



(11)

EP 4 485 694 A1

(12)

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

(43) Date of publication:
01.01.2025 Bulletin 2025/01

(51) International Patent Classification (IPC):
H01Q 15/00 (2006.01)

(21) Application number: **23773557.6**

(52) Cooperative Patent Classification (CPC):
H01Q 1/24; H01Q 15/00; H01Q 15/14

(22) Date of filing: **24.02.2023**

(86) International application number:
PCT/CN2023/078163

(87) International publication number:
WO 2023/179306 (28.09.2023 Gazette 2023/39)

(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 ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(30) Priority: **21.03.2022 CN 202210275987**

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(54) **METASURFACE UNIT AND BASE STATION THEREOF**

(57) Provided in the present application are a metasurface unit and a base station thereof. The metasurface unit comprises: a resonant unit (100), wherein the resonant unit (100) is configured to receive two paths of polarized incident signals, or, to radiate two paths of polarized reflection signals; a power divider (200), wherein the power divider (200) is connected to the resonant unit (100), and the power divider (200) is configured to combine, into a combined signal, the two paths of polarized incident signals, which are input by the resonant unit (100), and/or, divide an input reflected signal into the two paths of polarized reflection signals and output same to the resonant unit (100); and a phase shifter (300), wherein the phase shifter (300) is connected to the power divider, and the phase shifter is configured to perform phase modulation on the combined signal, which is input by the power divider (200), and output, to the power divider (200), the reflected signal, which is obtained by performing the phase modulation.

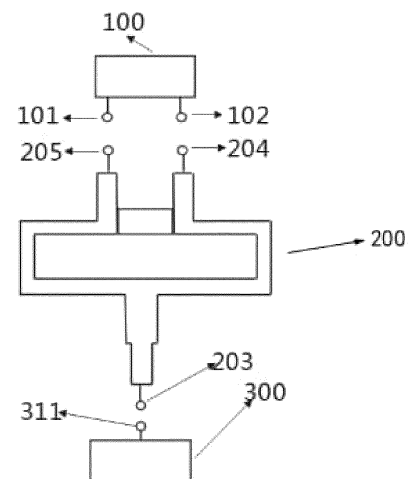


FIG. 1

Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application is based on and claims the priority of Chinese patent application No. 202210275987.2 filed on March 21, 2022, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present disclosure relates to but is not limited to the field of communication, in particular to a metasurface unit and a base station.

BACKGROUND

[0003] An artificial electromagnetic metasurface is an array of metasurface units arranged periodically, which can change propagation characteristics of electromagnetic waves and realize some special functions. For example, if a specific phase difference is designed between a reflected wave and an incident wave of each unit, the array of metasurface units can achieve an electromagnetic beam shaping function with a specific angle. The traditional artificial electromagnetic metasurface is a static structure, and its electromagnetic characteristics can not be changed, which can not meet current communication requirements. In recent years, a concept of programmable metasurface is put forward. A resonant unit of the metasurface unit is provided with a radio frequency (RF) switch, and a resonant frequency of a signal is adjusted through different states of the RF switch, thereby adjusting and controlling a reflection phase. The metasurface presents dynamic electromagnetic characteristics, thus realizing a programmable multi-beam shaping function.

[0004] A parameter fluctuation of the RF switch can easily cause a resonance frequency shift of the resonant unit and affect a phase modulation accuracy of the metasurface unit. In order to solve this problem, a combination of the resonant unit and a phase shifter is usually adopted, and the RF switch is arranged in the phase shifter. Although the resonant unit and the RF switch are separated, it is necessary to configure a phase shifter for each polarized signal, therefore the hardware cost is high.

SUMMARY

[0005] The following is a summary of the subject matters which are described in detail in the present disclosure. This summary is not intended to limit the scope of protection of the claims.

[0006] A metasurface unit and a base station are disclosed in embodiments of the present disclosure.

[0007] In accordance with a first aspect of the present disclosure, an embodiment provides a metasurface unit,

which includes a resonant unit, where the resonant unit is configured to receive two polarized incident signals or radiate two polarized reflected signals; a power divider, which is connected to the resonant unit, where the power divider is configured to combine the two polarized incident signals input by the resonant unit into a combined signal, and/or divide a reflected signal input by a phase shifter into the two polarized reflected signals and output the two polarized reflected signals to the resonant unit; and the phase shifter, which is connected to the power divider, where the phase shifter is configured to perform phase modulation on the combined signal input by the power divider and output the reflected signal obtained by the phase modulation to the power divider.

[0008] In accordance with a second aspect of the present disclosure, an embodiment provides a base station, which includes the metasurface unit according to the first aspect of the present disclosure.

[0009] Other features and advantages of the present disclosure will be set forth in the following description, and in part will be obvious from the description, or may be learned by practice of the present disclosure. Other advantages of the present disclosure may be realized and obtained by structures particularly pointed out in the description, claims and accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0010] The accompanying drawings are used to provide a further understanding of technical schemes of the present disclosure and constitute a part of the description. Together with the embodiments of the present disclosure, the accompanying drawings are used to explain the technical schemes of the present disclosure and do not constitute a limitation on the technical schemes of the present disclosure.

FIG. 1 is a schematic diagram of a metasurface unit provided in embodiment one of the present disclosure;

FIG. 2 is a front view of a power divider provided in embodiment one of the present disclosure;

FIG. 3 is an internal structure diagram of a phase shifter provided in embodiment one of the present disclosure;

FIG. 4 is an internal structure diagram of the phase shifter provided in embodiment two of the present disclosure;

FIG. 5 is an internal structure diagram of the phase shifter provided in embodiment three of the present disclosure;

FIG. 6 is a schematic diagram of 2-bit reflection amplitudes of the metasurface unit in the embodi-

ment of the present disclosure under an infinite period boundary;

FIG. 7 is a schematic diagram of 2-bit reflection phases of the metasurface unit in the embodiment of the present disclosure under the infinite period boundary.

DETAILED DESCRIPTION

[0011] In order to make purposes, technical schemes and advantages of the present disclosure more clear, the present disclosure will be further described in detail in combination with the accompanying drawings and embodiments. It should be understood that the embodiments described herein are only used to explain the present disclosure, and are not used to limit the present disclosure.

