



(11)

EP 4 510 386 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
19.02.2025 Bulletin 2025/08

(51) International Patent Classification (IPC):
H01Q 13/08 (2006.01)

(21) Application number: **22944355.1**

(52) Cooperative Patent Classification (CPC):
H01Q 13/08

(22) Date of filing: **02.06.2022**

(86) International application number:
PCT/CN2022/096982

(87) International publication number:
WO 2023/231027 (07.12.2023 Gazette 2023/49)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

- **TANG, Zhongshan**
Shenzhen, Guangdong 518129 (CN)
- **WEI, Meng**
Shenzhen, Guangdong 518129 (CN)
- **TAO, Jun**
Shenzhen, Guangdong 518129 (CN)
- **TIAN, Chao**
Shenzhen, Guangdong 518129 (CN)

(71) Applicant: **Shenzhen Yinwang Intelligent Technologies Co., Ltd.**
Shenzhen, Guangdong 518129 (CN)

(74) Representative: **Gill Jennings & Every LLP**
The Broadgate Tower
20 Primrose Street
London EC2A 2ES (GB)

(72) Inventors:
• **GAO, Chen**
Shenzhen, Guangdong 518129 (CN)

(54) **WAVE ABSORBING STRUCTURE, ANTENNA, RADAR, AND TERMINAL**

(57) This application discloses a wave-absorbing structure, an antenna, a radar, and a terminal. The wave-absorbing structure includes a resonance part, a load, and a wave-absorbing part. The resonance part may be configured to resonate with an antenna element that is in the antenna and that is configured to radiate a signal. When the resonance part resonates with the antenna element, the resonance part may receive energy from the antenna element through coupling. The resonance part may feed the load, to transfer the energy to the load. The wave-absorbing part covers the load, so that the energy of the load can be absorbed. In this way, the energy that is coupled from the antenna element to the wave-absorbing structure is absorbed, so that a surface wave of the antenna element can be reduced, and antenna pattern consistency is improved. Therefore, detection precision of the radar can be improved.

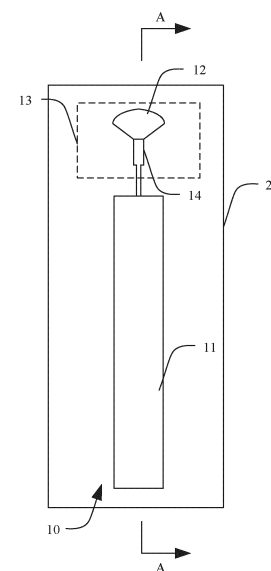


FIG. 1

Description

TECHNICAL FIELD

[0001] This application relates to the field of communication technologies, and in particular, to a wave-absorbing structure, an antenna, a radar, and a terminal.

BACKGROUND

[0002] With the development of in-vehicle radars, a requirement for antenna performance is increasingly high. Pattern consistency is one of important characteristics of an antenna. Better pattern consistency of the antenna indicates higher detection precision of a radar.

[0003] An array antenna layout is usually used in the in-vehicle radar. However, coupling paths such as a surface wave, spatial energy, and spurious emission of a feeder that are of an array antenna may cause a pattern jitter. As a result, pattern consistency of the antenna is not good enough, and consequently, operating performance of an antenna is affected. Therefore, how to improve the pattern consistency of the antenna is an urgent problem to be resolved.

SUMMARY

[0004] This application provides a wave-absorbing structure, an antenna, a radar, and a terminal, to improve pattern consistency of the antenna, so that detection precision of the radar is improved.

[0005] According to a first aspect, this application provides a wave-absorbing structure. The wave-absorbing structure includes a resonance part, a load, and a wave-absorbing part. Specifically, the resonance part is configured to resonate with an antenna element configured to radiate a signal, and is configured to feed the load. The wave-absorbing part is configured to cover the load, and is configured to absorb energy of the load.

[0006] When the wave-absorbing structure is used in an antenna, the resonance part may resonate with an antenna element, and energy is obtained from the antenna element through coupling. The resonance part feeds the load, may transfer coupled energy to the load, and then absorbs the energy by using the wave-absorbing part, to reduce a surface wave of the antenna element, so that pattern consistency of the antenna can be improved.

[0007] Specifically, the resonance part may be configured to resonate at a same frequency with the antenna element, and the same frequency represents a same frequency band. In this way, the resonance part may have an operating mode that is the same as or similar to an operating mode of the antenna element, so that the energy of the antenna element can be effectively transferred to the load.

[0008] When the resonance part does not match the load, the wave-absorbing structure may further include

an impedance transformation part, so that the resonance part is connected to the load through the impedance transformation part, and the resonance part feeds the load.

[0009] A type of the impedance transformation part is not specifically limited in this application. For example, the impedance transformation part may be a single-step impedance transformation part, a multi-section stepped-impedance transformation part, or a tapered-line impedance transformation part.

[0010] In the technical solutions of this application, a type of the load is not specifically limited either. For example, the load may be a single-resonance load or a multi-resonance load. A shape of the load may be a sector, a trapezoid, a rectangle, a spiral, or the like. This is not specifically limited herein.

[0011] When the wave-absorbing part is disposed, the wave-absorbing part may be connected to a dielectric substrate on which the antenna element is located, to fasten a location of the wave-absorbing part. Specifically, the wave-absorbing part may be connected to the dielectric substrate through hot riveting stud, adhesive bonding, threading, or the like.

[0012] According to a second aspect, this application provides an antenna. The antenna specifically includes at least one antenna element, a dielectric substrate, and the wave-absorbing structure in the first aspect. In the antenna with the structure, the wave-absorbing structure may resonate with and be coupled to the antenna element, and absorb coupled energy, so that a surface wave of the antenna element is reduced, thereby improving pattern consistency of the antenna.

[0013] During specific application, the antenna may further include a chip. The chip is disposed on the dielectric substrate, and is connected to the foregoing antenna element, to control the antenna element by using the chip.

[0014] In a specific technical solution, a wave-absorbing part in the wave-absorbing structure may cover the chip. In this way, the wave-absorbing part may implement a function of absorbing energy of a load and the chip, so that a manufacturing procedure can be simplified and manufacturing costs of the antenna can be reduced.

[0015] In another specific technical solution, the antenna may further include a wave-absorbing layer, and the wave-absorbing layer covers the chip. In the technical solution, the wave-absorbing part is configured to absorb energy of a load, and the wave-absorbing layer is configured to absorb energy of a chip layer. Certainly, the wave-absorbing part and the wave-absorbing layer may be made of a same material, to reduce manufacturing costs of the antenna.

[0016] In this application, specific layouts of the antenna element and the wave-absorbing structure are not limited. Specifically, a quantity of wave-absorbing structures and the layout of the wave-absorbing structure may be designed based on the layout of the antenna element. For example, in some technical solutions, the at least one

antenna element may include a first antenna element and a second antenna element, the wave-absorbing structure may include a first wave-absorbing structure, and the first wave-absorbing structure is disposed between the first antenna element and the second antenna element. In this way, the first wave-absorbing structure may absorb energy of the first antenna element and the second antenna element that are adjacent to the first wave-absorbing structure. In other words, when the antenna includes at least two antenna elements, the wave-absorbing structure may be disposed between two adjacent antenna elements.

[0017] In some other technical solutions, the at least one antenna element may include a third antenna element and a fourth antenna element that are adjacently arranged, the wave-absorbing structure includes a second wave-absorbing structure, and the second wave-absorbing structure is disposed on one side of the third antenna element. In other words, when the antenna includes at least two antenna elements that are adjacently disposed, the wave-absorbing structure may be disposed on one side of the antenna elements.

[0018] During actual application, the antenna may use various antenna array layouts. For example, in a specific technical solution, the at least one antenna element may include M fifth antenna elements and N sixth antenna elements, where $M \geq 2$ and $N \geq 1$. The wave-absorbing structure may include a third wave-absorbing structure and a fourth wave-absorbing structure. The M fifth antenna elements have gaps between each other, and the third wave-absorbing structure may be disposed between two adjacent fifth antenna elements. The N sixth antenna elements are adjacently arranged, and the fourth wave-absorbing structure may be disposed on at least one side of the N sixth antenna elements.

[0019] In this application, a type of the antenna element is not specifically limited. For example, the antenna element may be a microstrip antenna, a waveguide antenna, a slot antenna, or the like.

[0020] According to a third aspect, this application provides a radar. The radar includes a housing and at least one antenna in the second aspect, where the at least one antenna is disposed in the housing. In the foregoing radar, a wave-absorbing structure of the antenna may resonate with an antenna element and couple energy, and absorb the coupled energy, so that a surface wave of the antenna element is reduced, and pattern consistency of the antenna is improved, thereby improving detection precision of the radar. It may be understood that, during specific application, a specific shape and a material of the housing may be properly disposed based on an actual situation. This is not limited in this application.

[0021] According to a fourth aspect, this application provides a terminal. The terminal includes a controller and the radar in the third aspect. The controller is connected to the radar, to effectively control an operating status of the radar. Alternatively, the controller may per-

form processing based on data received from the radar for use in driving decision. The terminal may be a vehicle, a mobile phone, a base station, a ship, a satellite, an aircraft, an uncrewed aerial vehicle, or the like. A specific application scenario of the radar is not limited in this application. The terminal can implement relatively accurate detection by using the radar in the third aspect, so that an environment around the terminal can be detected in real time.

BRIEF DESCRIPTION OF DRAWINGS

[0022]

FIG. 1 is a schematic diagram of a structure of a wave-absorbing structure according to an embodiment of this application;

FIG. 2 is a schematic sectional view, along an A-A direction, of the wave-absorbing structure in FIG. 1;

FIG. 3 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application;

FIG. 4 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application;

FIG. 5 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application;

FIG. 6 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application;

FIG. 7 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application;

FIG. 8 is a schematic diagram of a return loss of the wave-absorbing structure in FIG. 1;

FIG. 9 is a schematic diagram of a structure of an antenna according to an embodiment of this application;

FIG. 10 is a schematic sectional view, along a B-B direction, of the antenna in FIG. 9;

FIG. 11 is a schematic diagram of another structure of an antenna according to an embodiment of this application;

FIG. 12 is a schematic diagram of another structure of an antenna according to an embodiment of this application;

FIG. 13 is a schematic sectional view, along a C-C direction, of the antenna in FIG. 12;

FIG. 14 is a schematic diagram of another structure of an antenna according to an embodiment of this application;

FIG. 15 is a schematic diagram of another structure of an antenna according to an embodiment of this application;

FIG. 16 is a schematic diagram of another structure of an antenna according to an embodiment of this application;

FIG. 17 is a horizontal pattern of an antenna without a wave-absorbing structure at a frequency of 76 GHz; FIG. 18 is a horizontal pattern of an antenna with a wave-absorbing structure at a frequency of 76 GHz; FIG. 19 is a horizontal pattern of an antenna without a wave-absorbing structure at a frequency of 81 GHz; and FIG. 20 is a horizontal pattern of an antenna with a wave-absorbing structure at a frequency of 81 GHz.

Reference numerals:

[0023]

10: wave-absorbing structure; 11: resonance part; 12: load; 13: wave-absorbing part; 14: impedance transformation part; 20: antenna; 21: antenna element; 22: dielectric substrate; 23: chip; 24: wave-absorbing layer; 25: ground plane; 10a: first wave-absorbing structure; 10b: second wave-absorbing structure; 10c: third wave-absorbing structure; 10d: fourth wave-absorbing structure; 21a: first antenna element; 21b: second antenna element; 21c: third antenna element; 21d: fourth antenna element; 21e: fifth antenna element; 21f: sixth antenna element.

DESCRIPTION OF EMBODIMENTS

[0024] To make the objectives, technical solutions, and advantages of this application clearer, the following further describes this application in detail with reference to the accompanying drawings.

