- 5 In an implementation form of the first aspect, the radiators are dual-polarization radiators; and each radiator is coupled to two of the feeding probes.

Accordingly, the solutions of this disclosure are suitable for both a single- and dual-polarized RF device.

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In an implementation form of the first aspect, the DN comprises a first DN layer and a second DN layer; and at least one of the radiators is coupled to one feeding probe of the first DN layer and to one feeding probe of the second DN layer.

- 15 In an implementation form of the first aspect, the first DN layer and the second DN layer are arranged in parallel to each other and in parallel to the dielectric structure and to the array of radiators.

This may be beneficial for medium size radiator arrays, and may reduce the footprint of
20 the RF device.

In an implementation form of the first aspect, the first DN layer and the second DN layer are arranged in parallel to each other and perpendicular to the dielectric structure and to the array of radiators.

25

This may be beneficial for large size radiator arrays-

- In an implementation form of the first aspect, the RF devices further comprises: a
30 conductive planar structure arranged between the DN and the array of radiators; wherein the conductive planar structure is configured as a common ground plane for all the radiators.

The conductive planar structure may serve as ground plane and reflector plane, and may provide stability to the RF device.

In an implementation form of the first aspect, a plurality of cavities are formed in the conductive planar structure; the dielectric structure comprises a plurality of dielectric elements, one dielectric element being arranged in each cavity of the conductive planar structure; and one radiator is arranged on the surface of each dielectric element.

That is, the dielectric structure may be a distributed structure. This solution enables a mechanically robust, while still light weight RF device. Further, the radiators may be separated and/or shielded from another by the design of the cavities to improve the performance.

In an implementation form of the first aspect, the conductive planar structure comprises one or two openings within each cavity; and one feeding probe extends through each opening of the cavity and is attached to the surface of the dielectric element that is arranged in the cavity.

The assembly of the RF device may be simplified in this way.

In an implementation form of the first aspect, each DN layer comprises a first dielectric sheet, a second dielectric sheet, and a bendable conductive sheet that is sandwiched between the first and the second dielectric sheet, the bendable conductive sheet comprising the RF circuitry of the DN layer; and each feeding probe is an extension of the bendable conductive sheet and protrudes from between the first and the second dielectric sheet.

Such a DN layer allows constructing a DN, which can be easily assembled, provides a good shielding of the RF circuitry, and is of light weight and cheap.

In an implementation form of the first aspect, each DN layer further comprises one or more rigid protrusions; and one of the feeding probes is guided by and extends from each of the protrusions.

In an implementation form of the first aspect, each rigid protrusion is inserted into one of the openings of the conductive planar structure.

Accordingly, the protrusions facilitate the assembly of the RF device, and protect the feeding probes. The set of protrusions may form a connector of the DN to the dielectric structure supporting the radiator array.

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In an implementation form of the first aspect, the array of radiators and/or the bendable conductive sheets of the one or more DN layers are respectively formed by a conductive foil; and the one or more radiators and the RF circuitry are respectively patterned on the conductive foil.

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The conductive foil allows assembling the entire array of radiators or RF circuitry of the RF device at once. The array of radiators and/or the RF circuitry may be pre-patterned or pre-produced. The conductive foil may be thin, and thus does not add much weight.

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In an implementation form of the first aspect, the bendable conductive sheets of the one or more DN layers and the array of radiators are formed by the same conductive foil or are formed by connected conductive foils; and/or each radiator is electrically connected to the one or two feeding probes.

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This allows further simplification of the RF device.

In an implementation form of the first aspect, an adhesive is arranged between each radiator and respectively the surface of the dielectric structure and the one or two feeding probes; and each radiator is capacitively or galvanically coupled to the one or two feeding probes.

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In an implementation form of the first aspect, the one or more radiators comprise one or more patch radiating elements.

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As the patch radiating elements are flat, they are well suited to be patterned on a thin conductive foil. All patch radiating elements may be the same, i.e., same size and shape. For instance, the patch radiating elements may be arranged in a matrix of rows and columns.

In an implementation form of the first aspect, the RF device further comprises: a second dielectric structure arranged on the array of radiators; and a planar array of one or more directors arranged on the second dielectric structure, each director being associated with one of the radiators.

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For example, the directors may be patch directors. As the patch directors are flat, they are well suited to be patterned on a thin conductive foil. All patch directors may be the same, i.e., same size and shape. For instance, the patch directors may be arranged in a matrix of rows and columns similar to the radiators.

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In an implementation form of the first aspect, the dielectric structure and/or the dielectric sheets of the one or more DN layers are respectively made of a foam.

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The foam may be rigid. At the same time, the foam adds only little weight and may have a low dielectric constant.

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A second aspect of this disclosure provides a method of assembling a RF device, the method comprising: providing a DN, which comprises one or more DN layers, each DN layer comprising RF circuitry designed to feed at least one radiator or to connect to another DN layer; wherein each DN layer further comprises one or more bendable feeding probes, each feeding probe protruding from the DN layer and being connected to the RF circuitry of the DN layer; arranging a planar dielectric structure on the DN; wherein the one or more feeding probes are extended through one or more gaps in the dielectric structure, and each feeding probe is bent onto and attached to a surface of the dielectric structure; and arranging a planar array of one or more radiators on the surface of the dielectric structure; wherein each radiator is coupled to one or two of the feeding probes.

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The method of assembling the RF device is easy and may be performed manually. Thus, also assembly of the RF device is simplified. Else, the same advantages as described above for the RF device of the first aspect are achieved.

BRIEF DESCRIPTION OF DRAWINGS

The above described aspects and implementation forms will be explained in the following description of specific embodiments in relation to the enclosed drawings, in which

- 5
- FIG. 1 shows a part of an RF device according to this disclosure.
- FIG. 2 shows a part of an exemplary RF device according to this disclosure with DN layer and directors.
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- FIG. 3 shows a part of an exemplary RF device according to this disclosure with two or more DN layers parallel to the radiator array.
- FIG. 4 shows a part of an exemplary RF device according to this disclosure with two or more DN layers perpendicular to the radiator array.
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- FIG. 5 shows a conductive planar structure with cavities for an exemplary RF device according to this disclosure.
- FIG. 6 shows cavities of a conductive planar structure of an exemplary RF device according to this disclosure, wherein the cavities are filled with dielectric structures.
- 20
- FIG. 7 shows an exemplary coupling of a feeding probe to a radiator in an exemplary RF device according to this disclosure.
- 25
- FIG. 8 shows an exemplary RF device according to this disclosure and a step of assembly.
- FIG. 9 shows a radiation pattern of an exemplary RF device according to this disclosure.
- 30
- FIG. 10 shows an example of a DN layer for an RF device according to this disclosure.

FIG. 11 shows an example of a DN layer for an RF device according to this disclosure

FIG. 12 shows a method for assembling an RF device according to this disclosure.

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DETAILED DESCRIPTION OF EMBODIMENTS

FIG. 1 shows a part of an exemplary RF device 100 according to this disclosure. The RF device 100 may be an antenna device. The part shown in FIG. 1 may be included multiple times in the RF device 100. The part shown in FIG. 1 may, for example, be a unit cell of the RF device, which may be repeated in the RF device. For example, many such unit cells may be arranged in rows and/or columns of the RF device 100.

As shown, the RF device 100 comprises a DN 101, which comprises one or more DN layers, wherein FIG. 1 shows exemplarily one such DN layer 101a. The DN layer 101a comprises RF circuitry 201 (shown in FIG. 2), wherein the RF circuitry 201 is designed to feed at least one radiator 104 or to connect to another DN layer.

The DN layer 101a further comprises one or more bendable feeding probes 102, wherein exemplarily one such feeding probe 102 is shown in FIG. 1. The feeding probe 102 protrudes from the DN layer 101a and is connected to the RF circuitry 201 of the DN layer 101a. This may be the similar for each feeding probe 102 of the RF device 100.