[0012] It should be noted that, although functional modules are divided in schematic diagrams of devices, in some cases, the functional modules can be divided differently, and steps shown or described in flowcharts may be executed in orders different from the orders in the flowcharts. Terms such as "first", "second" and the like in the description, claims or the accompanying drawings are used to distinguish similar objects, and are not necessarily used to describe a specific order or sequence.

[0013] A metasurface unit and a base station are disclosed in the the present disclosure. The metasurface unit includes a resonant unit, where the resonant unit is configured to receive two polarized incident signals or radiate two polarized reflected signals; a power divider, which is connected to the resonant unit, where the power divider is configured to combine the two polarized incident signals input by the resonant unit into a combined signal, and/or divide a reflected signal input by a phase shifter into the two polarized reflected signals and output the two polarized reflected signals to the resonant unit; and the phase shifter, which is connected to the power divider, where the phase shifter is configured to perform phase modulation on the combined signal input by the power divider and output the reflected signal obtained by the phase modulation to the power divider. According to the technical scheme of this embodiment, the combination and the division of the two polarized signals are realized through the power divider, so that the two polarized signals can share the same phase shifter, which effectively reduces the number of phase shifters in the metasurface unit and reduces the hardware cost.

[0014] The embodiments of the present disclosure will be described with reference to the accompanying drawings.

[0015] Referring to FIG. 1, a metasurface unit is disclosed, including:

- a resonant unit 100, where the resonant unit 100 is configured to receive two polarized incident signals or radiate two polarized reflected signals;

- a power divider 200, which is connected to the resonant unit 100, where the power divider 200 is configured to combine two polarized incident signals input by the resonant unit 100 into a combined signal, and/or divide a reflected signal input by a phase shifter 300 into the two polarized reflected signals and output the two polarized reflected signals to the resonant unit 100; and

- the phase shifter 300, which is connected to the power divider 200, where the phase shifter 300 is configured to perform phase modulation on the combined signal input by the power divider 200 and output the reflected signal obtained by the phase modulation to the power divider 200.

[0016] It should be noted that, in a working frequency band of the metasurface unit, the resonant unit 100 can realize a dual-polarization working mode, that is, the resonant unit 100 can receive two polarized incident electromagnetic wave signals in space through resonance, the two polarized incident signals are combined into a combined signal through the power divider 200, the combined signal is input to the phase shifter 300 for phase modulation, the signal after phase modulation is reflected back to the power divider 200, where the reflected signal is divided into two polarized reflected signals, and then the two polarized reflected signals are radiated outward in a form of electromagnetic waves through the resonant unit 100 to form reflected waves.

[0017] It should be noted that, a structure of the metasurface unit is disclosed in this embodiment, in which the phase shifter 300 and the resonant unit 100 are independent devices, so that device parameters of the phase shifter 300 do not affect the resonant frequency of the resonant unit 100, effectively ensuring the phase modulation accuracy and making the metasurface unit applicable to all frequency bands. In addition, the resonant unit 100 adopts the dual-polarization working mode, where two polarized signals with different polarizations are combined by the power divider 200 and then transmitted to the phase shifter 300. The two polarized signals share a phase shifter 300 for phase modulation. Under a condition of supporting the dual-polarization working mode, the number of the phase shifters 300 in the metasurface unit is halved, and the hardware cost is effectively reduced.

[0018] Various embodiments of the metasurface unit will be illustrated below.

EMBODIMENT ONE

[0019] In this embodiment, referring to FIG. 1, the resonant unit 100, the power divider 200 and the phase shifter 300 are all independent devices. The resonant unit 100 includes a first polarization port 101 and a second polarization port 102. The power divider 200 includes a first power divider port 205 and a second power divider

port 204. The first polarization port 101 is connected to the first power divider port 205, and the second polarization port 102 is connected to the second power divider port 204. The power divider 200 further includes a third power divider port 203, and the phase shifter 300 includes a phase shifter port 311. The third power divider port 203 is connected to the phase shifter port 311.

[0020] The resonant unit 100 is configured to: receive a first polarized incident signal and a second polarized incident signal, input the first polarized incident signal to the first power divider port 205 through the first polarization port 101, and input the second polarized incident signal to the second power divider port 204 through the second polarization port 102. Polarization directions of the first polarized incident signal and the second polarized incident signal are orthogonal to each other. The resonant unit 100 is also configured to radiate a first polarized reflected signal and a second polarized reflected signal. Polarization directions of the first polarized reflected signal and the second polarized reflected signal are orthogonal to each other. The first polarized reflected signal is input by the power divider 200 through the first power divider port 205, and the second polarized reflected signal is input by the power divider 200 through the second power divider port 204.

[0021] The power divider 200 is configured to: combine the first polarized incident signal and the second polarized incident signal into a combined signal, and input the combined signal to the phase shifter 300 through the third power divider port 203, such that the phase shifter 300 performs phase modulation on the combined signal to obtain a reflected signal. The power divider 200 is also configured to acquire the reflected signal input by the phase shifter 300 through the phase shifter port 311, and divide the reflected signal into the first polarized reflected signal and the second polarized reflected signal.

[0022] It should be noted that, the resonant unit 100 may be a microstrip antenna unit or a dipole antenna unit, and may also be other radiation units with resonance functions. In this embodiment, a device selection of the resonant unit 100 is not limited.

[0023] It should be noted that, in order to realize the dual-polarization working mode, the two polarized incident signals received or the two polarized reflected signals radiated by the resonant unit 100 may be two polarized signals with polarization directions orthogonal to each other. For example, the first polarized incident signal may be an electromagnetic wave signal with a polarization direction of 45 degrees in space, and the second polarized incident signal may be an electromagnetic wave signal with a polarization direction of negative 45 degrees in space. The combined signal obtained by combining the first polarized incident signal and the second polarized incident signal through the power divider 200 is then input to the phase shifter 300 for phase modulation. The obtained reflected signal is divided into the first polarized reflected signal with a polarization direction of 45 degrees and the second polarized re-

flected signal with a polarization direction of negative 45 degrees by the power divider 200, and then the first polarized reflected signal and the second polarized reflected signal are radiated by the resonant unit 100 in the form of electromagnetic waves to form the reflected waves. The polarization directions described in the above example is not a limitation to the technical scheme of this embodiment, as long as the polarization directions of the two input or output polarized signals can be ensured to be orthogonal to each other.

