



US011682833B2

(12) **United States Patent**  
**Wang et al.**

(10) **Patent No.:** **US 11,682,833 B2**  
(45) **Date of Patent:** **Jun. 20, 2023**

(54) **ANTENNA, PREPARATION METHOD THEREOF AND ELECTRONIC DEVICE**

(71) Applicant: **BOE Technology Group Co., Ltd.**, Beijing (CN)

(72) Inventors: **Feng Wang**, Beijing (CN); **Ziyu Zhang**, Beijing (CN); **Wei Wang**, Beijing (CN)

(73) Assignee: **BOE Technology Group Co., Ltd.**, Beijing (CN)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 44 days.

(21) Appl. No.: **17/343,767**

(22) Filed: **Jun. 10, 2021**

(65) **Prior Publication Data**

US 2022/0102851 A1 Mar. 31, 2022

(30) **Foreign Application Priority Data**

Sep. 28, 2020 (CN) ..... 202011043726.5

(51) **Int. Cl.**  
**H01Q 1/44** (2006.01)  
**H01Q 1/38** (2006.01)  
**H01Q 9/04** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/44** (2013.01); **H01Q 1/38** (2013.01); **H01Q 9/0471** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/44; H01Q 1/38; H01Q 9/0471; H01Q 13/28; H01Q 1/36  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,570,240 B2 *	10/2013	Tanaka	.....	H04B 13/00
				343/897
10,847,887 B2 *	11/2020	Tombs	.....	H01Q 9/0407
11,271,282 B2 *	3/2022	Jang	.....	G06F 1/1698
2009/0051620 A1 *	2/2009	Ishibashi	.....	H01Q 9/16
				343/897
2012/0287018 A1 *	11/2012	Parsche	.....	H01L 31/042
				29/601
2017/0352959 A1	12/2017	Sugita et al.		

OTHER PUBLICATIONS

Alexis Martin et al., "Mesh parameters influence on transparent and active antennas performance at microwaves", AIP Advances 7, 085120, 1-8 (2017).

Junho Park et al., "An Optically Invisible Antenna-on-Display Concept for Millimeter-Wave 5G Cellular Devices", IEEE Transactions on Antennas and Propagation, May 2019, pp. 2942-2952, vol. 67, No. 5.

\* cited by examiner

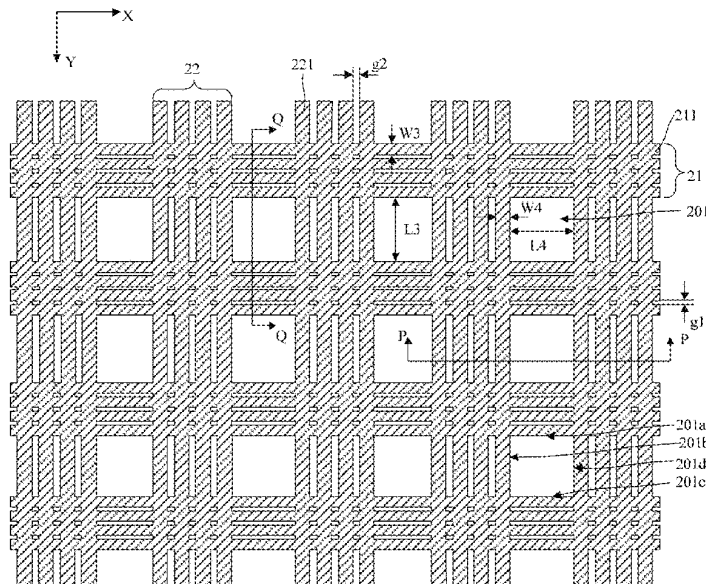
*Primary Examiner* — Seung H Lee

(74) *Attorney, Agent, or Firm* — Ling Wu; Stephen Yang; Ling and Yang Intellectual Property

(57) **ABSTRACT**

An antenna is provided. The antenna includes a transparent substrate and a metal layer disposed on the transparent substrate. The metal layer includes a plurality of hollow regions, at least one hollow region in the plurality of hollow regions is surrounded by at least one metal line group and the at least one metal line group includes at least one metal line; a cross section of the at least one metal line has a non-rectangular shape.

**17 Claims, 13 Drawing Sheets**





US011682837B2

(12) **United States Patent**  
**Wang et al.**

(10) **Patent No.:** **US 11,682,837 B2**  
(45) **Date of Patent:** **Jun. 20, 2023**

(54) **ANTENNA MODULE AND ELECTRONIC DEVICE**  
  
(71) Applicant: **PEGATRON CORPORATION**, Taipei (TW)  
  
(72) Inventors: **I Wen Wang**, Taipei (TW); **Ming Hong Lee**, Taipei (TW)  
  
(73) Assignee: **PEGATRON CORPORATION**, Taipei (TW)  
  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 29 days.