Further, the RF device 100 comprises a planar dielectric structure 103, which is arranged on (or adjacent to) the DN 101. The dielectric structure 103 may comprise a foam, or may be made of a rigid foam. The feeding probe 102 extends through a gap in the dielectric structure 103, and is bent onto and attached to a surface of the dielectric structure 103. This may be similar for each feeding probe 102.

The RF device 100 further comprises a planar array of one or more radiators 104, which is arranged on the surface of the dielectric structure 103. As an example, one such radiator 104 is shown in FIG. 1. The radiator 104 is in this case coupled to one of the feeding probes 102 of the RF device 100, namely the one shown in FIG. 1. The one or more radiators 104 may be used for radiating wireless signals of the RF device 100. To

this end, the radiators 104 are fed the signals by the DN 101 (also referred to as feeding network).

5 FIG. 2 shows an exemplary RF device 100, which builds on the RF device 100 shown in FIG. 1. Same elements in FIG. 1 and FIG. 2 are labelled with the same reference signs and may be implemented likewise.

10 The one or more radiators 104 comprise one or more patch radiating elements, i.e., the shown radiator 104 may be a patch radiating element (or patch radiator). In this case, the radiators 104 of the RF device 100 are single-polarization radiators, so that each radiator 104 is coupled to one feeding probe 102, as shown.

15 FIG. 2 also shows that the RF device 100 may further comprise a second dielectric structure 203, which is arranged on (or adjacent to) the array of radiators 104. The second dielectric structure 203 may comprise a foam or may be made of a rigid foam, for instance, may be of the same material as the first dielectric structure 103. A planar array of one or more directors 204, for example, implemented as patch directors, may be arranged on the second dielectric structure 203. Each director 204 is thereby associated
20 with one of the radiators 104, and may be configured to direct electromagnetic radiation emitted by its associated radiator 104.

FIG. 2 also indicates that and where a conductive planar structure 202 may be arranged between the DN 101 and the array of radiators 104 (will be described later in more detail).
25 The conductive planar structure 202 may be configured to function as a common ground plane and/or reflector plane for all the radiators 104 of the array of the RF device 100.

FIG. 2, in sum, shows an example of a single-polarization feeding mechanism of a radiator 104, particularly, patch radiating element. The DN layer 101a is arranged
30 underneath the array of radiators 104. The DN layer 101a may include a conductive foil (also referred to as foil) substrate, to implement the feeding probes 102. The conductive foil may be thin, and may add flexibility to bend at, for example, a 90° angles in more than one physical location. As shown in FIG. 2, the feeding probe 102 may be bent by about 90° to feed one polarization of the radiator 104.

FIG. 3 shows an exemplary RF device 100, which builds on the RF device 100 shown in FIG. 1. Same elements in FIG. 1 and FIG. 3 are labelled with the same reference signs and may be implemented likewise.

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The one or more radiators 104 comprise one or more patch radiating elements, i.e., the shown radiator 104 may be a patch radiating element (or patch radiator). In this case, the radiators 104 of the RF device 100 are dual-polarization radiators, so that each radiator 104 is coupled to two feeding probes 102 as shown. In particular, the DN 100 comprises in this example at least a first DN layer 101a and a second DN layer 101b, and the radiator 104 is coupled to one feeding probe 102 of the first DN layer 101a and to one feeding probe 102 of the second DN layer 101b. The first DN layer 101a and the second DN layer 101b may be arranged in parallel to each other, and in parallel to the dielectric structure 103 and to the array of radiators 104, as shown.

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FIG. 3 shows an example that is beneficial for medium size radiator arrays, wherein a few (e.g., 2 or 3) radiators 104 are connected to the DN 101 within a smaller foot print, The DN 101 is larger due to the two polarizations, and thus a stacked DN for the two polarizations can be implemented. The two polarizations may be combined on a single conductive foil. The DN 101 may be placed below the array of radiators 104, parallel to it and to each other. The flexibility of the folding probes 102 allows bending at any angle, for example, 90° angle, in order to reach the array of radiators 104 on top of the dielectric structure 103. Notably, to simplify the overall architecture, the array of radiators 104 (also referred to as patch layer) and the dual-polarization DN 101 can both be integrated into one conductive foil. For instance, the array of radiators 104 may be formed by a conductive foil, wherein the one or more radiators 104 are patterned on the conductive foil.

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FIG. 4 shows an exemplary RF device 100, which builds on the RF device 100 shown in FIG. 1. Same elements in FIG. 1 and FIG. 4 are labelled with the same reference signs and may be implemented likewise.

The one or more radiators 104 comprise one or more patch radiating elements, i.e., the shown radiator 104 may be a patch radiating element (or patch radiator). In this case, the

radiators 104 of the RF device 100 are dual-polarization radiators like in FIG. 3, so that each radiator 104 is again coupled to two feeding probes 102. In contrast to FIG. 3, however, the first DN layer 101a and the second DN layer 101b are arranged in parallel to each other, but perpendicular to the dielectric structure 103 and to the array of radiators 104 in FIG. 4.

FIG. 4 shows an example that is beneficial for large size arrays, in which the DN 101 becomes too bulky, so that the DN 101 is placed perpendicularly to the radiator plane. Larger size arrays may mean the number of radiators 104 are greater than 3. A first polarization may be provided by the left feeding probe 102, and a second polarization may be provided by the right feeding probe 102, and these feeding probes 102 may be implemented using different conductive foils.

FIG. 5 and FIG. 6 show an exemplary implementation of the planar conductive structure 202, which is indicated in FIG. 2, and of the dielectric structure 103. The planar conductive structure 202 may be a rigid conductive plate, and may provide structural stiffness and the common electrical ground plane and/or reflector plane to the RF device 100. The conductive planar structure 202 may be a rigid metallic plate.

As shown in FIG. 5, a plurality of cavities 501 may be formed in the conductive planar structure 202. In this case, as is shown in FIG. 6, the dielectric structure 103 may comprise or consist of a plurality of dielectric elements 601, i.e., may consist of disconnected pieces of dielectric material, for instance, foam. One of these dielectric elements 601 can be arranged in, or introduced into, each cavity 501 of the conductive planar structure 202. Moreover, as also shown in FIG. 6, one radiator 104 can be arranged on the surface of each dielectric element 601, so that each cavity 501 contains one radiator 104. Each cavity 501 may comprise – depending on whether the radiator 104 of the cavity 501 is single-polarization or dual-polarization – one or two openings 602, wherein one feeding probe 102 extends through each opening 602 and is attached to the surface of the dielectric element 601 that is arranged in the cavity 501.

As each cavity 501 holds one radiator 104, it may be referred to as a radiating cavity of the RF device 100. The planar structure 202 may contain a grid of vertical walls, which form the cavities and separate them from each other, potentially providing shielding. The

conductive planar structure 202 may further separate the radiating cavities from the DN layers 101a, 101b. Thus, the openings 602 may be provided to enable the interconnection(s).

5 FIG. 7 shows an exemplary coupling of a feeding probe 102 to a radiator 104 in an exemplary RF device 100 according to this disclosure. FIG. 7 particularly shows that the feeding probe 102 is bent onto the top of the dielectric structure 103, and the radiator 104 is arranged on the feeding probe 102. Thereby, an adhesive like a glue or epoxy is arranged between the radiator 104 and the feeding probe 102. The adhesive may also be
10 arranged between the surface of the dielectric structure 103 and the radiator 104, at locations where there is no feeding probe 102 beneath the radiator 104 (as the radiator 104 has a larger area than the feeding probe 102). The radiator 104 may be capacitively coupled to the feeding probe 102. This coupling can be the same for each radiator 104, and works likewise if the radiator 104 is connected to two feeding probes 102.