[0024] It should be noted that, the reflected signal in this embodiment may be a signal obtained by phase modulation for the first polarized incident signal or the second polarized incident signal. In this embodiment, the power divider 200 is adopted by the metasurface unit to divide the reflected signal, so that the first polarized incident signal with polarization direction of 45 degrees may be performed phase modulation to obtain the first polarized reflected signal with the polarization direction of 45 degrees and the second polarized reflected signal with the polarization direction of negative 45 degrees. A processing process for the second polarized incident signal with the polarization direction of negative 45 degrees is the same, and will not be repeated here.

[0025] It should be noted that, the power divider 200 may be a Wilkinson power divider, a 3dB bridge, a T-junction or an integrated component with a power distribution function. A device selection of the power divider 200 is not limited in this embodiment.

[0026] It should be noted that, the phase shifter 300 may be a device including a plurality of transmission lines and a plurality of RF switches, and each two transmission lines are connected by one of the plurality of RF switches, so that a series or parallel relationship is formed between the each two transmission lines, and different phase shifting effects can be achieved through combinations of states of the RF switches. The phase shifter 300 may also be an integrated component with a phase shifting function. A structure of the phase shifter 300 is not limited in this embodiment.

[0027] In addition, referring to FIG. 2, the power divider 200 further includes a power divider transmission line 201 and an isolation resistor 202, where the power divider transmission line 201 is respectively connected to the first power divider port 205, the second power divider port 204 and the third power divider port 203.

[0028] The isolation resistor 202 is arranged between a first segment line and a second segment line of the power divider transmission line 201, where the first segment line is arranged to be connected to the first power divider port 205, and the second segment line is arranged to be connected to the second power divider port 204.

[0029] It should be noted that, the power divider 200 shown in FIG. 2 is a Wilkinson power divider. When receiving electromagnetic waves, the resonant unit 100 inputs two polarized incident signals through the first power divider port 205 and the second power divider port 204, and the signal combination is realized through the

power divider 200. Similarly, when transmitting electromagnetic waves, the phase shifter 300 inputs the reflected signal through the third power divider port 203, and the power divider 200 distributes the reflected signal to the two polarization ports of the resonant unit, thus achieving the radiation of the two polarized signals.

[0030] It should be noted that, the power divider transmission line 201 may be a stripline structure as shown in FIG. 2, which is respectively connected to the first power divider port 205, the second power divider port 204 and the third power divider port 203, and the isolation resistor 202 is arranged between the first segment line which is connected to the first power divider port 205 and the second segment line which is connected to the second power divider port 204, so that isolation of the two polarized signals is realized. The isolation resistor 202 may be a surface mount resistor, and a resistance value of the isolation resistor 202 may be adjusted according to actual requirements.

[0031] In addition, referring to FIG. 3, the phase shifter 300 further includes a direct current (DC) blocking capacitor 302, a RF switch module and an alternating current (AC) blocking inductor 308 which are connected in series in sequence. The DC blocking capacitor 302 is connected to the phase shifter port 311. The phase shifter 300 includes a first phase shifter transmission line 301, a second phase shifter transmission line 304, a third phase shifter transmission line 305 and a fourth phase shifter transmission line 307. The RF switch module includes a first RF switch 310, a second RF switch 309 and a third RF switch 306. The DC blocking capacitor 302 is connected to the first RF switch 310 through the first phase shifter transmission line 301. The first RF switch 310 and the second RF switch 309 are connected in series through the second phase shifter transmission line 304. The second RF switch 309 and the third RF switch 306 are connected in series through the third phase shifter transmission line 305. The third RF switch 306 is connected to the AC blocking inductor 308 through the fourth phase shifter transmission line 307. The first phase shifter transmission line 301, the second phase shifter transmission line 304 and the third phase shifter transmission line 305 are respectively connected to a DC bias line 303.

[0032] It should be noted that, in this embodiment, the first phase shifter transmission line 301, the second phase shifter transmission line 304, the third phase shifter transmission line 305 and the fourth phase shifter transmission line 307 are connected in series through three RF switches to form a complete transmission line. The above transmission lines can adopt microstrip or stripline structures, and can be selected according to actual requirements.

[0033] It should be noted that, the DC blocking capacitor 302 can isolate direct current and prevent a bias current from entering the power divider 200. The AC blocking inductor 308 can isolate a RF signal and prevent the RF signal from entering the DC bias circuit 303. The

DC blocking capacitor 302 and the AC blocking inductor 308 may be surface mount devices, and may be a distributed capacitor and a distributed inductor respectively. Types and parameters of the DC blocking capacitor 302 and the AC blocking inductor 308 may be selected according to actual requirements.

[0034] It should be noted that, the three RF switches in this embodiment may be PIN transistors, varactors, triodes, field effect transistors, single-pole-single-throw or single-pole-multi-throw switches, etc. In this embodiment, selections of RF switches are not limited.