[0025] Reference to "an embodiment", "some embodiments", or the like described in this specification indicates that one or more embodiments of this application include a specific feature, structure, or characteristic described with reference to embodiments. Therefore, statements such as "in an embodiment", "in another embodiment", "in some embodiments", "in other embodiments", or "in some other embodiments" that appear at different places in this specification do not necessarily mean reference to a same embodiment. Instead, the statements mean "one or more but not all of embodiments", unless otherwise specifically emphasized in another manner. The terms "include", "comprise", "have", and variants thereof all mean "including but not limited to", unless otherwise specifically emphasized in another manner.

[0026] Terms used in the following embodiments are merely intended to describe particular embodiments, but are not intended to limit this application. The terms "one", "a", "the", "the foregoing", "this", and "the one" of singular forms used in this specification and the appended claims of this application are also intended to include expres-

sions such as "one or more", unless otherwise specified in the context clearly.

[0027] With the development of communication technologies, radars are widely used in vehicles. The radar usually transmits and receives an electromagnetic wave by using a planar antenna, to obtain location information about a measured object. An in-vehicle millimeter-wave radar is used as an example. The in-vehicle millimeter-wave radar may transmit and receive a millimeter wave by using a microstrip antenna, and then quickly and accurately obtain information about the measured object after the millimeter wave is processed. However, in a process of transmitting and receiving the millimeter wave, the microstrip antenna may excite a surface wave on a surface of a dielectric substrate, and the surface wave may generate radiation at a discontinuous place. As a result, antenna bandwidth is affected, a pattern generated by the microstrip antenna may also be distorted, and consequently, detection precision of the in-vehicle millimeter-wave radar is affected.

[0028] Therefore, this application provides a wave-absorbing structure, an antenna, a radar, and a terminal, to improve pattern consistency of the antenna, so that detection precision of the radar is improved.

[0029] FIG. 1 is a schematic diagram of a structure of a wave-absorbing structure according to an embodiment of this application. FIG. 2 is a schematic sectional view, along an A-A direction, of the wave-absorbing structure in FIG. 1. As shown in FIG. 1 and FIG. 2, this application provides a wave-absorbing structure 10. The wave-absorbing structure 10 may be used in an antenna, or may be used in another apparatus that needs to absorb radiation energy. The following describes the wave-absorbing structure 10 in this application by using an antenna application scenario as an example.

[0030] When the wave-absorbing structure 10 is used in the antenna, the wave-absorbing structure 10 may be disposed on a dielectric substrate 22 of the antenna. Specifically, the wave-absorbing structure 10 includes a resonance part 11, a load 12, and a wave-absorbing part 13. The resonance part 11 may be configured to resonate with an antenna element that is in the antenna and that is configured to radiate a signal. When the resonance part 11 resonates with the antenna element, energy may be coupled from the antenna element to the resonance part 11. The resonance part 11 may feed the load 12, so that the energy coupled from the antenna element can be transferred to the load 12. For ease of illustration, only a dashed line is used to indicate a location of the wave-absorbing part 13 in FIG. 1, but a shape and a size of the wave-absorbing part 13 are not limited. Actually, as shown in FIG. 2, when the load 12 is disposed on the dielectric substrate 22, the wave-absorbing part 13 covers the load 12, to absorb the energy of the load 12. In other words, the wave-absorbing part 13 surrounds a periphery of the load 12, so that the energy radiated by the load 12 is absorbed by the wave-absorbing part 13. In addition, to absorb the energy of the load 12 more effec-

tively, the wave-absorbing part 13 may be further fastened to a position covering the load 12. For example, in a specific embodiment, the wave-absorbing part 13 may be connected to the dielectric substrate 22, to fasten the location of the wave-absorbing part 13. In this embodiment, the wave-absorbing part 13 may be connected to the dielectric substrate 22 through hot riveting stud, adhesive bonding, threading, or the like. This is not specifically limited herein. Certainly, in another embodiment, the wave-absorbing part 13 may alternatively be connected to the load 12. In this way, the energy coupled from the antenna element to the wave-absorbing structure 10 is absorbed by the wave-absorbing part 13, so that a surface wave of the antenna element can be reduced, and pattern consistency of the antenna can be improved.

[0031] The resonance part 11 resonates with and is coupled to the antenna element, to transfer the energy of the antenna element to the wave-absorbing structure 10. For example, in some embodiments, the resonance may be resonance at a same frequency. To be specific, the resonance part 11 may be configured to resonate at a same frequency with the antenna element, and the same frequency represents a same frequency band. In this case, when the antenna operates, the resonance part 11 resonates in an operating frequency band of the antenna element. In this way, the resonance part 11 may have an operating mode that is the same as or similar to an operating mode of the antenna element, so that the energy of the antenna element can be effectively transferred to the load 12.

[0032] In some embodiments, when the resonance part 11 matches the load 12, the resonance part 11 may be directly connected to the load 12, to feed the load 12. Optionally, when the resonance part 11 does not match the load 12, the wave-absorbing structure 10 may further include an impedance transformation part 14, so that the resonance part 11 is connected to the load 12 through the impedance transformation part 14, and the resonance part 11 feeds the load 12 after impedance transformation is performed on the energy that is coupled from the antenna element to the resonance part 11.

[0033] It should be noted that a specific type of the impedance transformation part 14 is not limited in this embodiment of this application, and is subject to a function that impedance transformation can be implemented. As shown in FIG. 1, in some embodiments, the impedance transformation part 14 may be a multi-section stepped-impedance transformation part. FIG. 3 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application. As shown in FIG. 3, in some other embodiments, the impedance transformation part 14 may alternatively be a single-step impedance transformation part. FIG. 4 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application. As shown in FIG. 4, in some other embodiments, the impedance transformation part 14 may alter-

natively be a tapered-line impedance transformation part.

[0034] In this embodiment of this application, a type of the load 12 is not specifically limited either. For example, the load 12 may be a single-resonance load or a multi-resonance load. In addition, a specific shape of the load 12 is not limited. As shown in FIG. 1 to FIG. 4, in some embodiments, the shape of the load 12 may be a sector. FIG. 5 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application. As shown in FIG. 5, in some other embodiments, the shape of the load 12 may alternatively be a trapezoid. FIG. 6 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application. As shown in FIG. 6, in some other embodiments, the shape of the load 12 may alternatively be a rectangle. In addition, the load 12 may alternatively be a spiral, an irregular shape, or the like. This is not specifically limited herein. Certainly, during actual application, coupled energy may be selected and determined based on the operating mode of the antenna element, to design parameters such as a specific type, a shape, and/or a size of the load 12. FIG. 7 is a schematic diagram of another structure of a wave-absorbing structure according to an embodiment of this application. As shown in FIG. 7, in a specific embodiment, the shape of the load 12 may alternatively be an irregular shape formed by combining a trapezoid and a sector. In another specific embodiment, the shape of the load 12 may alternatively be an irregular shape formed by combining a trapezoidal structure and a rectangular structure.

[0035] It should be noted that, for ease of illustrating the load 12 and the impedance transformation part 14, the wave-absorbing part 13 is not shown in the wave-absorbing structure 10 in FIG. 3 to FIG. 7.

[0036] When the wave-absorbing structure 10 operates, a return loss (Return Loss, RL) of the wave-absorbing structure 10 changes with a frequency. In the communication field, the return loss is a ratio of power reflected by an input signal to power of the input signal. Usually, the return loss is in a unit of decibel (dB), and a value is a negative number. In a desirable case, when the wave-absorbing structure 10 in this application completely matches impedance, reflected power is zero, that is, there is no reflected power. In this case, the return loss is infinitesimal. When input power is completely reflected, the return loss is 0 dB. However, during actual application, the impedance cannot be completely matched. Therefore, the wave-absorbing structure 10 has reflected power, and a smaller value of the return loss indicates better wave-absorbing performance of the wave-absorbing structure 10.

[0037] FIG. 8 is a schematic diagram of a return loss of the wave-absorbing structure in FIG. 1. As shown in FIG. 8, an example in which an operating frequency of the antenna element is between 73 GHz and 81 GHz is used. Generally, in the field of mobile communication, the return loss is generally required to be less than -14 dB. How-

ever, the return loss of the wave-absorbing structure 10 in this application is between -45 dB and -47 dB. In other words, the wave-absorbing structure 10 does not generate a large quantity of return losses when absorbing the energy of the antenna element. In this case, radiation of a surface wave on an antenna array, so that energy coupling between antenna elements can be improved, and pattern consistency of the antenna can be improved.

[0038] Based on a same technical concept, this application provides an antenna. FIG. 9 is a schematic diagram of a structure of an antenna according to an embodiment of this application. FIG. 10 is a schematic sectional view, along a B-B direction, of the antenna in FIG. 9. As shown in FIG. 9 and FIG. 10, an antenna 20 specifically includes at least one antenna element 21, a dielectric substrate 22, and the wave-absorbing structure 10 in the foregoing embodiment. In the antenna 20 with the structure, the antenna element 21 and the wave-absorbing structure 10 may be disposed on a same side of the dielectric substrate 22 and adjacently disposed. The wave-absorbing structure 10 is configured to: resonate with and be coupled to the antenna element 21, and absorb coupled energy, so that a surface wave of the antenna element 21 is reduced, and pattern consistency of the antenna 20 is improved.

[0039] FIG. 11 is a schematic diagram of another structure of an antenna according to an embodiment of this application. As shown in FIG. 11, in a specific embodiment, the antenna element 21 is a waveguide antenna. A resonance part 11 of the wave-absorbing structure 10 is connected to and resonates with the antenna element 21. Certainly, in addition, the antenna element 21 may alternatively be a microstrip antenna, a slot antenna, or the like. This is not specifically limited herein.

[0040] Still refer to FIG. 9 and FIG. 10. The antenna 20 may further include a chip 23. The chip 23 is disposed on the dielectric substrate 22, and is connected to the antenna element 21, to control the antenna element 21 by using the chip 23. In some embodiments of this application, a wave-absorbing part 13 may cover the chip 23. In this embodiment, the wave-absorbing part 13 may implement a function of absorbing energy of a load 12 and the chip 23, so that a manufacturing procedure can be simplified and manufacturing costs of the antenna 20 can be reduced. In addition, during specific application, the antenna 20 may further include a ground plane 25. The ground plane 25 is disposed on a side that is of the dielectric substrate 22 and that is away from the antenna element 21.

[0041] FIG. 12 is a schematic diagram of another structure of an antenna according to an embodiment of this application. FIG. 13 is a schematic sectional view, along a C-C direction, of the antenna in FIG. 12. As shown in FIG. 12 and FIG. 13, in some other embodiments, the antenna 20 may alternatively include a wave-absorbing layer 24, and the wave-absorbing layer 24 covers the chip 23. In this embodiment, the wave-absorbing part 13 is configured to absorb the energy of the load 12, and the

wave-absorbing layer 24 is configured to absorb the energy of the chip 23. Certainly, the wave-absorbing part 13 and the wave-absorbing layer 24 may be made of a same material, to reduce the manufacturing costs of the antenna 20.

[0042] In this application, specific layouts of the antenna element 21 and the wave-absorbing structure 10 are not limited. FIG. 14 is a schematic diagram of another structure of an antenna according to an embodiment of this application. As shown in FIG. 14, in some embodiments, the at least one antenna element 21 may include a first antenna element 21a and a second antenna element 21b, the wave-absorbing structure 10 may include a first wave-absorbing structure 10a, and the first wave-absorbing structure 10a is disposed between the first antenna element 21a and the second antenna element 21b. In this way, the first wave-absorbing structure 10a may absorb energy of the first antenna element 21a and the second antenna element 21b that are adjacent to the first wave-absorbing structure 10a. In other words, when the antenna 20 includes at least two antenna elements 21 that are spaced from each other, the wave-absorbing structure 10 may be disposed between two adjacent antenna elements 21.