(21) Appl. No.: **17/565,160**

(22) Filed: **Dec. 29, 2021**

(65) **Prior Publication Data**  
US 2022/0247078 A1 Aug. 4, 2022

(30) **Foreign Application Priority Data**  
Feb. 4, 2021 (TW) ..... 110104180

(51) **Int. Cl.**  
**H01Q 5/378** (2015.01)  
**H01Q 5/335** (2015.01)  
**H01Q 5/371** (2015.01)  
**H01Q 1/02** (2006.01)  
**H01Q 1/24** (2006.01)  
**H01Q 1/48** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 5/378** (2015.01); **H01Q 1/02** (2013.01); **H01Q 1/243** (2013.01); **H01Q 5/335** (2015.01); **H01Q 5/371** (2015.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 5/378; H01Q 5/335; H01Q 5/371; H01Q 1/02; H01Q 1/243; H01Q 1/48  
See application file for complete search history.

(56) **References Cited**  
**U.S. PATENT DOCUMENTS**  
  
2012/0105292 A1 5/2012 Wong et al.  
2012/0223867 A1 9/2012 Morton et al.  
2016/0064832 A1 3/2016 Shin et al.  
2018/0026326 A1\* 1/2018 Noh ..... H01Q 1/52 343/904  
2019/0123423 A1\* 4/2019 Wu ..... H01Q 1/243

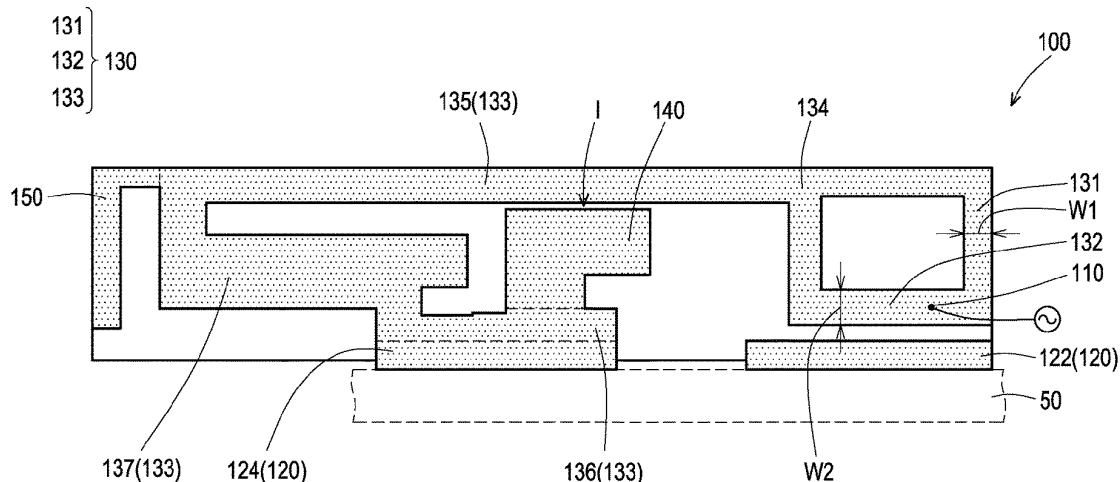
**FOREIGN PATENT DOCUMENTS**  
  
TW 383193 6/2010

**OTHER PUBLICATIONS**  
  
“Search Report of Europe Counterpart Application”, dated Jun. 7, 2022, pp. 1-11.  
  
\* cited by examiner

*Primary Examiner* — Andrea Lindgren Baltzell  
(74) *Attorney, Agent, or Firm* — J.C. Patents

(57) **ABSTRACT**  
  
An antenna module, including a feed point, a ground plane, a main radiator, and a parasitic radiator, is provided. The main radiator includes a first portion, a second portion, and a third portion. The first portion and the second portion extend from the feed point and meet at an intersection after turning. The third portion has a first section and a second section. The first section of the third portion is connected to the intersection, and the second section is connected to the ground plane. The parasitic radiator is connected to the second section and extends towards the first section of the third portion and keeps a coupling gap away from the first section.

**17 Claims, 10 Drawing Sheets**





US011682846B2

(12) **United States Patent**  
**Dolatsha et al.**

(10) **Patent No.:** **US 11,682,846 B2**  
(45) **Date of Patent:** **Jun. 20, 2023**

(54) **ANTENNA DEVICE WITH CELL STRUCTURE AND ARRAY OF ANTENNA DEVICES**

(58) **Field of Classification Search**  
CPC ..... H01Q 21/065; H01Q 1/48; H01Q 1/523;  
H01Q 9/0414; H01Q 9/045  
See application file for complete search history.