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Accordingly, FIG. 7 shows a solution for a transition between DN 101 and radiator array, wherein the feeding probe 102 from a DN layer 101a, 101b is configured to transfer energy to the radiator 104. In this disclosure, a capacitive coupling method may be used to feed the radiators 104. A conductive foil of the DN layer 101a, 101b, of which the
20 feeding probe 102 may be an extension, and a conductive foil forming the array of radiators 104, may be different conductive layers with the separation by the adhesive, e.g., a 25 μm glue layer. Alternatively, the feeding probe 102 and the radiator 104 could be connected galvanically, which may be applicable for small to medium size arrays.

25 FIG. 8 shows an exemplary RF device 100 according to this disclosure, and a step of its assembly. In FIG. 8(a), the RF device 100 comprises the dielectric structure 103, the array of radiators 104 arranged on the dielectric structure 103, for instance, implemented by a conductive and patterned foil, and the DN 101. As can be seen, the DN 101 comprises multiple DN layers 101a, 101b, which are arranged in parallel to another but
30 perpendicular to the array of radiators 104. In FIG. 8(b), the same RF device 100 is shown, but now with additionally the second dielectric structure 203 supporting the array of directors 204 assembled to it.

The RF device 100 of FIG. 8 may provide an antenna architecture with several columns of DN layers 101a, 101b. Each DN layer 101a, 101b may be coupled through the conductive planar structure 202 to the radiators 104 using insertable flaps and the feeding probes 102. The assembly procedure can be automatized to reduce the assembly time.

5 The array of directors 204 may be added on top of the array of radiators 104 at the final stage, to complete the antenna assembly.

FIG. 9 shows a radiation pattern of an exemplary RF device 100 according to this disclosure. In particular, a vertical radiation pattern is shown in FIG. 9(a), and a horizontal radiation pattern is shown in FIG. 9(b). The desired radiating performance is

10 been satisfied, while the assembly time of the RF device 100 is shortened, and the DN 101 simplified.

FIG. 10 and 11 shows an example of a DN layer 101a for an RF device 100 according to this disclosure. FIG. 10 shows that the DN layer 101a comprises a first dielectric sheet 1001, a second dielectric sheet 1002, and a bendable conductive sheet 1003, which is sandwiched between the first and the second dielectric sheet 1001, 1002. The bendable conductive sheet 1003 comprises the RF circuitry 201 of the DN layer 101a, for instance, as a conductive pattern. Each feeding probe 102 of the DN layer 101a is an extension of

15 the bendable conductive sheet 1003, and protrudes from between the first and the second dielectric sheet 1001, 1002.

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Moreover, as shown in FIG. 11, the DN layer 101a may further comprises one or more rigid protrusions 1004. In FIG. 10, it is indicated that these protrusions 1004 may be

25 formed by protrusions of the first and the second dielectric sheet 1001, 1002, respectively. One of the feeding probes 102 is guided by and extends from each of the protrusions 1004. The protrusion helps to protect the feeding probe 102. Further, the protrusion 1004 can be used to assemble the RF device 100. In particular, with reference to FIG. 6, each of the protrusions 1004 can be inserted into one of the openings 602 of the conductive

30 planar structure 202.

In FIG. 10, the bendable conductive sheet 1003 of the DN layer 101a may be formed by a conductive foil. The RF circuitry 201 may be patterned on the conductive foil. The dielectric sheets 1001, 1002 may be made of foam. Accordingly, a DN 101 can be

implemented in foam plus foil. An RF connector may feed it, and may comprise devices to provide adequate phases and amplitudes to the radiators 104. A stripline technology may be used for the DN 101.

- 5 FIG. 10 also shows that the DN layer 101a may comprise a bendable conductive sheet 1005 functioning as ground plane and/or shielding. The bendable conductive sheet 1005 may be wrapped around the dielectric sheets 1001, 1002, and may be adhered to the dielectric sheets 1001, 1002.
- 10 FIG. 12 shows a method 1200 of assembling a RF device 100 according to this disclosure. The method 1200 comprises a step 1201 of providing a DN 101, which comprises one or more DN layers 101a, 101b, wherein each DN layer 101a, 101b comprises RF circuitry 201 designed to feed at least one radiator 104 or to connect to another DN layer 101b, 101a. Each DN layer 101a, 101b further comprises one or more bendable feeding probes
- 15 102, wherein each feeding probe 102 protrudes from the DN layer 101a, 101b and is connected to the RF circuitry 201 of the DN layer 101a, 101b. The method 1200 further comprises a step 1202 of arranging a planar dielectric structure 103 on the DN 101. One or more feeding probes 102 are extended through one or more gaps in the dielectric structure 103, and each feeding probe 102 is bent onto and attached to a surface of the
- 20 dielectric structure 103. The method 1200 further comprises a step 1203 of arranging a planar array of one or more radiators 104 on the surface of the dielectric structure 103, wherein each radiator 104 is coupled to one or two of the feeding probes 102

In this disclosure, a DN 101 with insertable tabs (i.e., the feeding probes 102 and

25 optionally protrusions 1004) is presented to simplify the feeding mechanism of (medium or large) antenna arrays of radiators 104. In an example, each radiator 104 has corresponding feeding probe(s) 102, which are guided through the conductive planar structure 202, which may be a reflector and/or ground plane. A foam support structure 103 may be cut in shape for allowing the insertable tabs and feeding probes 102 to feed

30 corresponding antenna radiators 104.

The present disclosure has been described in conjunction with various embodiments as examples as well as implementations. However, other variations can be understood and effected by those persons skilled in the art and practicing the claimed matter, from the

studies of the drawings, this disclosure and the independent claims. In the claims as well as in the description the word “comprising” does not exclude other elements or steps and the indefinite article “a” or “an” does not exclude a plurality. A single element or other unit may fulfill the functions of several entities or items recited in the claims. The mere
5 fact that certain measures are recited in the mutual different dependent claims does not indicate that a combination of these measures cannot be used in an advantageous implementation.

Claims

1. A radio frequency, RF, device (100) comprising:
 - a distribution network, DN, (101) which comprises one or more DN layers (101a, 101b), each DN layer (101a, 101b) comprising RF circuitry (201) designed to feed at least one radiator (104) or to connect to another DN layer (101a, 101b);
 - wherein each DN layer (101a, 101b) further comprises one or more bendable feeding probes (102), each feeding probe (102) protruding from the DN layer (101a, 101b) and being connected to the RF circuitry (201) of the DN layer (101a, 101b);
 - a planar dielectric structure (103) arranged on the DN (101);
 - wherein the one or more feeding probes (102) extend through one or more gaps in the dielectric structure (103), and each feeding probe (102) is bent onto and attached to a surface of the dielectric structure (103); and
 - a planar array of one or more radiators (104) arranged on the surface of the dielectric structure (103);
 - wherein each radiator (104) is coupled to one or two of the feeding probes (102).
2. The RF device (100) according to claim 1, wherein:
 - the radiators (104) are single-polarization radiators; and
 - each radiator (104) is coupled to one of the feeding probes (102).
3. The RF device (100) according to claim 1, wherein:
 - the radiators (104) are dual-polarization radiators; and
 - each radiator (104) is coupled to two of the feeding probes (102).
4. The RF device (100) according to claim 3, wherein:
 - the DN (100) comprises a first DN layer (101a) and a second DN layer (101b);
 - and
 - at least one of the radiators (104) is coupled to one feeding probe (102) of the first DN layer (101a) and to one feeding probe (102) of the second DN layer (101b).
5. The RF device (100) according to claim 4, wherein the first DN layer (101a) and the second DN layer (101b) are arranged in parallel to each other and in parallel to the dielectric structure (103) and to the array of radiators (104).