[0035] It should be noted that, in the phase shifter 300 of this embodiment, the three RF switches are connected through the first phase shifter transmission line 301, the second phase shifter transmission line 304 and the third phase shifter transmission line 305, so that series connections of the phase shifter transmission lines is realized, and four phases, i.e., 2-bit phase states, can be realized through different states of the three RF switches, therefore the phase quantization accuracy can be effectively improved and the scalability is good. For example, the combined signal is input through the phase shifter port 311, passes through the DC blocking capacitor 302, and then enters the RF switch module. The combined signal passes through the RF switch which is turned on until the signal reaches an open circuit or short circuit terminal and is reflected. Different combinations of turn-on states of the three RF switches can realize four phase states, in which, when all the three RF switches are turned off, a combination state is "00", and a corresponding reflection phase is 0 degree; when the first RF switch 310 is turned on, the combination state is "01", and the corresponding reflection phase is negative 90 degrees; when the first RF switch 310 and the second RF switch 309 are turned on, the combination state is "10", and the corresponding reflection phase is negative 180 degrees; and when the first RF switch 310, the second RF switch 309 and the third RF switch 306 are turned on, the combination state is "11", and the corresponding reflection phase is negative 270 degrees. FIG. 6 shows a schematic diagram of reflection amplitudes obtained by using the metasurface unit of this embodiment. At the abscissa of 2.5GHz, the four curves correspond to the combination states "00", "01", "11" and "10" respectively from top to bottom. FIG. 7 shows a schematic diagram of reflection phases. At the abscissa of 2.5GHz, the four curves correspond to the combination states "00", "01", "10" and "11" from top to bottom. As can be seen from FIGS. 6 and 7, the reflection phases and the reflection amplitudes are different in different combination states, therefore the metasurface unit has strong expansibility and high phase quantization accuracy.

EMBODIMENT TWO

[0036] The metasurface unit of this embodiment is similar to that of the embodiment one, except the following main differences.

[0037] Referring to FIG. 4, the phase shifter 300 includes a first phase shifter transmission line 301, a second phase shifter transmission line 304, a third phase shifter transmission line 305, a fourth phase shifter transmission line 307 and a fifth phase shifter transmission line 313. The RF switch module includes a third RF switch 306 and an RF switch group 312. The RF switch group 312 includes a first RF switch 310 and a second RF switch 309.

[0038] The DC blocking capacitor 302 is connected to the first RF switch 310 through the first phase shifter transmission line 301. The first RF switch 310 and the second RF switch 309 are connected in parallel through the second phase shifter transmission line 304 and the fifth phase shifter transmission line 313. The second RF switch 309 and the third RF switch 306 are connected in series through the third phase shifter transmission line 305. The third RF switch 306 is connected to the AC blocking inductor 308 through the fourth phase shifter transmission line 307.

[0039] It should be noted that, in the RF switch module of this embodiment, the second phase shifter transmission line 304 and the fifth phase shifter transmission line 313 are connected in parallel, and a 2-bit phase response can also be achieved through different states of the three RF switches, with a difference that a configuration direction of the second RF switch 309 in this embodiment is different from that of the second RF switch 309 in the embodiment one, and two DC blocking capacitors 302 and a bias circuit 303 are adaptively arranged at the fifth phase shifter transmission line 313. A difference between this embodiment and the embodiment one is that a connection mode of the RF switches and the transmission lines is different, but the principle is basically the same, so the details are not repeated here.

EMBODIMENT THREE

[0040] The metasurface unit of this embodiment is similar to that of the embodiment two, except the following main differences.

[0041] Referring to FIG. 5, the RF switch module includes at least two RF switch groups 312. The at least two RF switch groups 312 are connected in series with each other.

[0042] It should be noted that, in this embodiment, a RF switch group 312 is added on the basis of the embodiment two, so that the phase shifter 300 can realize 8-bit phase states through five RF switches, further improving the accuracy of phase adjustment. The principle that the turn-on states of the five RF switches determine the reflection phase is similar to the principle of the embodiment two, except that one bit is added to describe the 8-bit phase states. For example, the combination state is "000" in a fully-turned-off state and "111" in a fully-turned-on state. For the sake of simplicity, the principle is not repeated here.

[0043] Except for the above differences, other parts of

the metasurface unit of this embodiment can refer to the description of the embodiment two, and will not be repeated here for the sake of simplicity.

[0044] A base station is also disclosed in the present disclosure. The base station includes the metasurface unit as described in any of the above embodiments.

[0045] It should be noted that, after any one of the above-mentioned metasurface units is applied to the base station, since the power divider is arranged in the metasurface unit, in the dual-polarization working mode, two polarized signals share a phase shifter, which effectively reduces the number of phase shifters and reduces the hardware cost.

[0046] The embodiment of the present disclosure includes a resonant unit, where the resonant unit is configured to receive two polarized incident signals or radiate two polarized reflected signals; a power divider, which is connected to the resonant unit, where the power divider is configured to combine the two polarized incident signals input by the resonant unit into a combined signal, and/or divide a reflected signal input by a phase shifter into the two polarized reflected signals and output the two polarized reflected signals to the resonant unit; and the phase shifter, which is connected to the power divider, where the phase shifter is configured to perform phase modulation on the combined signal input by the power divider and output the reflected signal obtained by the phase modulation to the power divider. According to the technical scheme of this embodiment, the combination and the division of the two polarized signals are realized through the power divider, so that the two polarized signals can share the same phase shifter, which effectively reduces the number of phase shifters in the metasurface unit and reduces the hardware cost.

[0047] Several embodiments of the present disclosure have been described above, but the present disclosure is not limited to the above embodiments, and those familiar with this field can make various equivalent variations or substitutions within the scope of the present disclosure, which are included in the scope defined by the claims of the present disclosure.

Claims

1. A metasurface unit, comprising:

a resonant unit, wherein the resonant unit is configured to receive two polarized incident signals or radiate two polarized reflected signals; a power divider, which is connected to the resonant unit, wherein the power divider is configured to combine the two polarized incident signals input by the resonant unit into a combined signal, and/or divide a reflected signal input by a phase shifter into the two polarized reflected signals and output the two polarized reflected signals to the resonant unit; and

the phase shifter, which is connected to the power divider, wherein the phase shifter is configured to perform phase modulation on the combined signal input by the power divider, and output the reflected signal obtained by the phase modulation to the power divider.

2. The metasurface unit of claim 1, wherein:

the resonant unit comprises a first polarization port and a second polarization port, and the power divider comprises a first power divider port and a second power divider port, wherein the first polarization port is connected to the first power divider port, and the second polarization port is connected to the second power divider port;

the resonant unit is configured to receive a first polarized incident signal and a second polarized incident signal, and input the first polarized incident signal to the first power divider port through the first polarization port, and the second polarized incident signal to the second power divider port through the second polarization port, wherein polarization directions of the first polarized incident signal and the second polarized incident signal are orthogonal to each other; and

the resonant unit is configured to radiate a first polarized reflected signal and a second polarized reflected signal, wherein polarization directions of the first polarized reflected signal and the second polarized reflected signal are orthogonal to each other, the first polarized reflected signal is input by the power divider through the first power divider port, and the second polarized reflected signal is input by the power divider through the second power divider port.