[0043] FIG. 15 is a schematic diagram of another structure of an antenna according to an embodiment of this application. As shown in FIG. 15, in some other embodiments, the at least one antenna element 21 may include a third antenna element 21c and a fourth antenna element 21d that are adjacently arranged, and the wave-absorbing structure 10 includes a second wave-absorbing structure 10b. The second wave-absorbing structure 10b is disposed on one side of the third antenna element 21c. In other words, when the antenna 20 includes at least two antenna elements 21 that are adjacently disposed, the wave-absorbing structure 10 may be disposed on one side of the antenna elements 21. Certainly, the second wave-absorbing structure 10b may also be disposed on the other side of the plurality of antenna elements 21 that are adjacently disposed, or no second wave-absorbing structure 10b may be disposed. This is not specifically limited herein.

[0044] During actual application, the antenna 20 may use various antenna array layouts, and a quantity of wave-absorbing structures 10 and a location of the wave-absorbing structure 10 may be disposed based on a specific antenna array layout. FIG. 16 is a schematic diagram of another structure of an antenna according to an embodiment of this application. As shown in FIG. 16, in a specific embodiment, the at least one antenna element 21 may include M fifth antenna elements 21e and N sixth antenna elements 21f, where $M \geq 2$ and $N \geq 1$. The wave-absorbing structure 10 may include a third wave-absorbing structure 10c and a fourth wave-absorbing structure 10d. The M fifth antenna elements 21e may have gaps between each other, and the at least one third wave-absorbing structure 10c is disposed between two adjacent fifth antenna elements 21e. The N sixth antenna

elements 21f are adjacently arranged, and the at least one fourth wave-absorbing structure 10d is disposed on at least one side of the N sixth antenna elements 21f.

[0045] The antenna 20 is further described by using an example in which the antenna element 21 uses a 3T4R (3 Transmitter & 4 Receiver) antenna element array. The wave-absorbing structure 10 may resonates with each antenna element 21. Specifically, the 3T4R antenna element array includes three fifth antenna elements 21e and four sixth antenna elements 21f. Two third wave-absorbing structures 10c may be disposed between any two adjacent fifth antenna elements 21e. In addition, eight wave-absorbing structures 10 may be respectively disposed on two sides of the three fifth antenna elements 21e. The four sixth antenna elements 21f are adjacently disposed, and ten fourth wave-absorbing structures 10d are respectively disposed on two sides of the four sixth antenna elements 21f.

[0046] An example in which an operating frequency is 76 GHz is used. A 3T4R antenna in which the wave-absorbing structure 10 is disposed is compared with a 3T4R antenna in which no wave-absorbing structure 10 is disposed. FIG. 17 is a horizontal pattern of an antenna without a wave-absorbing structure at a frequency of 76 GHz. It should be noted that, in FIG. 17, a horizontal coordinate represents a theta (θ , in a unit of degree (deg)) component, and a vertical coordinate represents a gain (in a unit of decibel (dB)). A schematic diagram above the horizontal coordinate indicates that in a condition of the frequency of 76 GHz, when a phi (ϕ , in a unit of degree (deg)) component is 0 degrees, an increment of each of the four sixth antenna elements changes with θ . A schematic diagram below the horizontal coordinate indicates that in the condition of the frequency of 76 GHz, when the phi component is 90 degrees, the increment of each of the four sixth antenna elements changes with θ . As shown in FIG. 17, when the antenna without the wave-absorbing structure 10 operates at the frequency of 76 GHz, coupling is performed between the sixth antenna elements due to impact of the surface wave. As a result, fluctuation of a gain of the sixth antenna element is relatively large at a large angle (when theta is near ± 70 degrees, as shown by D in FIG. 17) on a horizontal plane (that is, phi = 0 degrees), and a maximum difference of the gain is 4.1 dB. Therefore, consistency between the sixth antenna elements is relatively poor. FIG. 18 is a horizontal pattern of an antenna with a wave-absorbing structure at a frequency of 76 GHz. It should be noted that, in FIG. 18, a horizontal coordinate represents the theta component, and a vertical coordinate represents the gain. A schematic diagram above the horizontal coordinate indicates that in the condition of the frequency of 76 GHz, when the phi component is 0 degrees, the increment of each of the four sixth antenna elements 21f changes with θ . A schematic diagram below the horizontal coordinate indicates that in the condition of the frequency of 76 GHz, when the phi component is 90 degrees, the increment of each of the four sixth antenna

elements 21f changes with θ . As shown in FIG. 18, when the antenna 20 in this embodiment of this application operates at the frequency of 76 GHz, because the wave-absorbing structure 10 absorbs energy of an adjacent antenna element 21, the fluctuation of the gain of the sixth antenna element 21f is relatively large at the large angle (when theta is near ± 70 degrees, as shown by E in FIG. 18) on the horizontal plane (that is, phi = 0 degrees), and the maximum difference of the gains is 0.2 dB. Compared with the antenna without the wave-absorbing structure 10, the fluctuation of the gain is reduced.

[0047] An example in which the operating frequency is 81 GHz is used. The 3T4R antenna in which the wave-absorbing structure 10 is disposed is compared with the 3T4R antenna in which no wave-absorbing structure 10 is disposed. FIG. 19 is a horizontal pattern of an antenna without a wave-absorbing structure at a frequency of 81 GHz. It should be noted that, in FIG. 19, a horizontal coordinate represents the theta component, and a vertical coordinate represents the gain. A schematic diagram above the horizontal coordinate indicates that in a condition of the frequency of 81 GHz, when the phi component is 0 degrees, the increment of each of the four sixth antenna elements changes with θ . A schematic diagram below the horizontal coordinate indicates that in the condition of the frequency of 81 GHz, when the phi component is 90 degrees, the increment of each of the four sixth antenna elements changes with θ . As shown in FIG. 19, when the antenna without the wave-absorbing structure 10 operates at the frequency of 81 GHz, coupling is performed between the sixth antenna elements due to the impact of the surface wave. As a result, fluctuation of the gain of the sixth antenna element is relatively large at the large angle (when theta is near ± 70 degrees, as shown by F in FIG. 19) on the horizontal plane (that is, phi = 0 degrees), and a maximum difference of the gain is 7.2 dB. Therefore, consistency between the sixth antenna elements is relatively poor. FIG. 20 is a horizontal pattern of an antenna with a wave-absorbing structure at a frequency of 81 GHz. It should be noted that, in FIG. 20, a horizontal coordinate represents the theta component, and a vertical coordinate represents the gain. A schematic diagram above the horizontal coordinate indicates that in the condition of the frequency of 81 GHz, when the phi component is 0 degrees, the increment of each of the four sixth antenna elements 21f changes with θ . A schematic diagram below the horizontal coordinate indicates that in the condition of the frequency of 81 GHz, when the phi component is 90 degrees, the increment of each of the four sixth antenna elements 21f changes with θ . As shown in FIG. 20, when the antenna 20 in this embodiment of this application operates at the frequency of 81 GHz, because the wave-absorbing structure 10 absorbs the energy of the adjacent antenna element 21, the fluctuation of the gain of the sixth antenna element 21f is relatively large at the large angle (when theta is near ± 70 degrees, as shown by G in FIG. 20) on the horizontal plane (that is, phi = 0 degrees),

and the maximum difference of the gains is 3.8 dB. Compared with the antenna without the wave-absorbing structure 10, the fluctuation of the gain is reduced.

[0048] Therefore, the wave-absorbing structure 10 in this application can effectively absorb the energy of the antenna element 21, reduce energy coupling between the antenna elements 21, and suppress the surface wave of the antenna, so that a fluctuation of a gain of a pattern of the antenna 20 at a large angle on a horizontal plane can be improved, and consistency between the antenna elements 21 can be improved.

[0049] Based on a same technical concept, this application further provides a radar. Specifically, the radar includes a housing and at least one antenna 20 in the foregoing embodiment. Specifically, the antenna 20 may be disposed in the housing. In the radar in this embodiment, a wave-absorbing structure 10 in the antenna 20 may resonate with and be coupled to an antenna element 21 in the antenna 20, and absorb energy received through coupling, to improve energy coupling between antenna elements 21, reduce a surface wave of the antenna 20 array, improve pattern consistency of the antenna 20, so that detection precision of the radar can be further improved. It may be understood that, during specific application, a specific shape and a material of the housing may be properly disposed based on an actual situation. This is not limited in this application.

[0050] Based on a same technical concept, this application further provides a terminal. The terminal includes a controller and the radar in the foregoing embodiment. The controller is connected to the radar, to effectively control an operating status of the radar. Alternatively, the controller may perform processing based on data received from the radar for use in driving decision. The terminal may be a vehicle, a mobile phone, a base station, a ship, a satellite, an aircraft, an uncrewed aerial vehicle, or the like. A specific application scenario of the radar is not limited in this application.

[0051] It is clear that a person skilled in the art can make various modifications and variations to this application without departing from the scope of this application. This application is intended to cover these modifications and variations of this application provided that they fall within the scope of protection defined by the claims of this application and their equivalent technologies.

Claims

1. A wave-absorbing structure, comprising a resonance part, a load, and a wave-absorbing part, wherein

the resonance part is configured to resonate with an antenna element configured to radiate a signal, and is configured to feed the load; and the wave-absorbing part is configured to cover the load, and is configured to absorb energy of

the load.

2. The wave-absorbing structure according to claim 1, wherein the resonance part is configured to resonate at a same frequency with the antenna element, and the same frequency represents a same frequency band.
3. The wave-absorbing structure according to claim 1 or 2, wherein the wave-absorbing structure further comprises an impedance transformation part, and the impedance transformation part is connected to the resonance part and the load.
4. The wave-absorbing structure according to claim 3, wherein the impedance transformation part comprises a single-step impedance transformation part, a multi-section stepped-impedance transformation part, or a tapered-line impedance transformation part.
5. The wave-absorbing structure according to any one of claims 1 to 4, wherein the load comprises a single-resonance load or a multi-resonance load.
6. The wave-absorbing structure according to any one of claims 1 to 5, wherein a shape of the load is a sector, a trapezoid, a rectangle, or a spiral.
7. The wave-absorbing structure according to any one of claims 1 to 6, wherein the wave-absorbing part is connected to a dielectric substrate on which the antenna element is located.
8. An antenna, comprising at least one antenna element, a dielectric substrate, and the wave-absorbing structure according to any one of claims 1 to 7.
9. The antenna according to claim 8, wherein the antenna further comprises a chip, and the chip is disposed on the dielectric substrate, and is connected to the at least one antenna element.
10. The antenna according to claim 9, wherein the wave-absorbing part covers the chip.
11. The antenna according to claim 9, wherein the antenna further comprises a wave-absorbing layer, and the wave-absorbing layer covers the chip.
12. The antenna according to any one of claims 8 to 11, wherein the at least one antenna element comprises a first antenna element and a second antenna element, the wave-absorbing structure comprises a first wave-absorbing structure, and the first wave-absorbing structure is disposed between the first antenna element and the second antenna element.