6. The RF device (100) according to claim 4, wherein the first DN layer (101a) and the second DN layer (101b) are arranged in parallel to each other and perpendicular to the dielectric structure (103) and to the array of radiators (104).
- 5
7. The RF device (100) according to one of the claims 1 to 6, further comprising:
a conductive planar structure (202) arranged between the DN (101) and the array of radiators (104);
wherein the conductive planar structure (202) is configured as a common ground
10 plane for all the radiators (104).
8. The RF device (100) according to claim 7, wherein:
a plurality of cavities (501) are formed in the conductive planar structure (202);
the dielectric structure (103) comprises a plurality of dielectric elements (601),
15 one dielectric element (601) being arranged in each cavity (501) of the conductive planar structure (202); and
one radiator (104) is arranged on the surface of each dielectric element (601).
9. The RF device (100) according to claim 8, wherein:
20 the conductive planar structure (202) comprises one or two openings (602) within each cavity (501); and
one feeding probe (102) extends through each opening (602) of the cavity (501) and is attached to the surface of the dielectric element (601) that is arranged in the cavity (501).
- 25
10. The RF device (100) according to one of the claims 1 to 9, wherein:
each DN layer (101a, 101b) comprises a first dielectric sheet (1001), a second dielectric sheet (1002), and a bendable conductive sheet (1003) that is sandwiched between the first and the second dielectric sheet (1001, 1002), the bendable conductive sheet (1003) comprising the RF circuitry (201) of the DN layer (101a, 101b); and
30 each feeding probe (102) is an extension of the bendable conductive sheet (1003) and protrudes from between the first and the second dielectric sheet (1001, 1002).
11. The RF device (100) according to claim 10, wherein:

each DN layer (101a, 101b) further comprises one or more rigid protrusions (1004); and

one of the feeding probes (102) is guided by and extends from each of the protrusions (1004).

5

12. The RF device (100) according to claim 9 and 11, wherein each rigid protrusion (1004) is inserted into one of the openings (602) of the conductive planar structure (202).

13. The RF device (100) according to one of the claims 1 to 12, wherein:

10 the array of radiators (104) and/or the bendable conductive sheets (1003) of the one or more DN layers (101a, 101b) are respectively formed by a conductive foil; and

the one or more radiators (104) and the RF circuitry (201) are respectively patterned on the conductive foil.

15 14. The RF device according to claim 13, wherein:

the bendable conductive sheets (1003) of the one or more DN layers (101a, 101b) and the array of radiators (104) are formed by the same conductive foil or are formed by connected conductive foils; and/or

20 each radiator (104) is electrically connected to the one or two feeding probes (102).

15. The RF device (100) according to one of the claims 1 to 13, wherein:

an adhesive is arranged between each radiator (104) and respectively the surface of the dielectric structure (103) and the one or two feeding probes (102); and

25 each radiator (104) is capacitively or galvanically coupled to the one or two feeding probes (102).

16. The RF device (100) according to one of the claims 1 to 15, wherein the one or more radiators (104) comprise one or more patch radiating elements.

30

17. The RF device (100) according to one of the claims 1 to 16, further comprising:

a second dielectric structure (203) arranged on the array of radiators (104); and

a planar array of one or more directors (204) arranged on the second dielectric structure (203), each director (204) being associated with one of the radiators (104).

18. The RF device (100) according to one of the claims 1 to 17, wherein the dielectric structure (103) and/or the dielectric sheets (1001, 1002) of the one or more DN layers (101a, 101b) are respectively made of a foam.

5

19. A method (1200) of assembling a radio frequency, RF, device (100), the method (1200) comprising:

10 providing (1201) a distribution network, DN, (101) which comprises one or more DN layers (101a, 101b), each DN layer (101a, 101b) comprising RF circuitry (201) designed to feed at least one radiator (104) or to connect to another DN layer (101a, 101b);

wherein each DN layer (101a, 101b) further comprises one or more bendable feeding probes (102), each feeding probe (102) protruding from the DN layer (101a, 101b) and being connected to the RF circuitry (201) of the DN layer (101a, 101b);

15 arranging (1202) a planar dielectric structure (103) on the DN (101);

wherein the one or more feeding probes (102) are extended through one or more gaps in the dielectric structure (103), and each feeding probe (102) is bent onto and attached to a surface of the dielectric structure (103); and

20 arranging (1203) a planar array of one or more radiators (104) on the surface of the dielectric structure (103);

wherein each radiator (104) is coupled to one or two of the feeding probes (102).