3. The metasurface unit of claim 2, wherein:

the power divider comprises a third power divider port, the phase shifter comprises a phase shifter port, and the third power divider port is connected to the phase shifter port;

the power divider is configured to combine the first polarized incident signal and the second polarized incident signal into the combined signal, and input the combined signal to the phase shifter through the third power divider port, such that the phase shifter performs phase modulation on the combined signal to obtain the reflected signal; and

the power divider is configured to acquire the reflected signal input by the phase shifter through the phase shifter port, and divide the reflected signal into the first polarized reflected signal and the second polarized reflected signal.

4. The metasurface unit of claim 3, wherein:

the power divider comprises a power divider transmission line and an isolation resistor, wherein the power divider transmission line is respectively connected to the first power divider port, the second power divider port and the third power divider port; and

the isolation resistor is arranged between a first segment line and a second segment line of the power divider transmission line, wherein the first segment line is configured to be connected to the first power divider port, and the second segment line is configured to be connected to the second power divider port.

5. The metasurface unit of claim 3, wherein:

the phase shifter comprises a direct current, DC, blocking capacitor, a radio frequency, RF, switch module and an alternating current, AC, blocking inductor which are connected in series in sequence, wherein the DC blocking capacitor is connected to the phase shifter port, and the RF switch module is configured to perform phase modulation on the combined signal to obtain the reflected signal.

6. The metasurface unit of claim 5, wherein:

the phase shifter comprises a first phase shifter transmission line, a second phase shifter transmission line, a third phase shifter transmission line and a fourth phase shifter transmission line, and the RF switch module comprises a first RF switch, a second RF switch and a third RF switch; and

the DC blocking capacitor is connected to the first RF switch through the first phase shifter transmission line, the first RF switch and the second RF switch are connected in series through the second phase shifter transmission line, the second RF switch and the third RF switch are connected in series through the third phase shifter transmission line, and the third RF switch is connected to the AC blocking inductor through the fourth phase shifter transmission line.

7. The metasurface unit of claim 6, wherein:

the first phase shifter transmission line, the second phase shifter transmission line and the third phase shifter transmission line are respectively connected to a DC bias line.

8. The metasurface unit of claim 5, wherein:

the phase shifter comprises a first phase shifter transmission line, a second phase shifter transmission line, a third phase shifter transmission

line, a fourth phase shifter transmission line and a fifth phase shifter transmission line, the RF switch module comprises a third RF switch and a RF switch group, and the RF switch group comprises a first RF switch and a second RF switch; 5
and
the DC blocking capacitor is connected to the first RF switch through the first phase shifter transmission line, the first RF switch and the second RF switch are connected in parallel 10
through the second phase shifter transmission line and the fifth phase shifter transmission line, the second RF switch and the third RF switch are connected in series through the third phase shifter transmission line, and the third RF switch 15
is connected to the AC blocking inductor through the fourth phase shifter transmission line.

9. The metasurface unit of claim 8, wherein:
the second phase shifter transmission line and the fifth phase shifter transmission line are respectively connected to a DC bias line. 20
10. The metasurface unit of claim 8, wherein the RF switch module comprises at least two RF switch groups connected in series. 25
11. A base station, comprising the metasurface unit of any one of claims 1 to 10. 30

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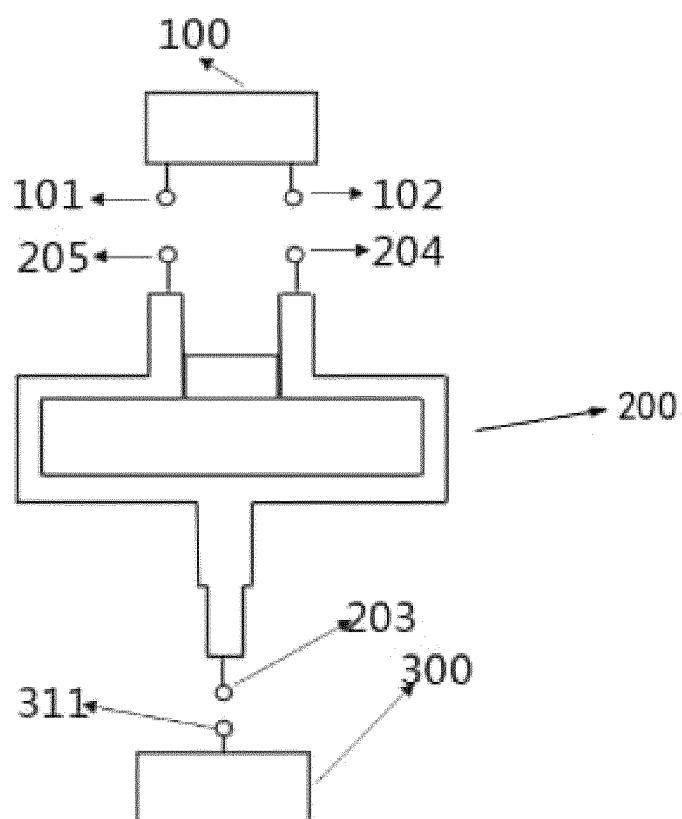