13. The antenna according to any one of claims 8 to 11, wherein the at least one antenna element comprises a third antenna element and a fourth antenna element that are adjacently arranged, the wave-absorbing structure comprises a second wave-absorbing structure, and the second wave-absorbing structure is disposed on one side of the third antenna element. 5
14. The antenna according to any one of claims 8 to 11, wherein the at least one antenna element comprises M fifth antenna elements and N sixth antenna elements, wherein $M \geq 2$ and $N \geq 1$; and the wave-absorbing structure comprises a third wave-absorbing structure and a fourth wave-absorbing structure, the M fifth antenna elements have gaps between each other, the third wave-absorbing structure is disposed between two adjacent fifth antenna elements, the N sixth antenna elements are adjacently arranged, and the fourth wave-absorbing structure is disposed on at least one side of the N sixth antenna elements. 10 15 20
15. The antenna according to any one of claims 8 to 14, wherein the antenna element comprises a microstrip antenna, a waveguide antenna, or a slot antenna. 25
16. A radar, comprising a housing and at least one antenna according to any one of claims 8 to 15, wherein the at least one antenna is disposed in the housing. 30
17. A terminal, comprising a controller and the radar according to claim 16, wherein the controller is connected to the radar. 35

40

45

50

55

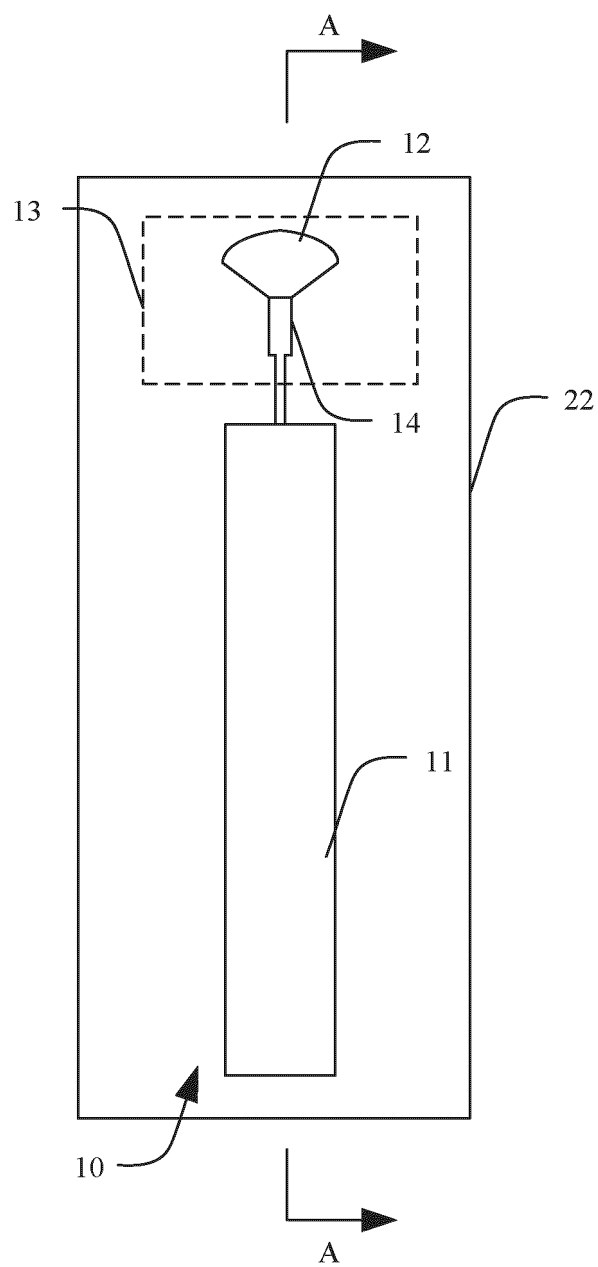


FIG. 1

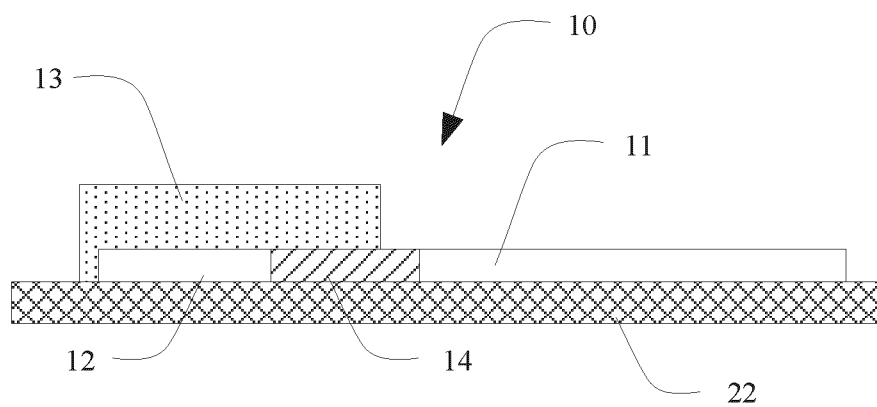


FIG. 2

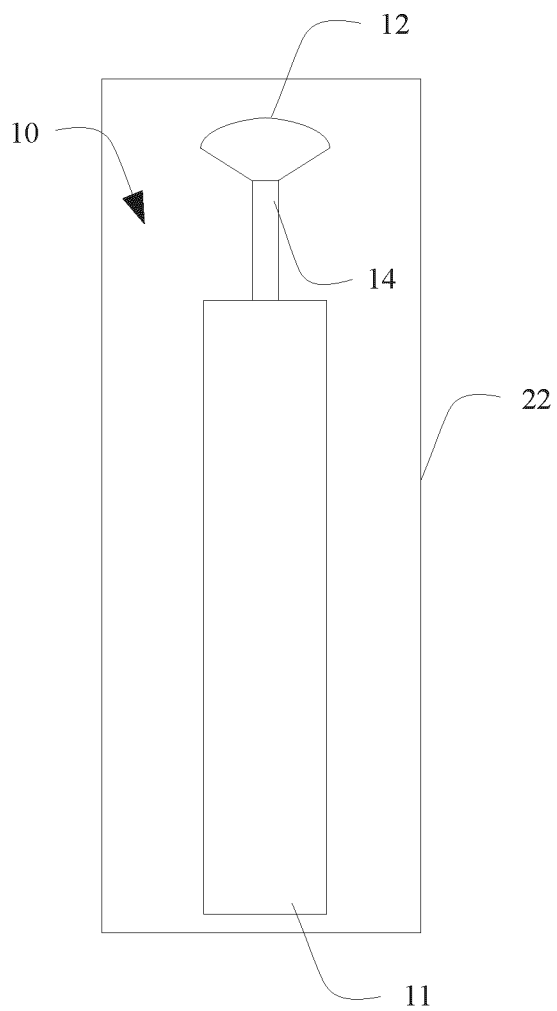


FIG. 3

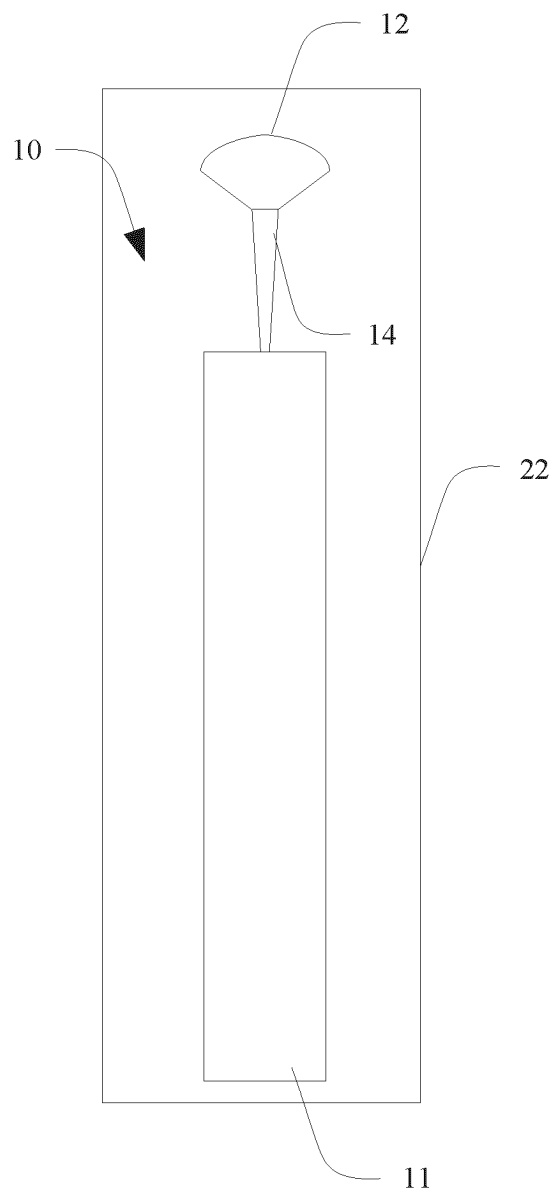


FIG. 4

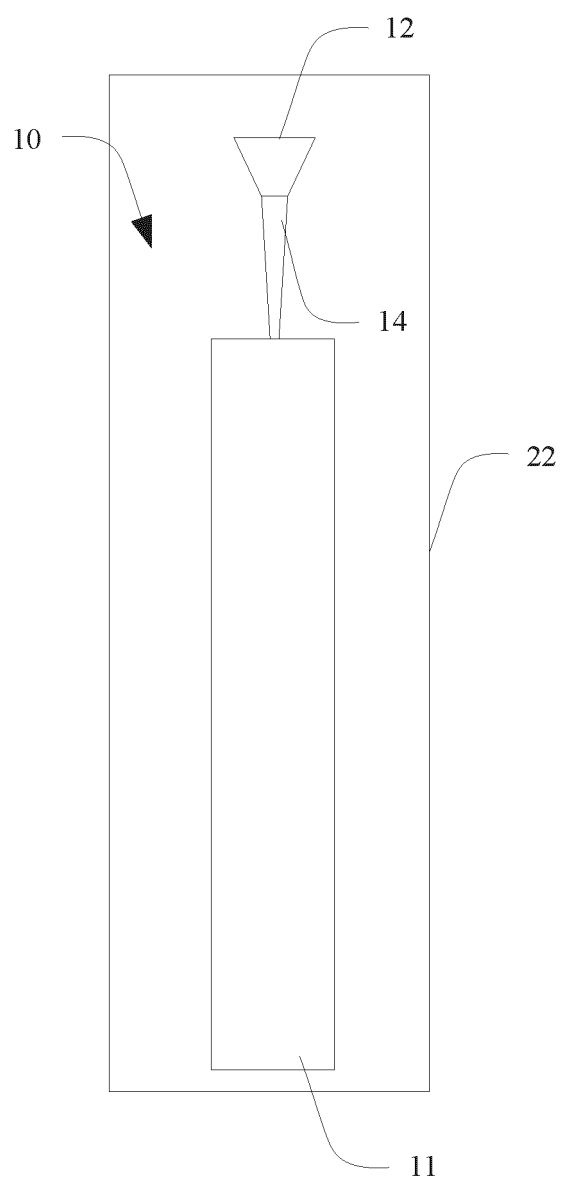


FIG. 5

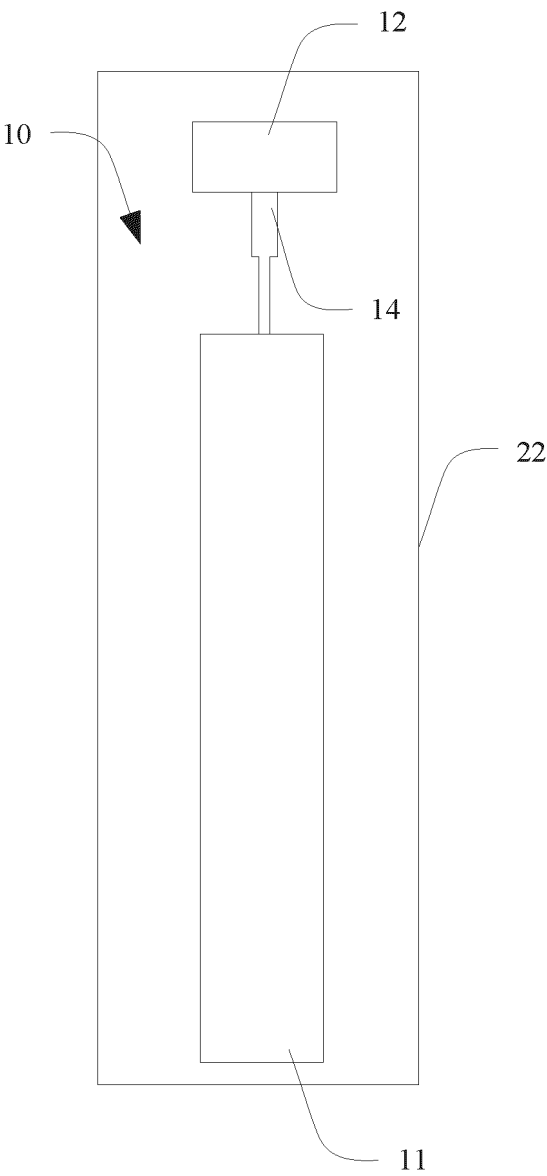


FIG. 6

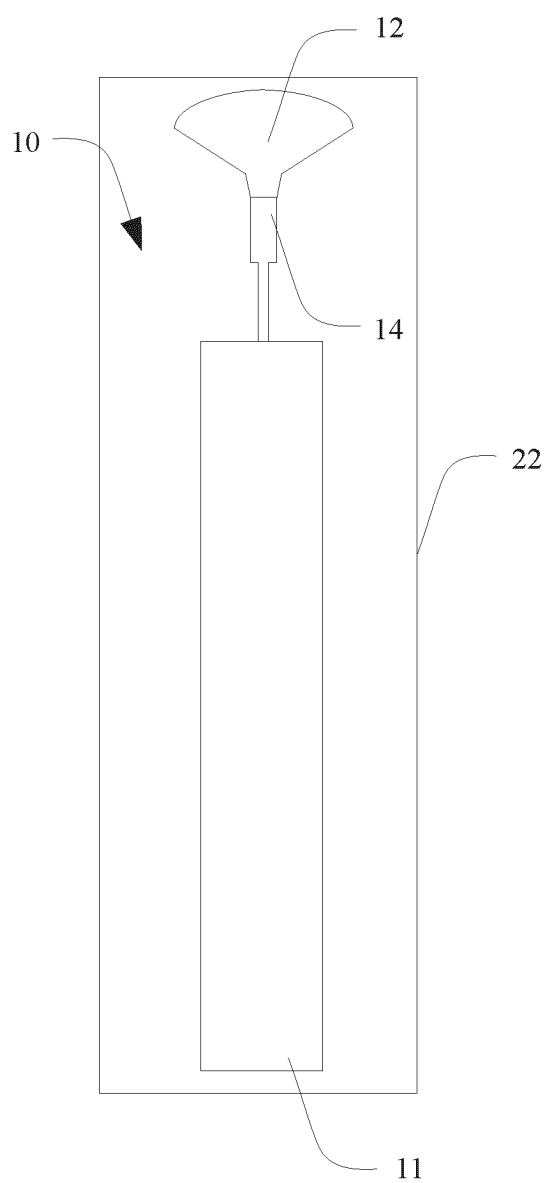


FIG. 7

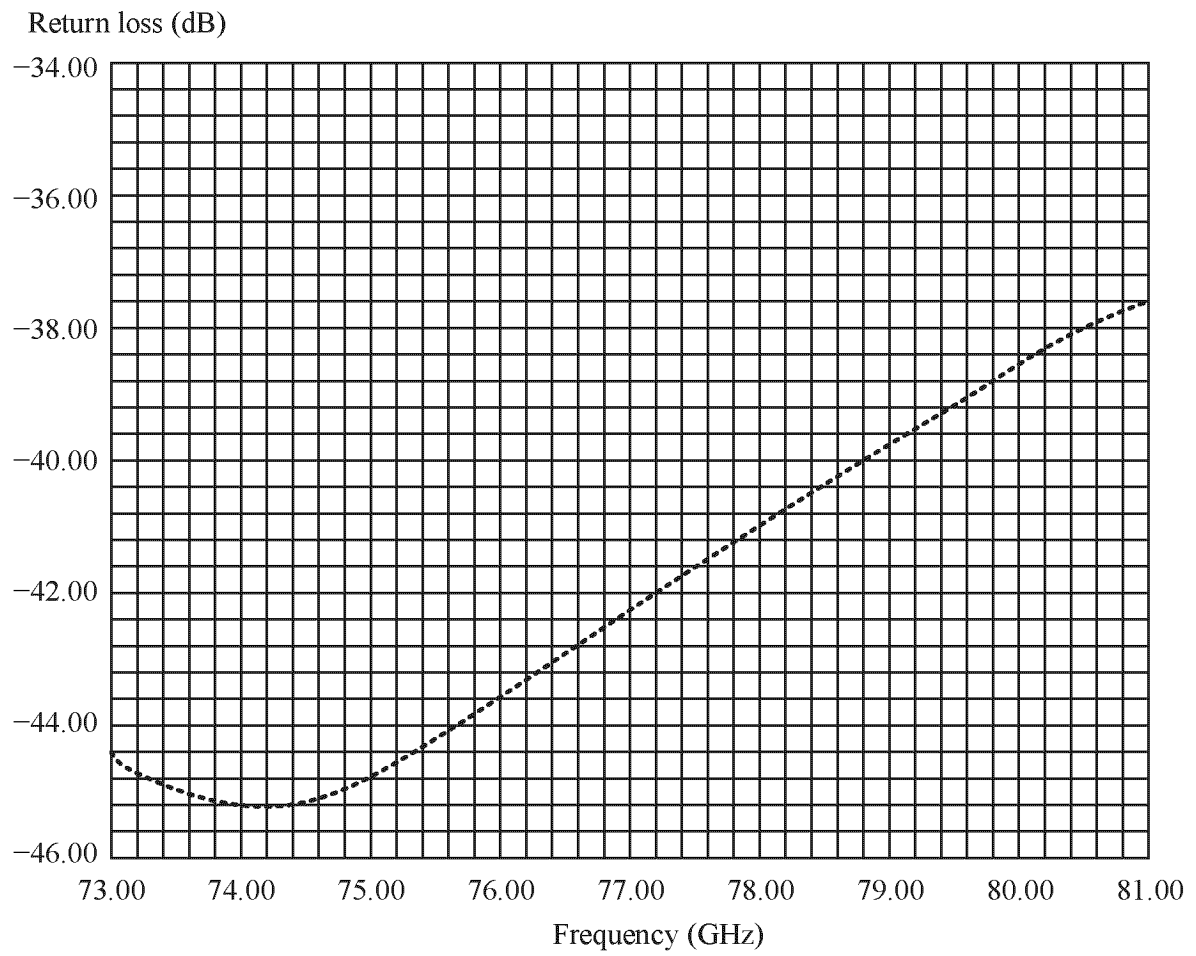


FIG. 8

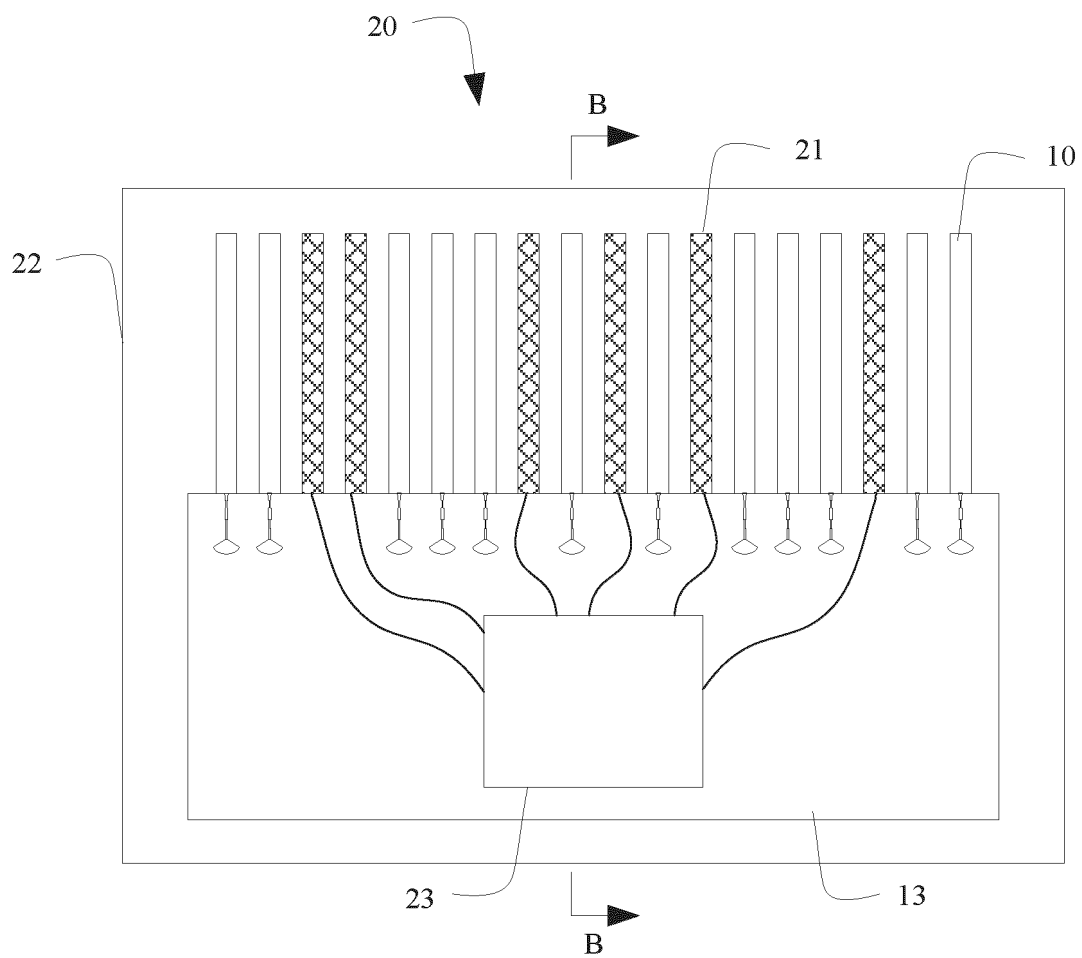


FIG. 9

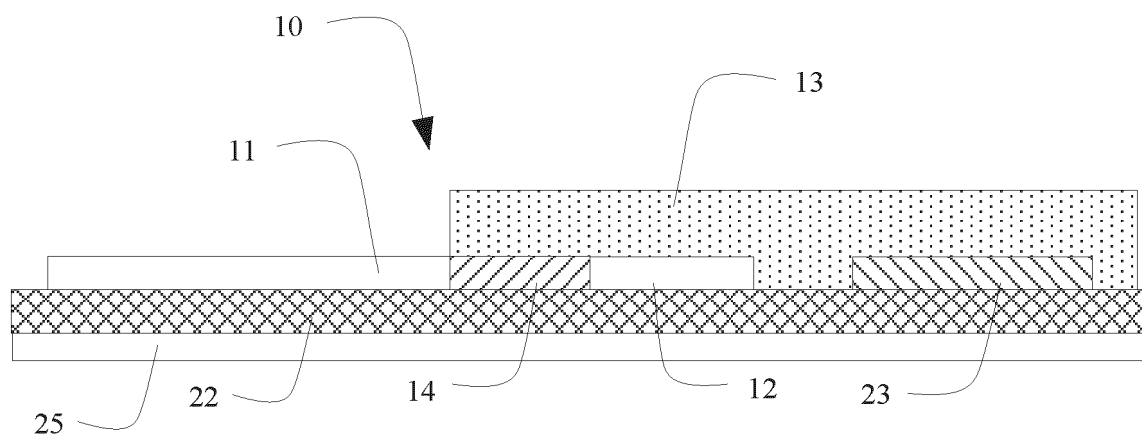


FIG. 10