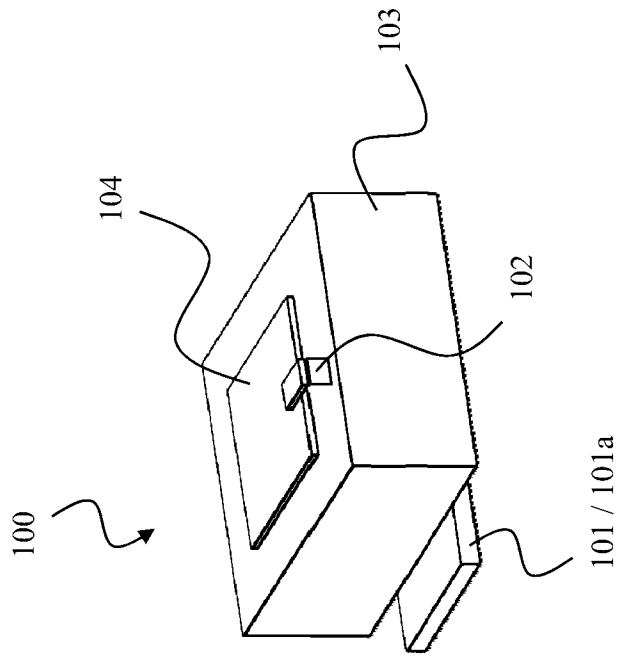


FIG. 1

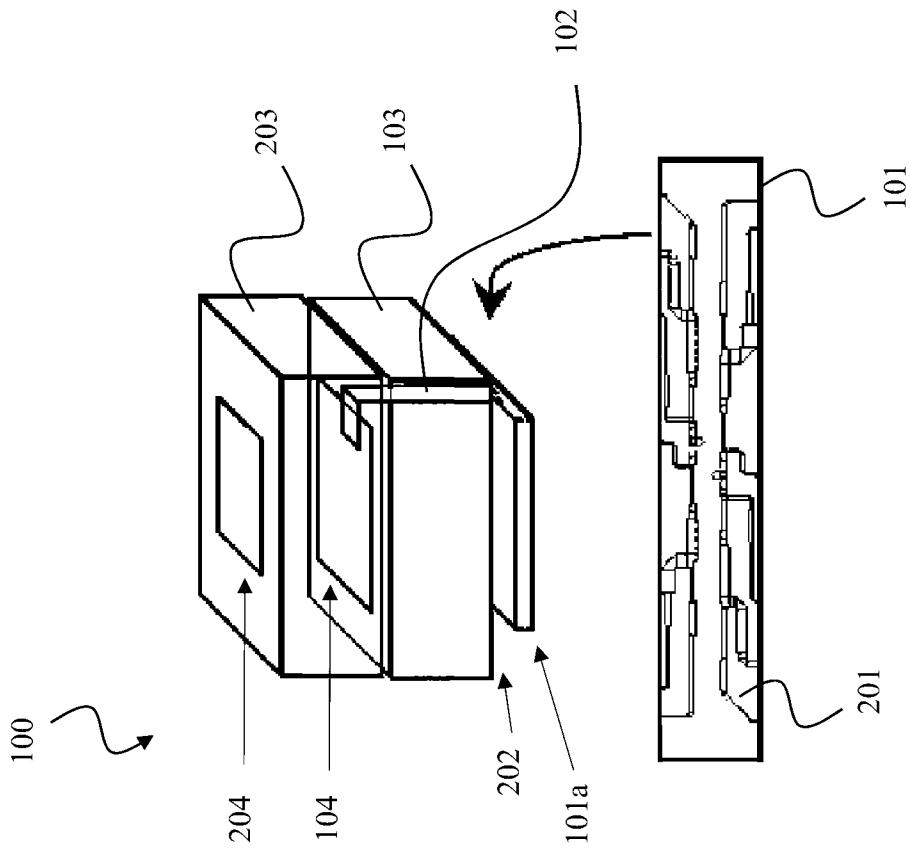


FIG. 2

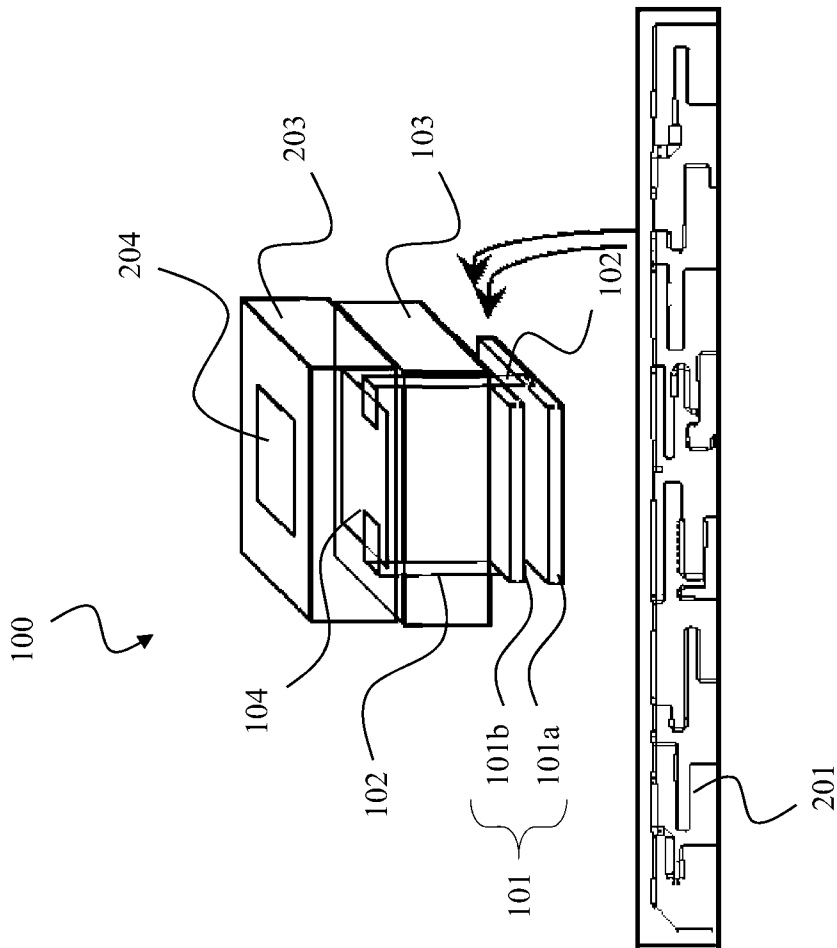


FIG. 3

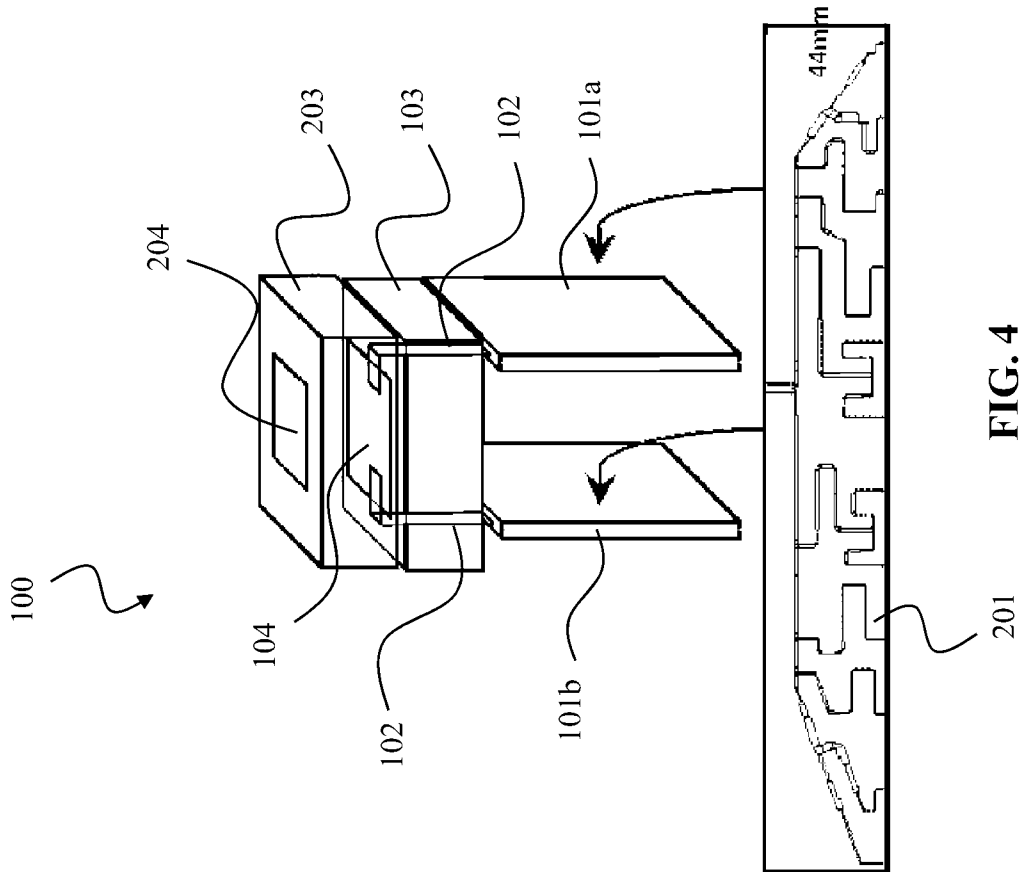


FIG. 4

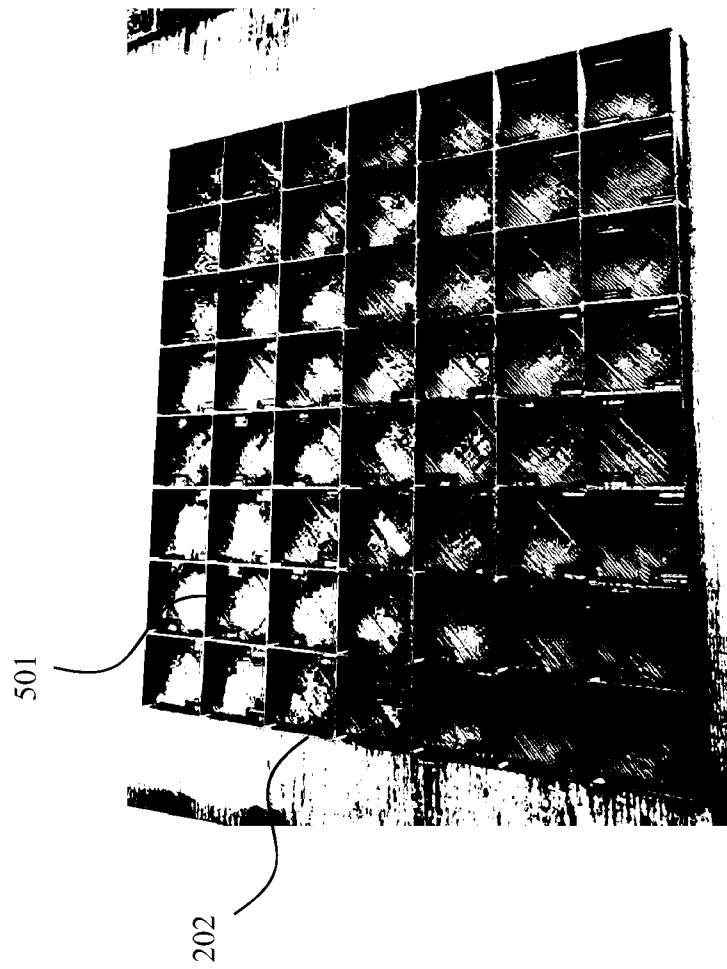


FIG. 5

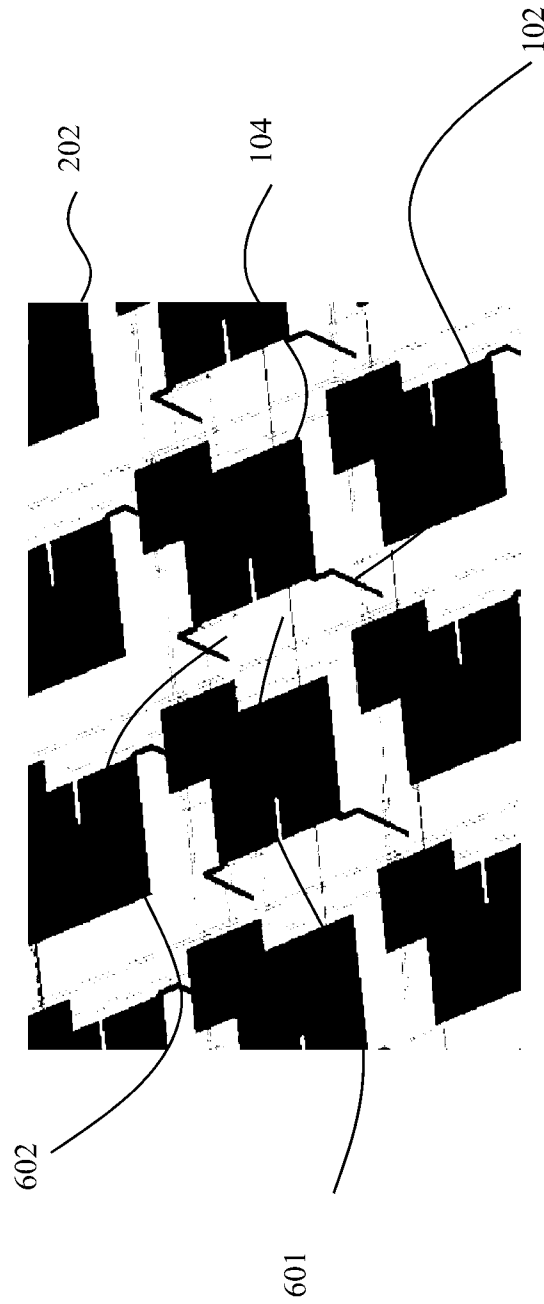


FIG. 6

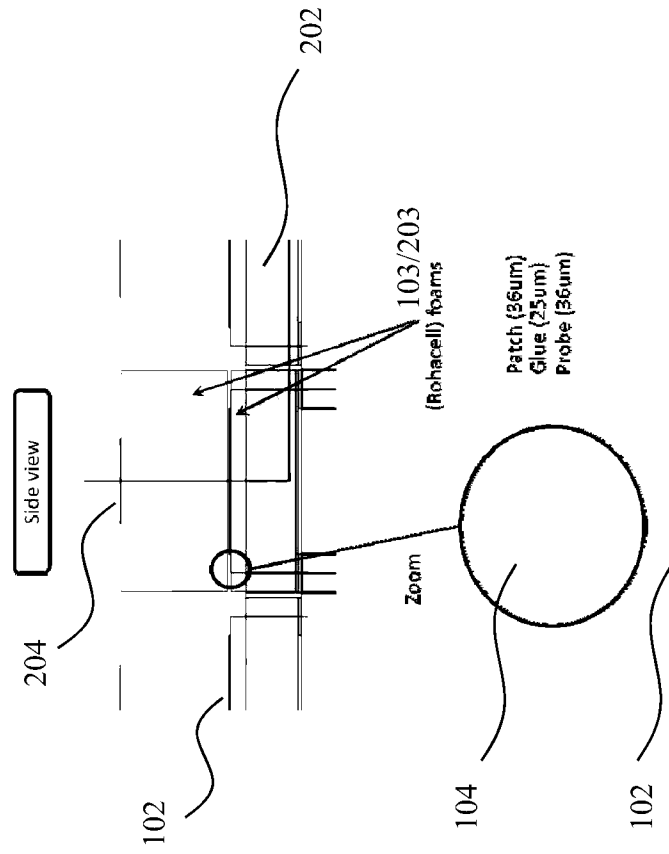


FIG. 7

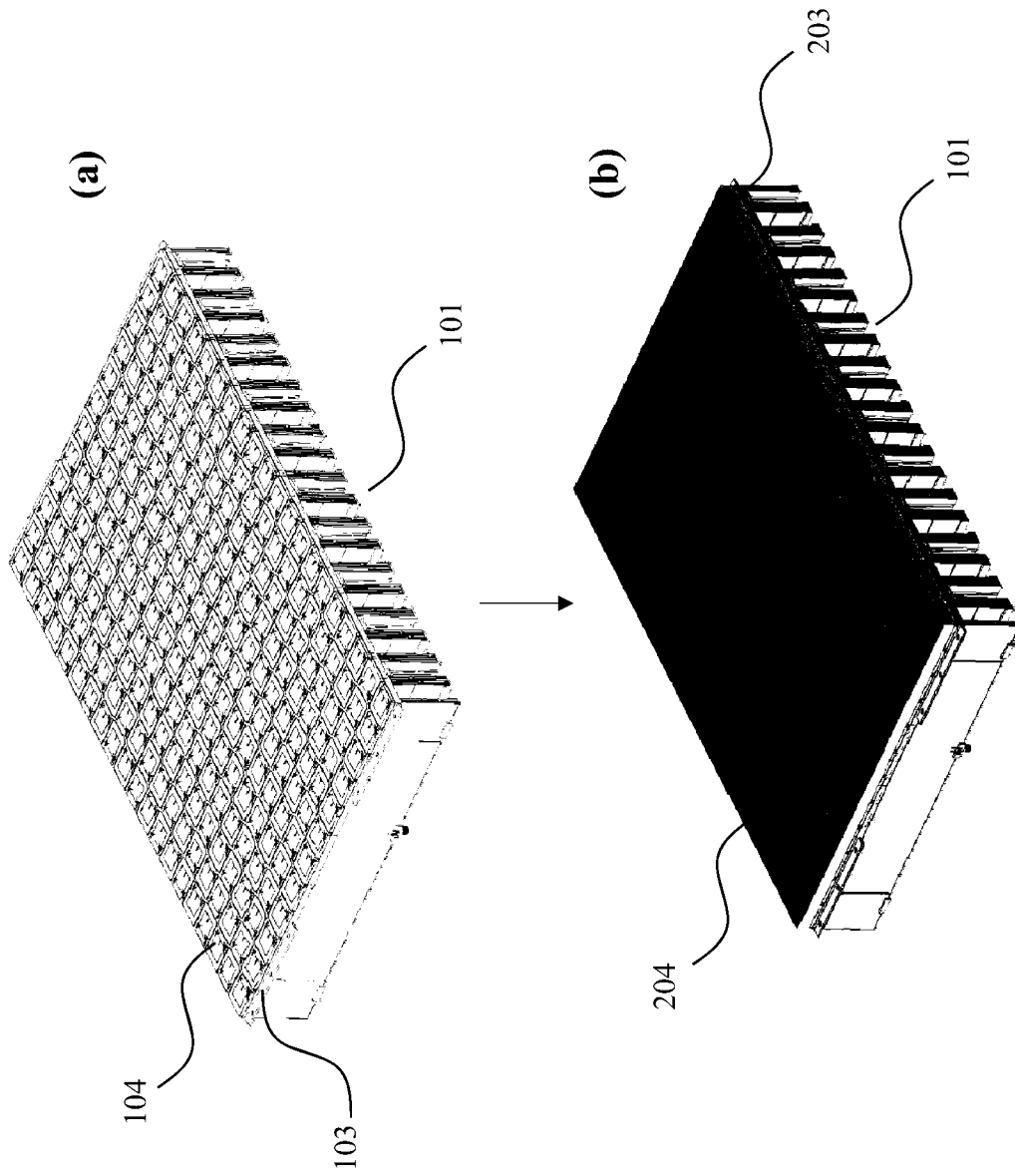


FIG. 8

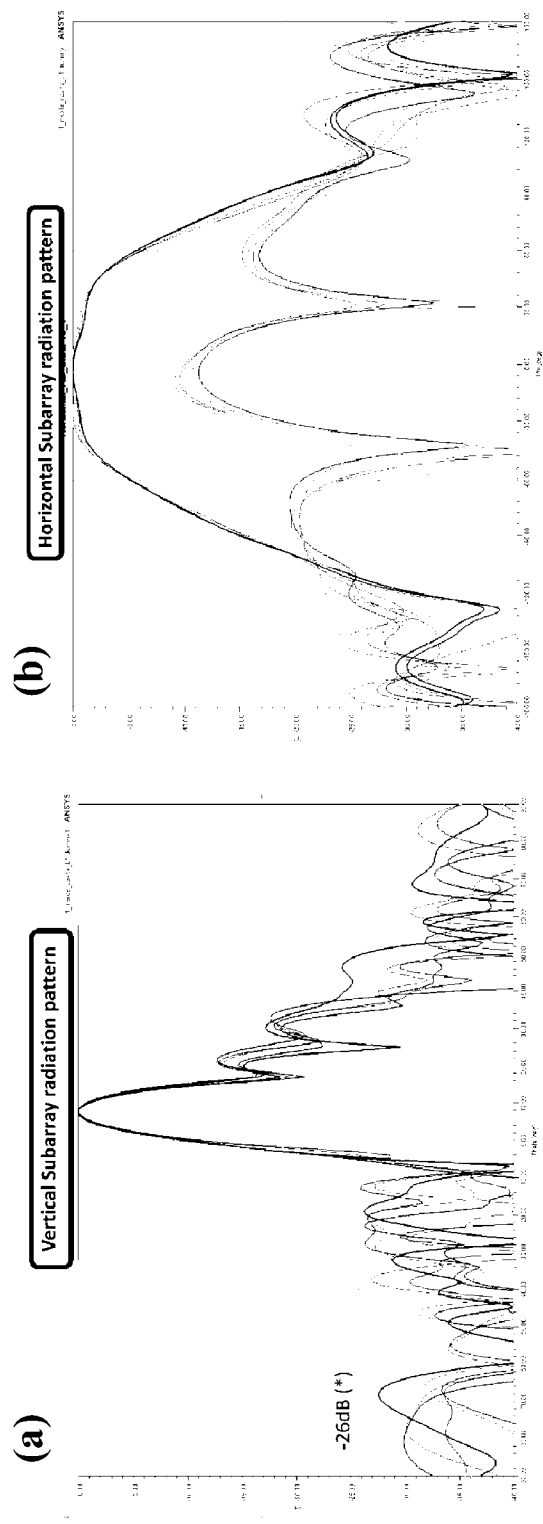


FIG. 9

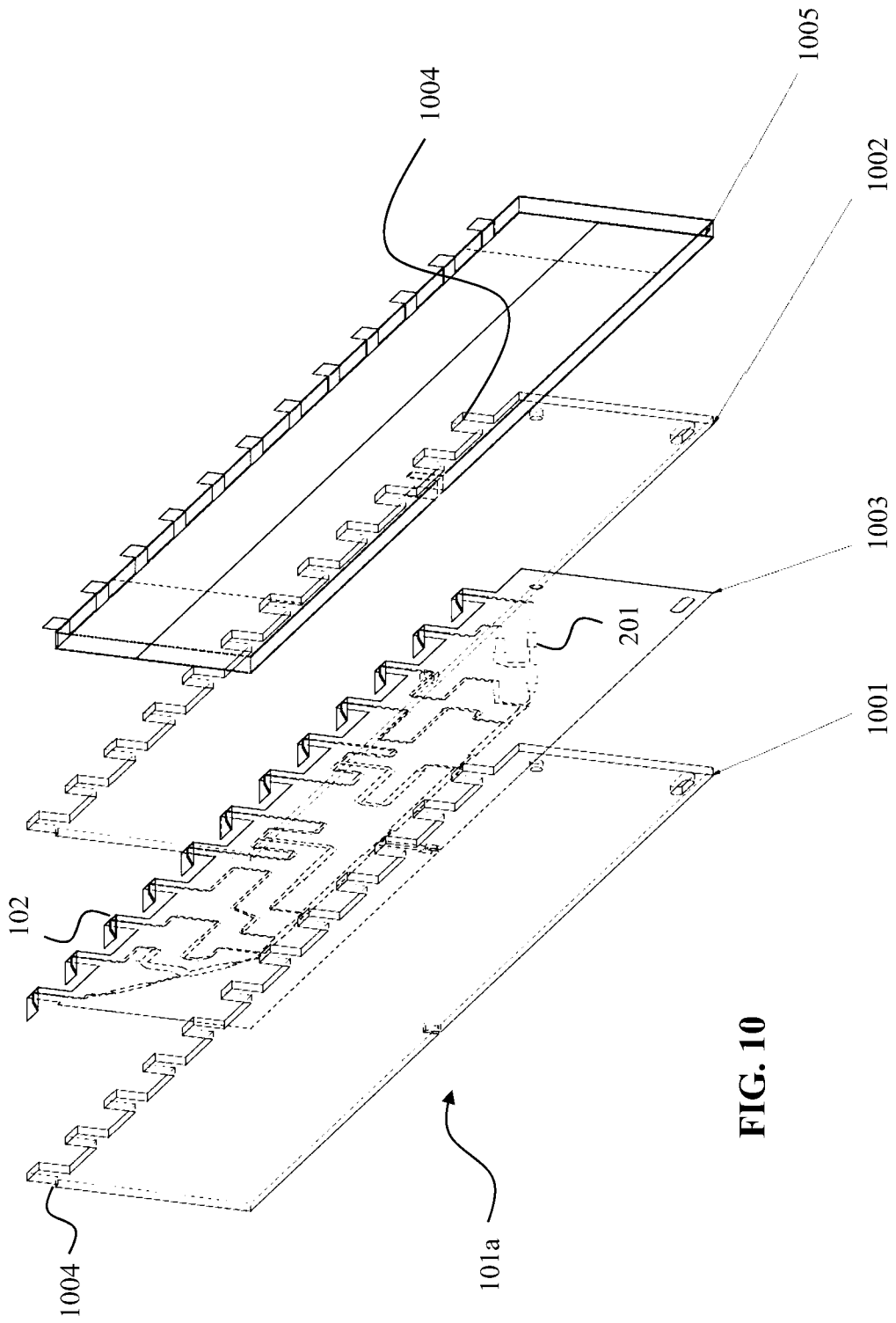


FIG. 10

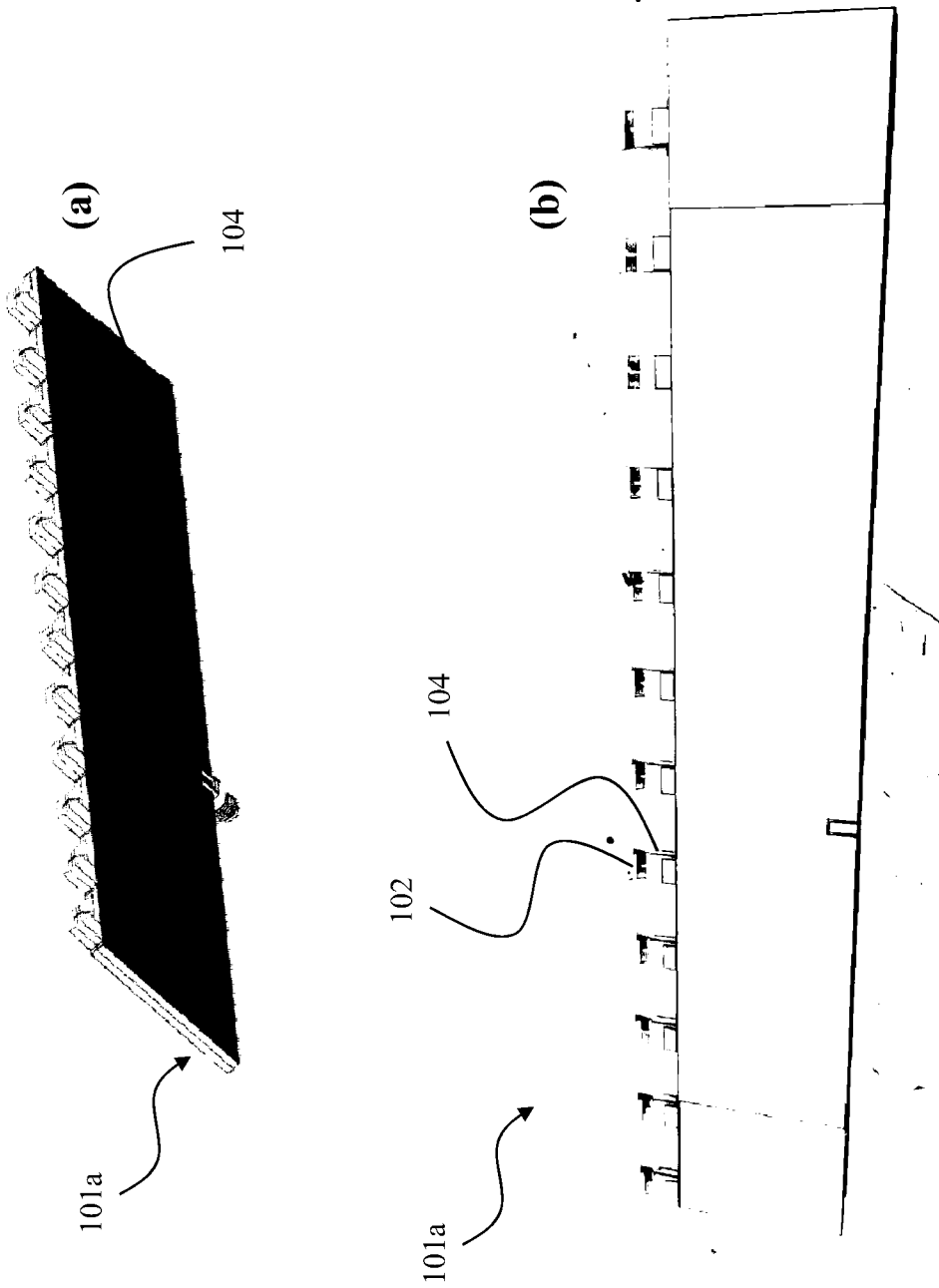


FIG. 11

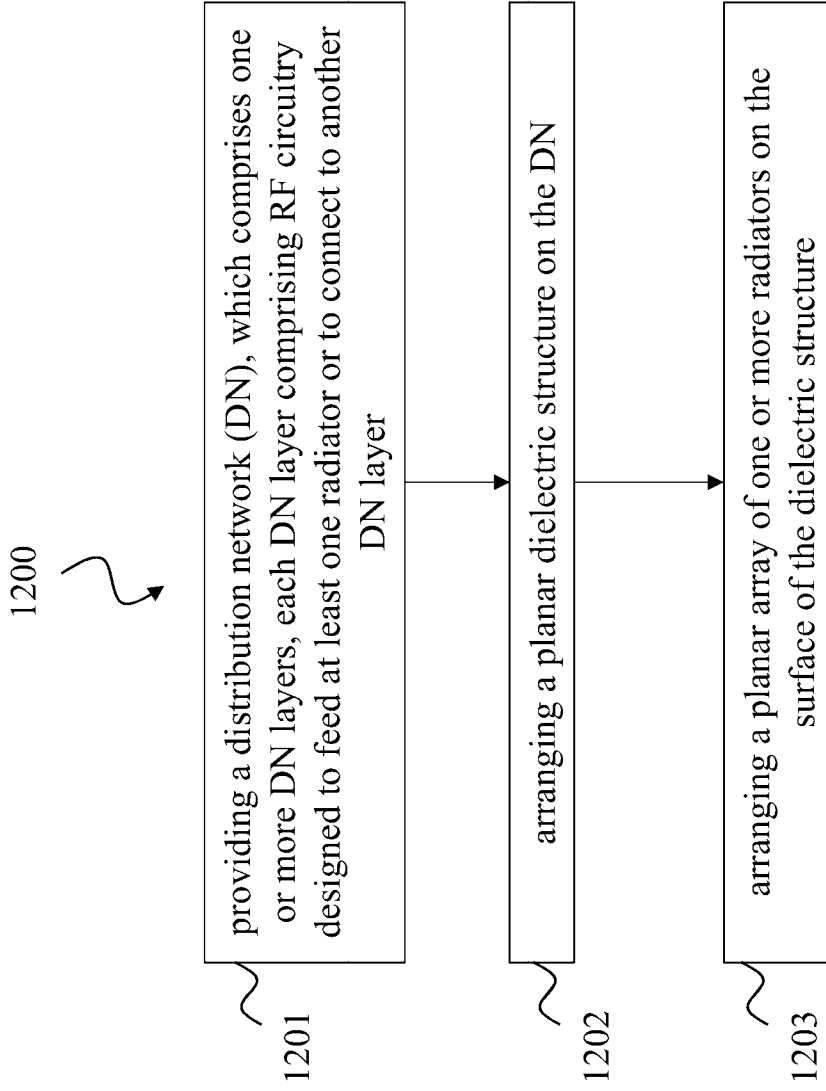