FIG. 1

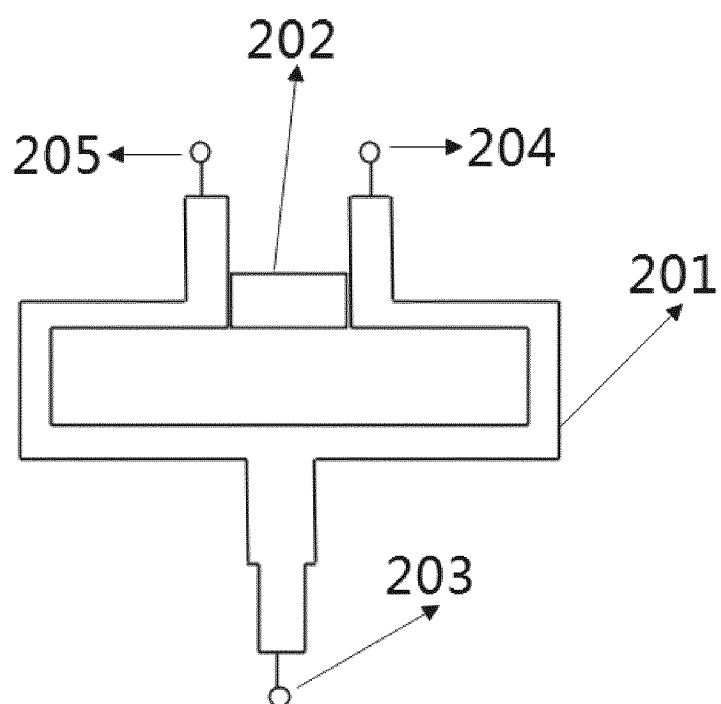


FIG. 2

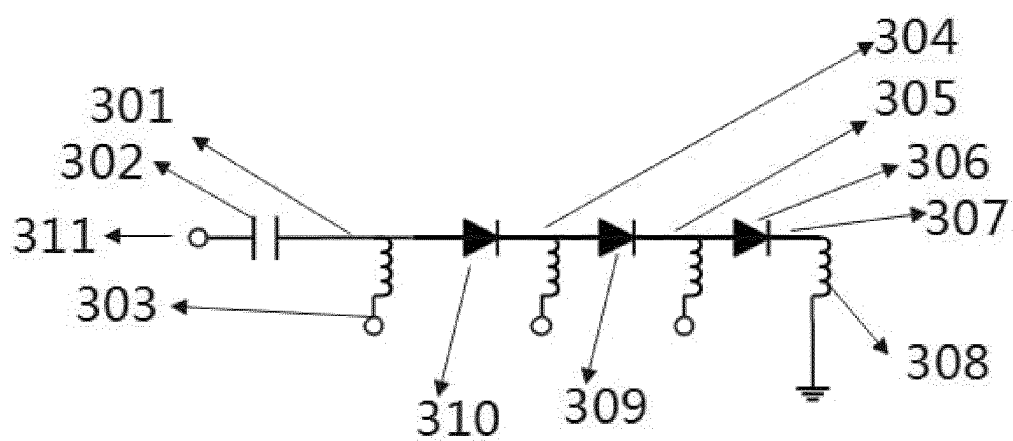


FIG. 3

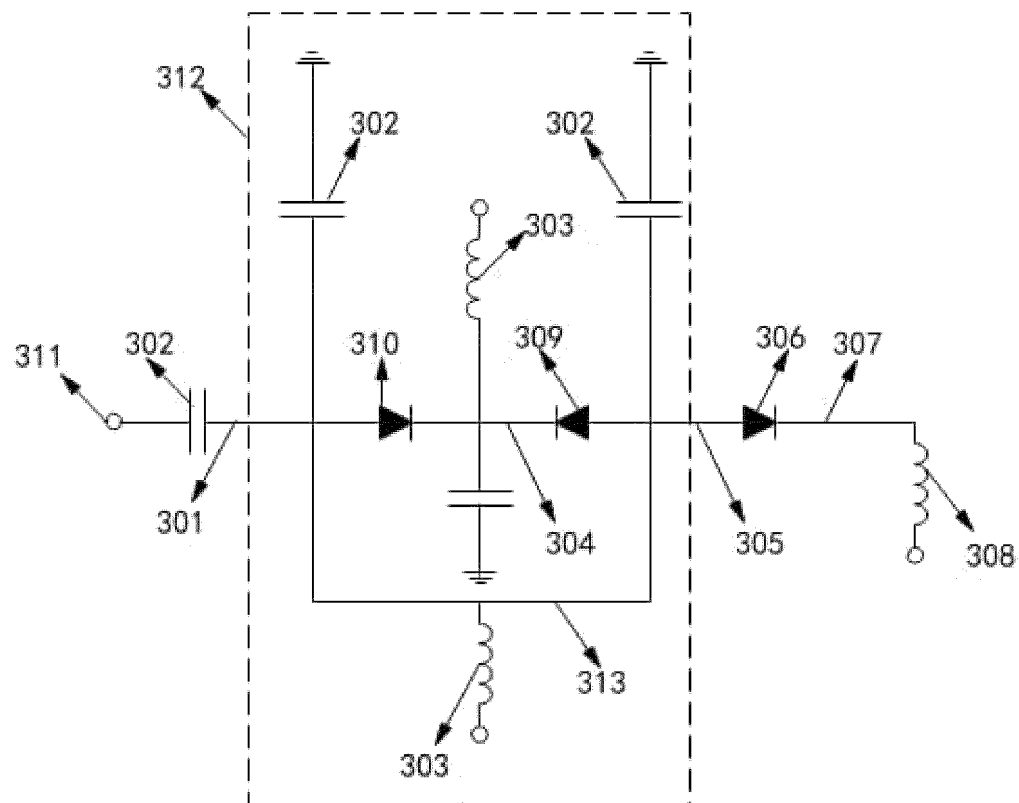


FIG. 4

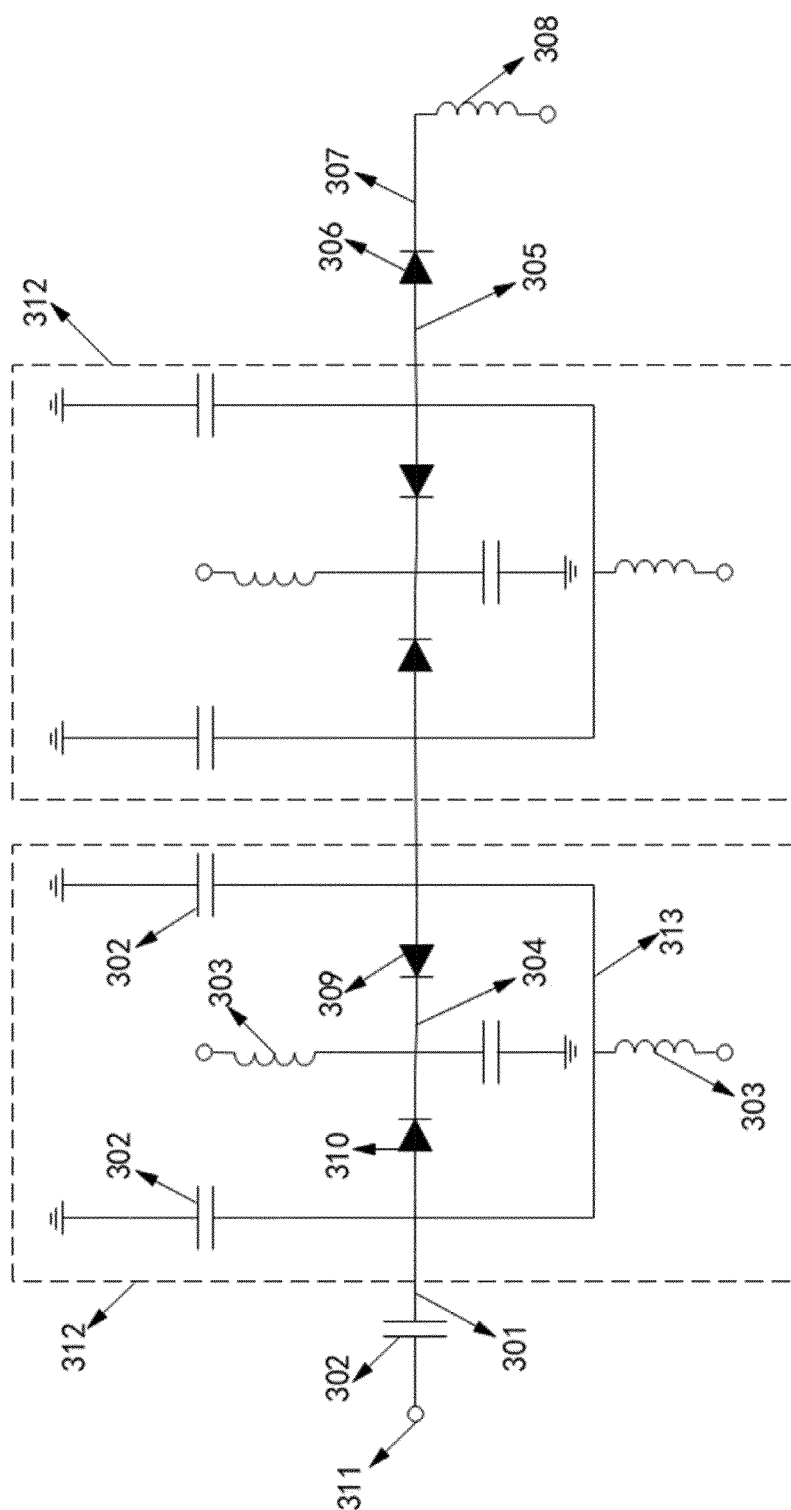


FIG. 5

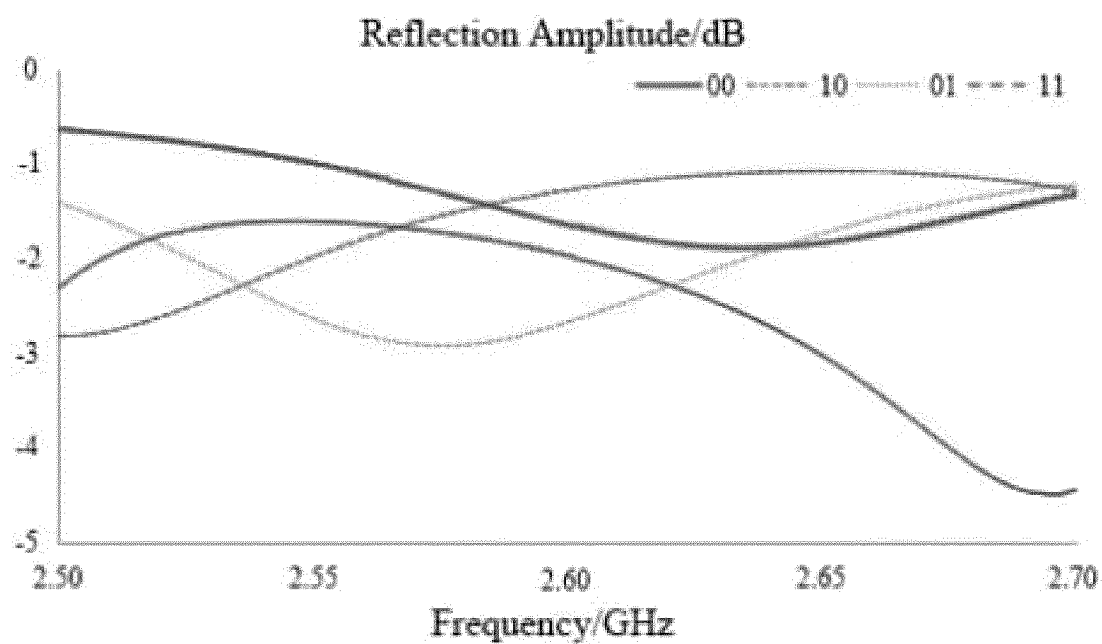


FIG. 6

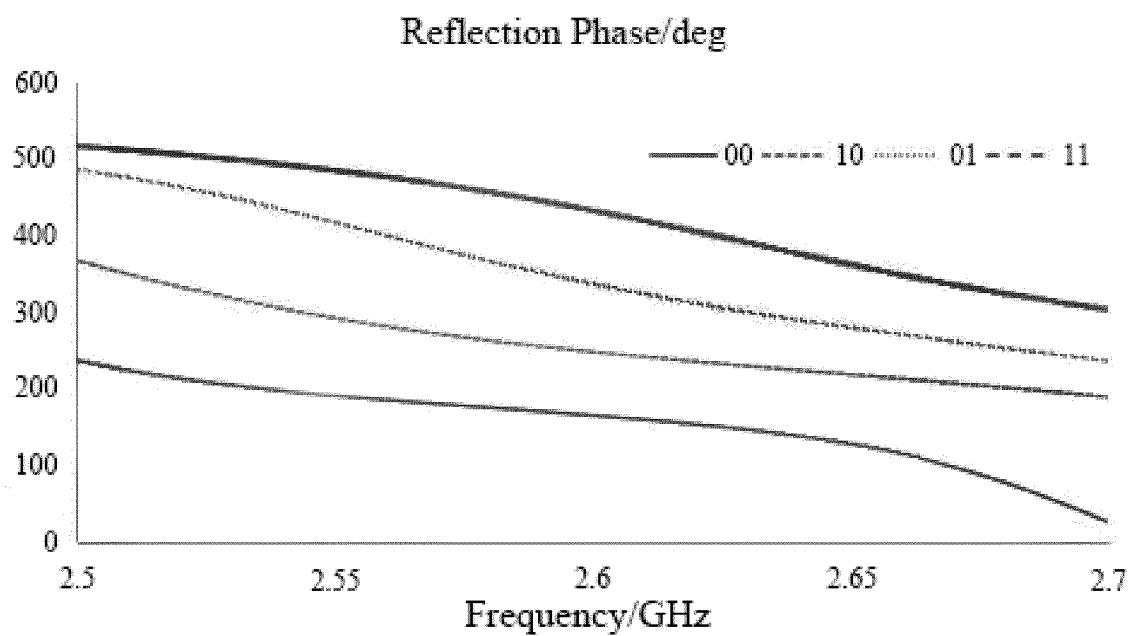


FIG. 7

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/078163

A. CLASSIFICATION OF SUBJECT MATTER H01Q 15/00(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) IPC: H01Q																					
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																					
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CNTXT, ENTXTC, CJFD, CNKI, VEN, ENTXT, IEEE: 反射, 超表面, 人工电磁, 超构材料, 超材料, 超结构, 智能, 可重构, 可编程, 数字编码, 比特, 谐振单元, 移相器, 相移, 极化, 偏振, 功分器, 电桥, T型结, T形结, 功率分配, 合路, 分路, reflect, metasurface, Intelligent Reflecting Surface, IRS, Reconfigurable Intelligent Surface, RIS, phase 1d shift+, dual 1w polari+, power 1d(division or divid+)																					
C. DOCUMENTS CONSIDERED TO BE RELEVANT																					
<table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>CN 114188726 A (YANGTZE RIVER DELTA INSTITUTE OF RESEARCH (HUZHOU) OF ELECTROTECHNICS UNIVERSITY) 15 March 2022 (2022-03-15) description, paragraphs 27-31, and figures 1-8</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>CN 111063994 A (XIDIAN UNIVERSITY) 24 April 2020 (2020-04-24) entire document</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>CN 113764900 A (XIDIAN UNIVERSITY) 07 December 2021 (2021-12-07) entire