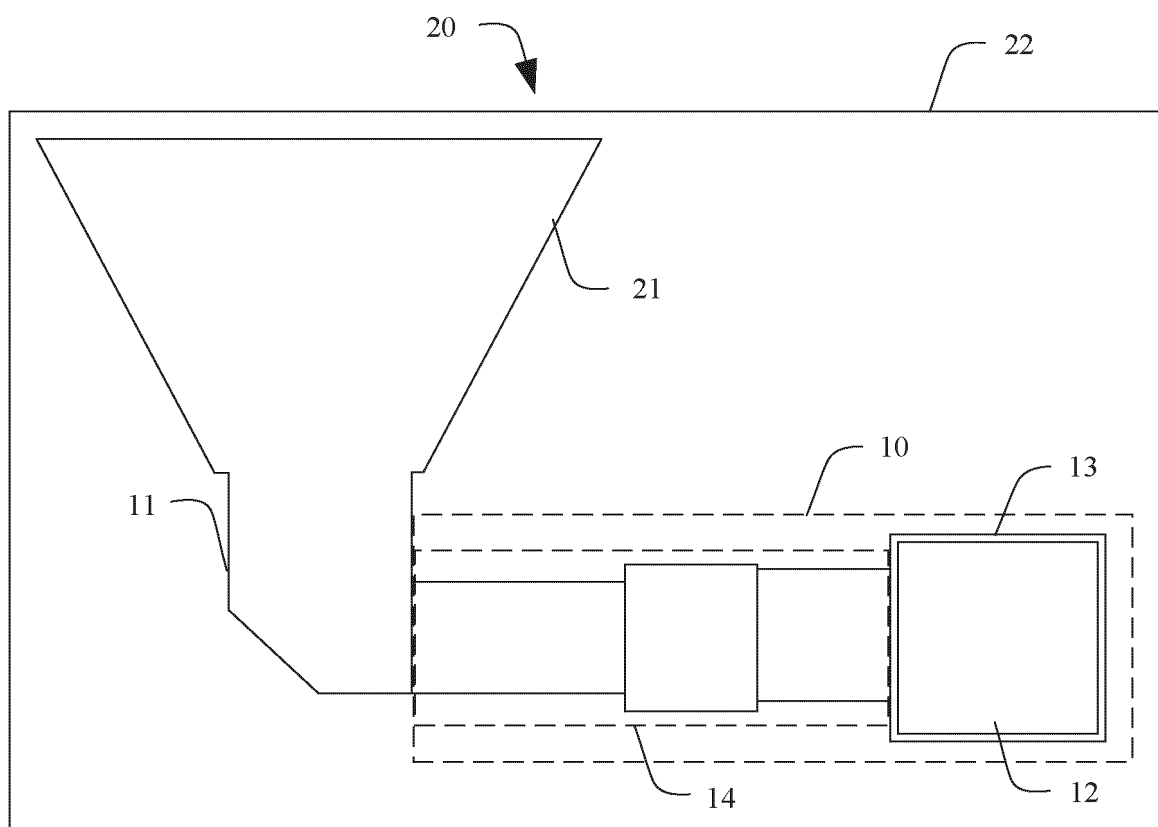


FIG. 11

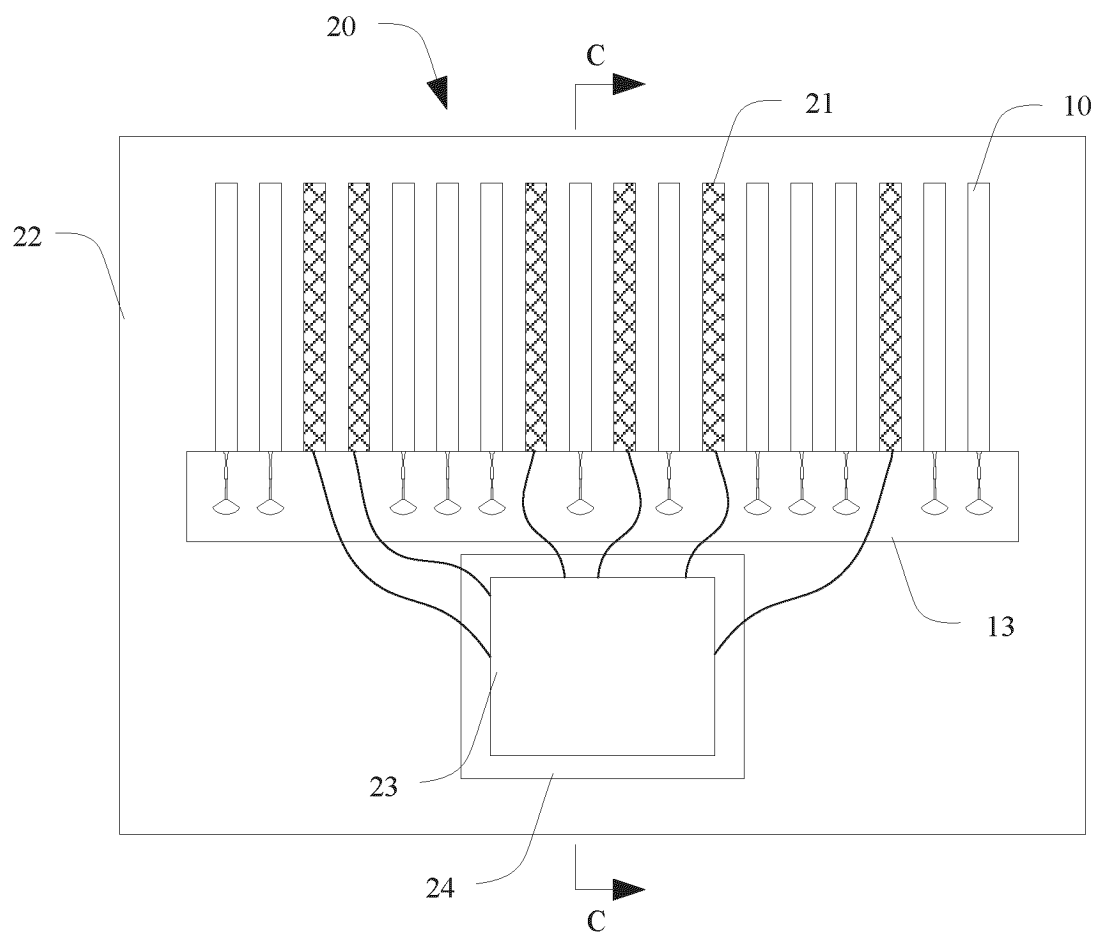


FIG. 12

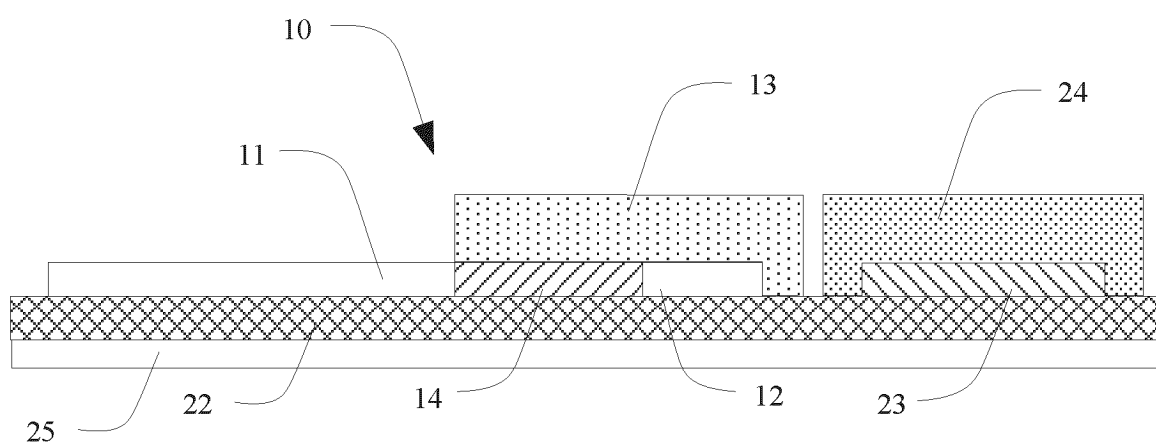


FIG. 13

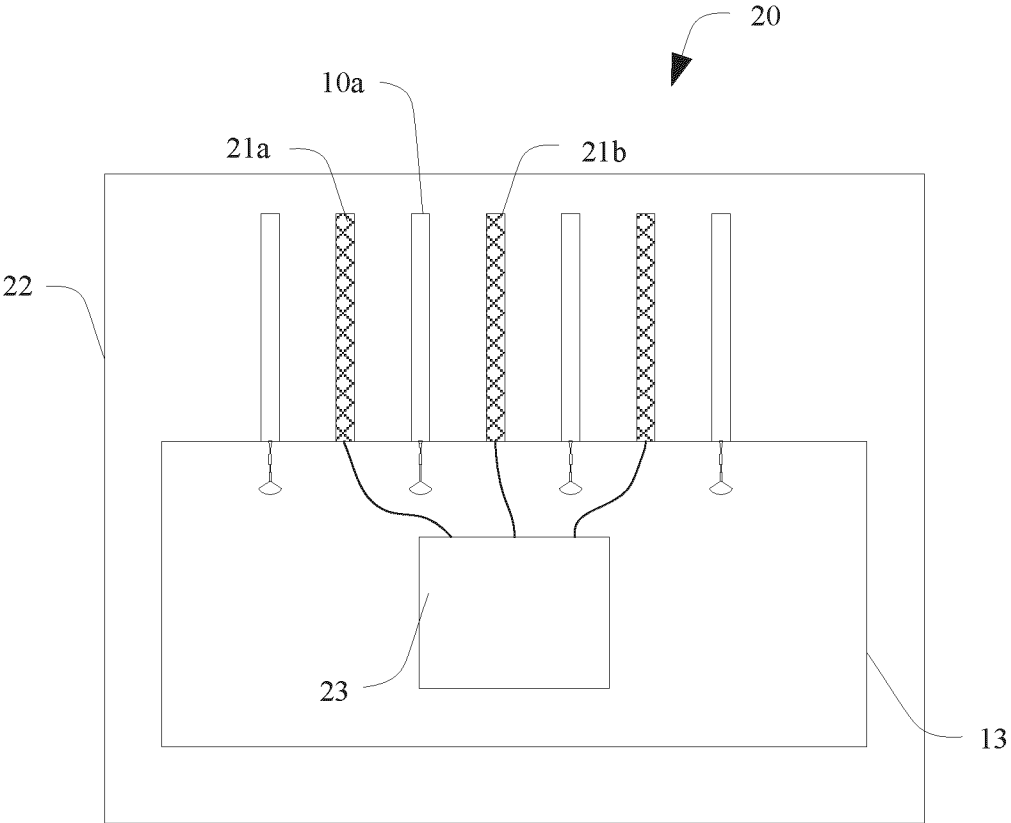


FIG. 14

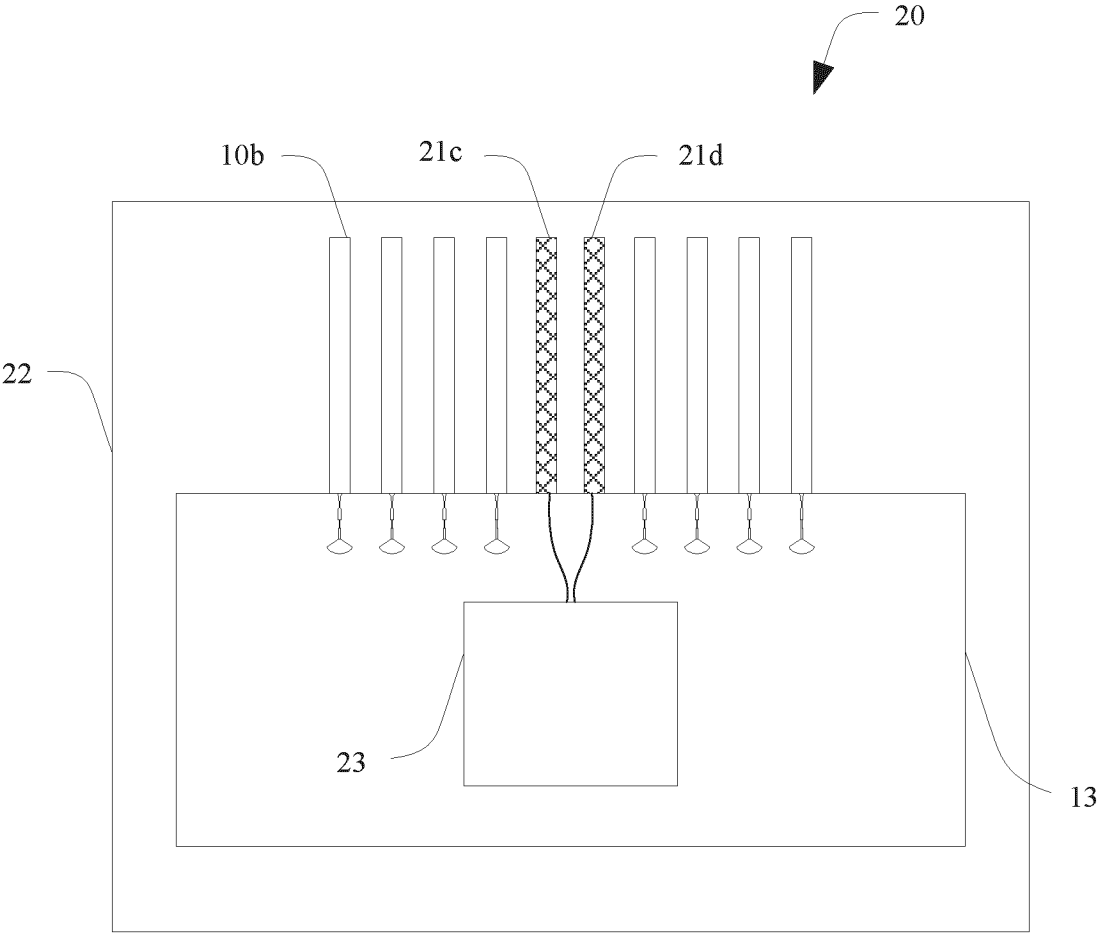


FIG. 15

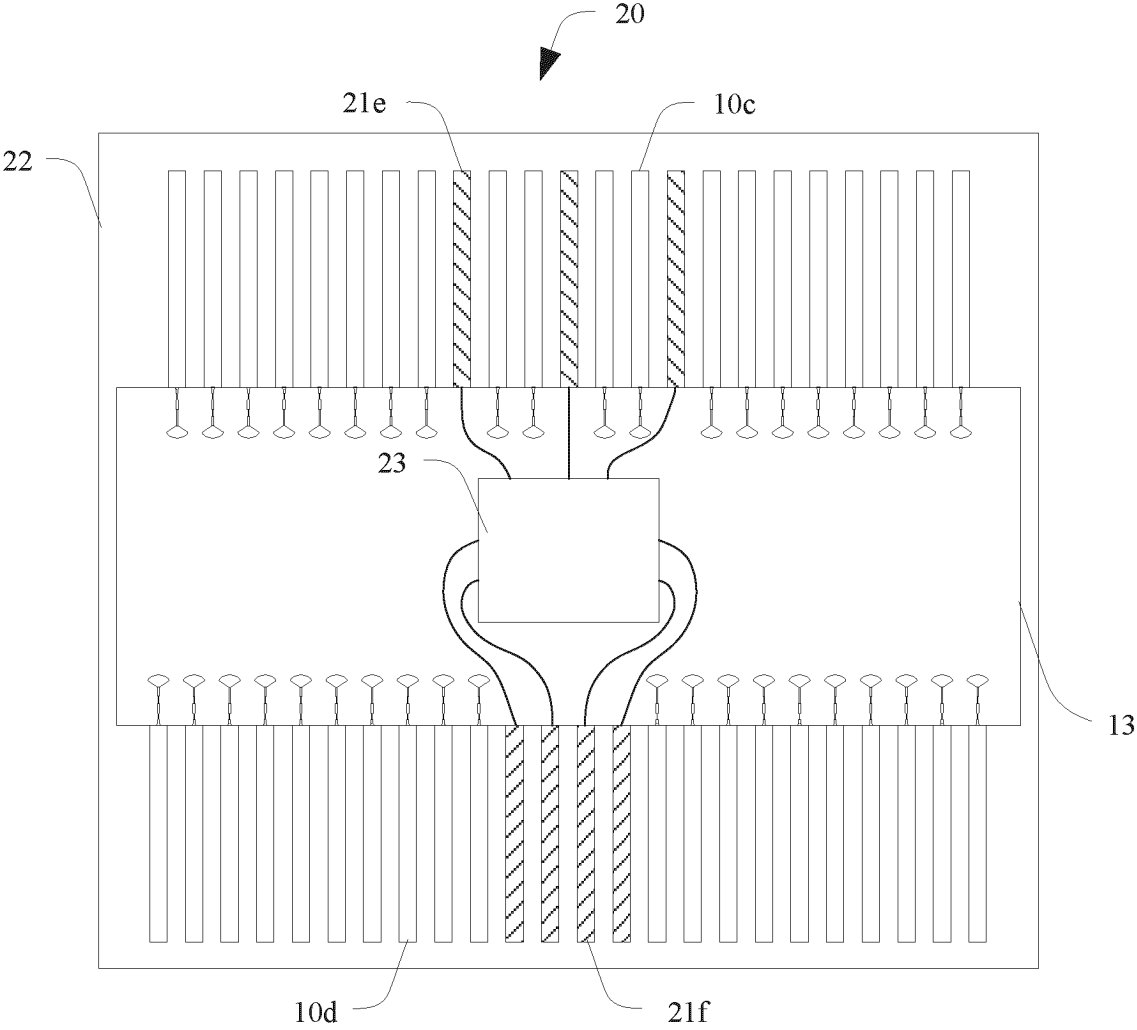


FIG. 16

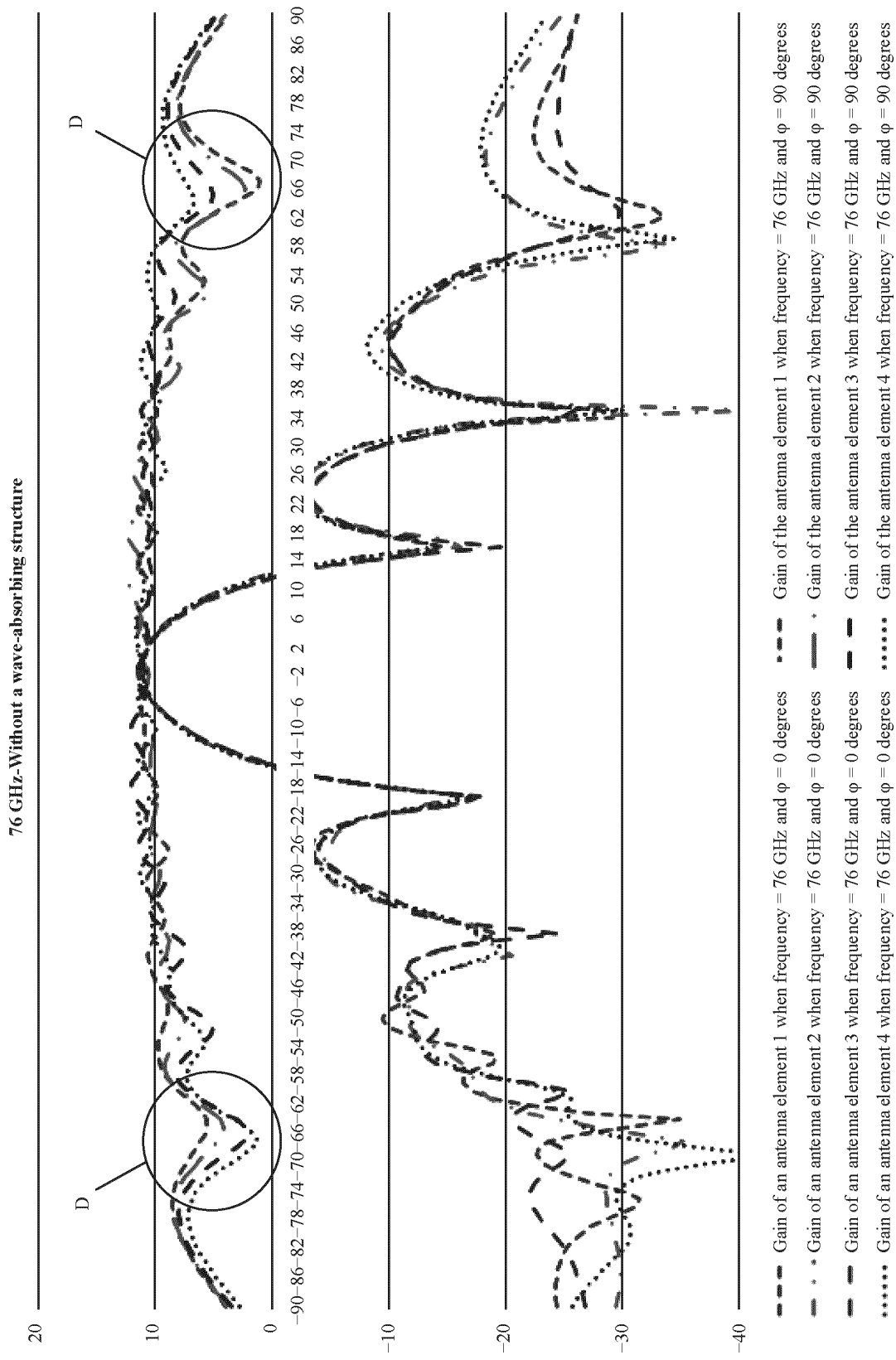


FIG. 17

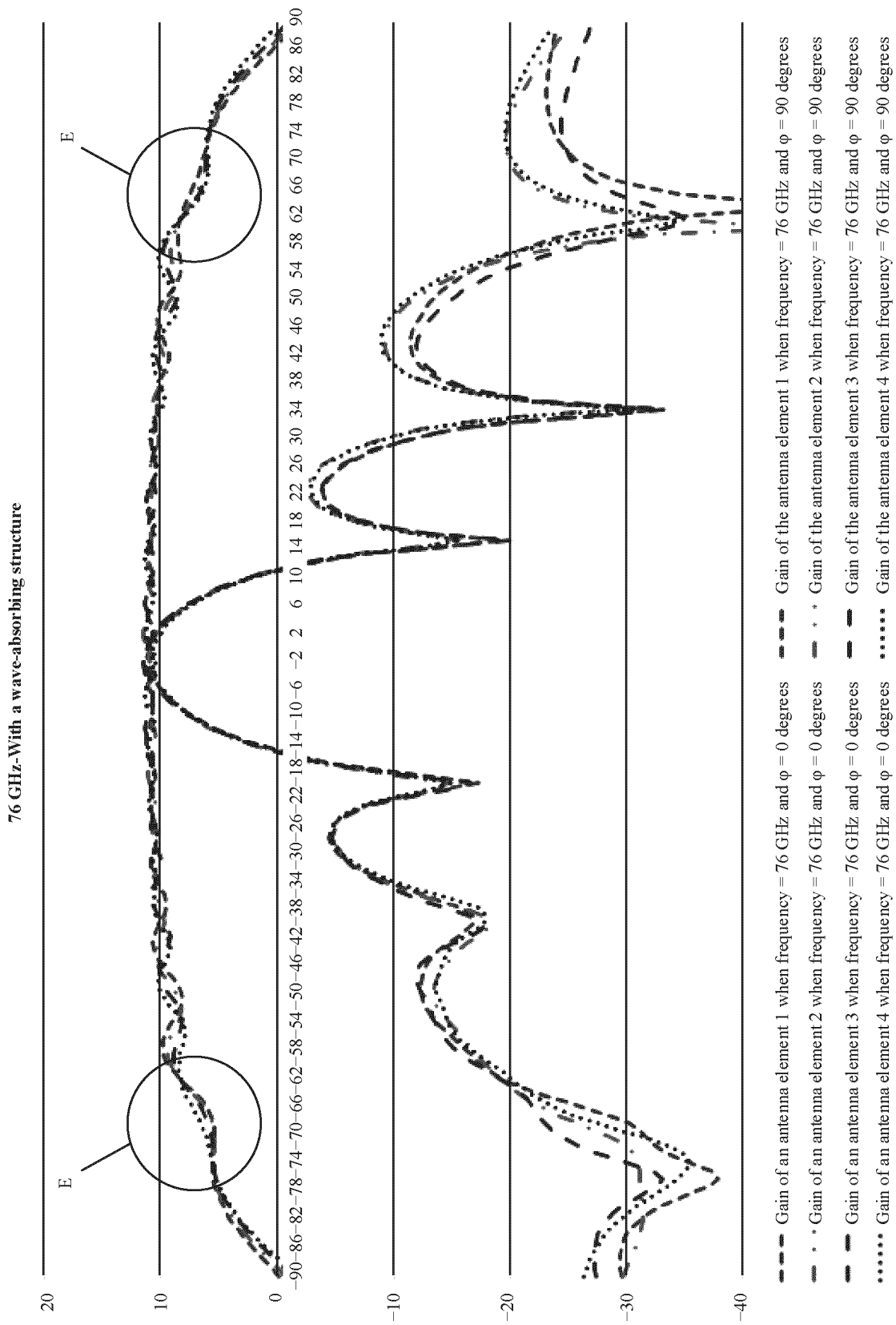


FIG. 18

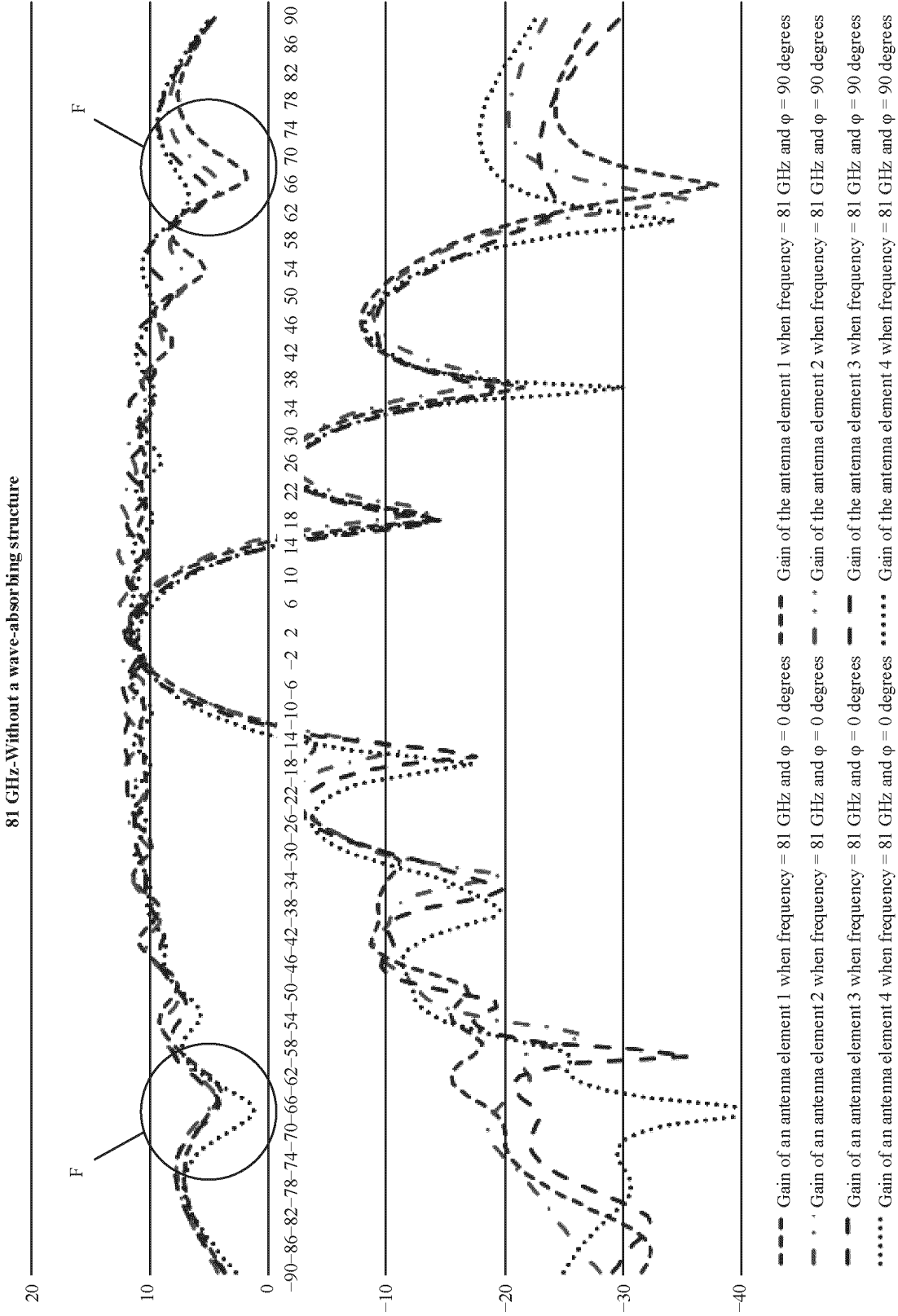


FIG. 19

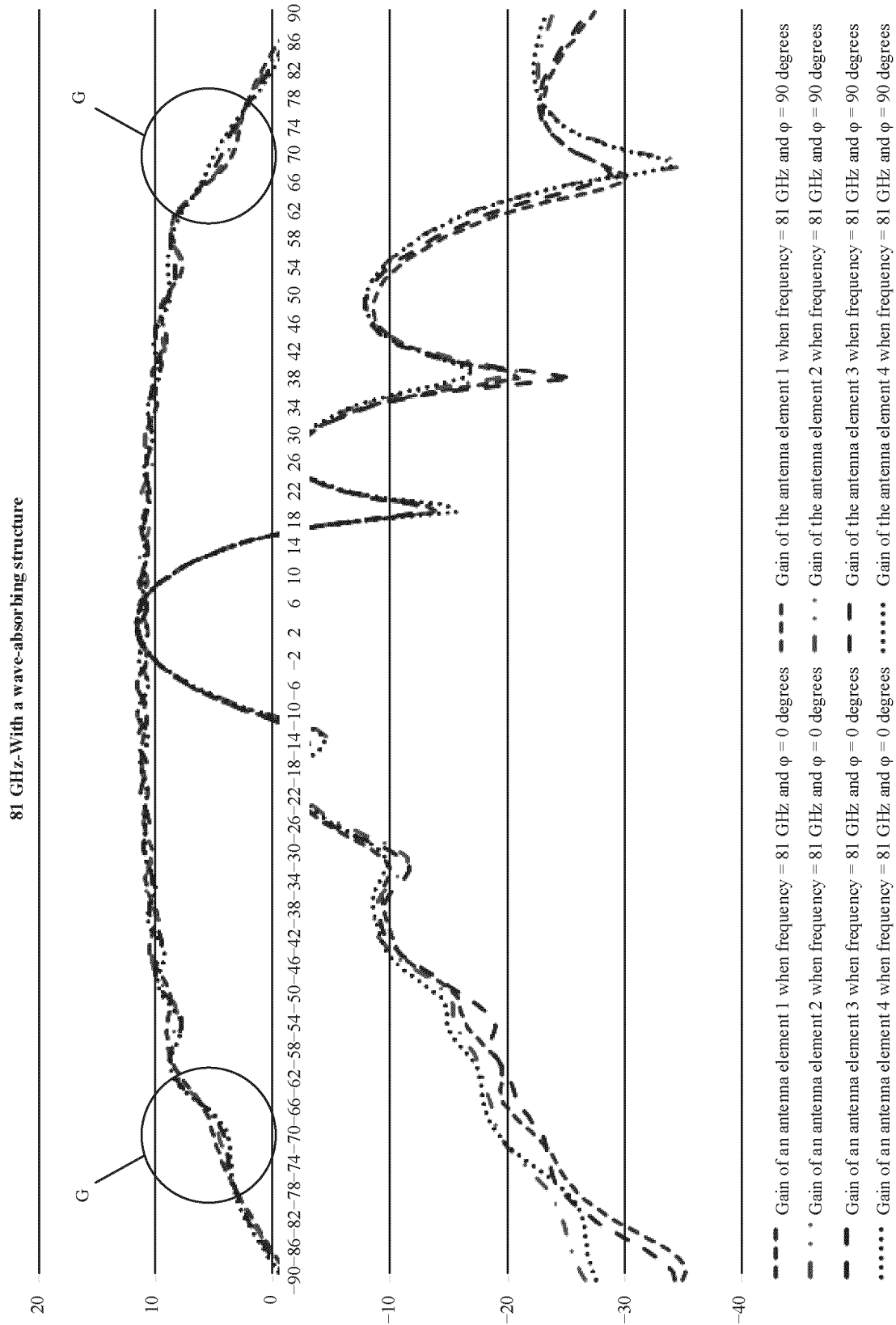


FIG. 20

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2022/096982

5	A. CLASSIFICATION OF SUBJECT MATTER H01Q 13/08(2006.01)i According to International Patent Classification (IPC) or to both national classification and IPC		
10	B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) H01Q Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
15	Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNPAT, CNKI, WPI, EPODOC: 天线, 雷达, 吸波, 谐振, 负载, 表面波, antenna, radar, wave, absorb, resonance, surface		