FIG. 12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/098437

A. CLASSIFICATION OF SUBJECT MATTER		
H01Q21/06(2006.01)i		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched IPC:H01Q		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CJFD,CNTXT,ENTXTC,VEN,ENTXT,CNKI,IEEE:distribution,feed,network,DN,power,divider,splitter,allocation,bendable,bent,bended,"L",probe?		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 212412193 U (GUANGDONG TONGYU COMMUNICATION EQUIP CO) 26 January 2021 (2021-01-26) the description, paragraphs 14-18, figures 1-4	1-5, 13, 14, 16-19
A	CN 109193152 A (ANHUI YAOFENG RADAR TECHNOLOGY CO LTD) 11 January 2019 (2019-01-11) the whole document	1-19
A	CN 110176663 A (JIANGSU 3CORETEL INFORMATION COMMUNICATI) 27 August 2019 (2019-08-27) the whole document	1-19
A	CN 113013588 A (UNIV NANJING SCI & TECHNOLOGY) 22 June 2021 (2021-06-22) the whole document	1-19
A	CN 201956461 U (UNIV SOUTHEAST) 31 August 2011 (2011-08-31) the whole document	1-19
A	US 2010177012 A1 (LAIRD TECHNOLOGIES INC) 15 July 2010 (2010-07-15) the whole document	1-19
<input type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "D" document cited by the applicant in the international application "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 23 February 2024		Date of mailing of the international search report 23 February 2024
Name and mailing address of the ISA/CN CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION 6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China		Authorized officer MA,Jing Telephone No. (+86) 010-62412156

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2023/098437

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	212412193	U	26 January 2021	None			
CN	109193152	A	11 January 2019	None			
CN	110176663	A	27 August 2019	None			
CN	113013588	A	22 June 2021	None			
CN	201956461	U	31 August 2011	None			
US	2010177012	A1	15 July 2010	US	8072384	B2	06 December 2011