document</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>CN 113890578 A (ZHEJIANG UNIVERSITY CITY COLLEGE) 04 January 2022 (2022-01-04) entire document</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>CN 113871861 A (SOUTHEAST UNIVERSITY) 31 December 2021 (2021-12-31) entire document</td> <td>1-11</td> </tr> <tr> <td>A</td> <td>CN 113991312 A (SOUTHEAST UNIVERSITY) 28 January 2022 (2022-01-28) entire document</td> <td>1-11</td> </tr> </tbody> </table>	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	A	CN 114188726 A (YANGTZE RIVER DELTA INSTITUTE OF RESEARCH (HUZHOU) OF ELECTROTECHNICS UNIVERSITY) 15 March 2022 (2022-03-15) description, paragraphs 27-31, and figures 1-8	1-11	A	CN 111063994 A (XIDIAN UNIVERSITY) 24 April 2020 (2020-04-24) entire document	1-11	A	CN 113764900 A (XIDIAN UNIVERSITY) 07 December 2021 (2021-12-07) entire document	1-11	A	CN 113890578 A (ZHEJIANG UNIVERSITY CITY COLLEGE) 04 January 2022 (2022-01-04) entire document	1-11	A	CN 113871861 A (SOUTHEAST UNIVERSITY) 31 December 2021 (2021-12-31) entire document	1-11	A	CN 113991312 A (SOUTHEAST UNIVERSITY) 28 January 2022 (2022-01-28) entire document	1-11
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<table border="1"> <tr> <td>Date of the actual completion of the international search 08 June 2023</td> <td>Date of mailing of the international search report 08 June 2023</td> </tr> </table>	Date of the actual completion of the international search 08 June 2023	Date of mailing of the international search report 08 June 2023																			