20	C. DOCUMENTS CONSIDERED TO BE RELEVANT		
	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
	A	CN 102227040 A (XIDIAN UNIVERSITY) 26 October 2011 (2011-10-26) description, paragraphs 2-16 and 23-37	1-17
25	A	CN 114221139 A (XIAN ELECTRONIC SCIENCE AND TECHNOLOGY UNIV HANGZHOU INSTITUTE OF RESEARCH) 22 March 2022 (2022-03-22) entire document	1-17
	A	CN 102110891 A (NORTHWESTERN POLYTECHNIC UNIVERSITY) 29 June 2011 (2011-06-29) entire document	1-17
30	A	CN 111883934 A (XIDIAN UNIVERSITY et al.) 03 November 2020 (2020-11-03) entire document	1-17
	A	US 2021143537 A1 (KUANG-CHI CUTTING EDGE TECHNOLOGY LTD.) 13 May 2021 (2021-05-13) entire document	1-17
35	A	LANDY, N. I. et al. "A Perfect Metamaterial Absorber" <i>Physical Review Letters</i> , 31 December 2008 (2008-12-31), entire document	1-17
40	☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
45	* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "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		
50	Date of the actual completion of the international search 06 December 2022		Date of mailing of the international search report 16 December 2022
55	Name and mailing address of the ISA/CN China National Intellectual Property Administration (ISA/ CN) No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088, China Facsimile No. (86-10)62019451		Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2022/096982

5	Patent document cited in search report			Publication date (day/month/year)		Patent family member(s)		Publication date (day/month/year)	
	CN	102227040	A	26 October 2011		None			
	CN	114221139	A	22 March 2022		None			
10	CN	102110891	A	29 June 2011		None			
	CN	111883934	A	03 November 2020		None			
	US	2021143537	A1	13 May 2021		JP	2021532650	A	25 November 2021
						EP	3813194	A1	28 April 2021
						WO	2020019675	A1	30 January 2020
15									
20									
25									
30									
35									
40									
45									
50									
55									

Form PCT/ISA/210 (patent family annex) (January 2015)