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2023/078163

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	CN 110911845 A (PEKING UNIVERSITY) 24 March 2020 (2020-03-24) entire document	1-11
A	KR 102374150 B1 (AGENCY FOR DEFENSE DEVELOPMENT) 11 March 2022 (2022-03-11) entire document	1-11
A	US 10218426 B1 (TOSHIBA K. K.) 26 February 2019 (2019-02-26) entire document	1-11
A	US 2018109002 A1 (FOO SENGLEE) 19 April 2018 (2018-04-19) entire document	1-11
A	Krishna Kumar Kishor et al. "An Amplifying Reconfigurable Reflectarray Antenna" <i>IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION</i> , Vol. 60, No. 1., 31 January 2012 (2012-01-31), pages 197-205	1-11

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2023/078163

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 114188726 A	15 March 2022	None	
CN 111063994 A	24 April 2020	None	
CN 113764900 A	07 December 2021	None	
CN 113890578 A	04 January 2022	None	
CN 113871861 A	31 December 2021	None	
CN 113991312 A	28 January 2022	None	
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KR 102374150 B1	11 March 2022	None	
US 10218426 B1	26 February 2019	JP 2019050521 A	28 March 2019
		US 2019081685 A1	14 March 2019
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		EP 3520173 A4	02 October 2019
		EP 3520173 B1	22 September 2021

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Patent documents cited in the description

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