(71) Applicant: **Movandi Corporation**, Irvine, CA (US)

(56) **References Cited**

(72) Inventors: **Nemat Dolatsha**, San Jose, CA (US);  
**Alfred Grau Besoli**, Irvine, CA (US);  
**Yifan Wang**, South Brisbane (AU);  
**Maryam Rofougaran**, Rancho Palos Verdes, CA (US); **Ahmadreza Rofougaran**, Newport Beach, CA (US)

U.S. PATENT DOCUMENTS

2019/0020110 A1\* 1/2019 Paulotto ..... H01Q 5/20

FOREIGN PATENT DOCUMENTS

(73) Assignee: **Movandi Corporation**, Irvine, CA (US)

CN 110676578 A \* 1/2020 ..... H01Q 1/38

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 64 days.

\* cited by examiner

*Primary Examiner* — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — Chip Law Group

(21) Appl. No.: **17/493,995**

(57) **ABSTRACT**

(22) Filed: **Oct. 5, 2021**

An antenna device includes a first patch radiator and a second patch radiator arranged over the first patch radiator. The antenna device further includes a central ground pin connected substantially at a center portion of the first patch radiator. The antenna device further includes a plurality of conductive feeding pins connected to the first patch radiator and separated by at least one slot of a plurality of slots provides in the first patch radiator. The antenna device further includes a cell structure having a cavity that includes a polygonal-shaped base and a metallic fence arranged at four or more side walls of the cavity. The first patch radiator and the second patch radiators are arranged in the cavity of the cell structure and are at least partially surrounded by the metallic fence such that a plurality of antenna control parameters are decoupled from each other.

(65) **Prior Publication Data**

US 2022/0294124 A1 Sep. 15, 2022

**Related U.S. Application Data**

(60) Provisional application No. 63/160,481, filed on Mar. 12, 2021.

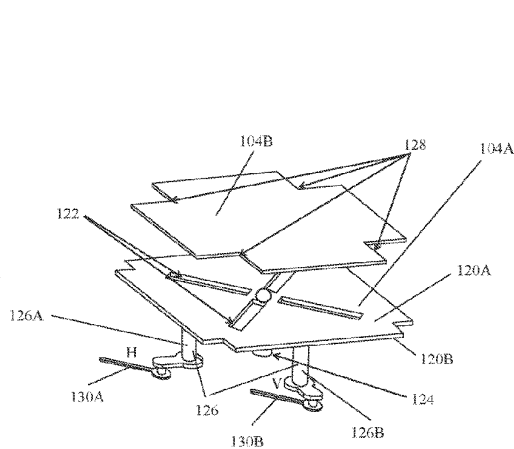
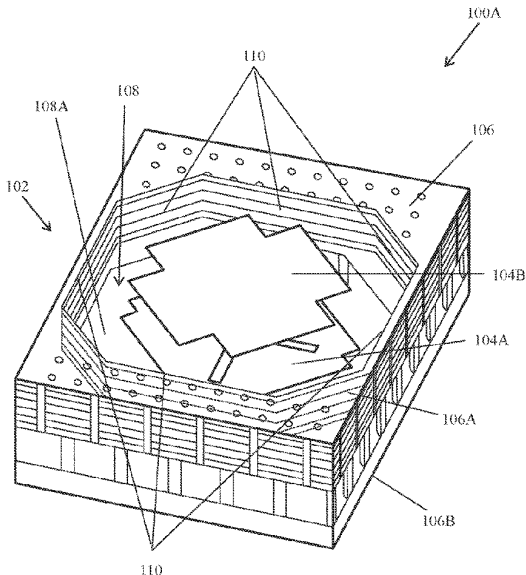
(51) **Int. Cl.**

**H01Q 1/48** (2006.01)  
**H01Q 21/06** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 1/52** (2006.01)

(52) **U.S. Cl.**

CPC ..... **H01Q 21/065** (2013.01); **H01Q 1/48** (2013.01); **H01Q 1/523** (2013.01); **H01Q 9/045** (2013.01); **H01Q 9/0414** (2013.01)

**20 Claims, 11 Drawing Sheets**





US011687128B2

(12) **United States Patent**  
**Lee et al.**

(10) **Patent No.:** **US 11,687,128 B2**  
(45) **Date of Patent:** **Jun. 27, 2023**

(54) **ELECTRONIC DEVICE INCLUDING FLEXIBLE DISPLAY AND ANTENNA**

(71) Applicant: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)

(72) Inventors: **Wonho Lee**, Suwon-si (KR); **Hoyoung Jeong**, Suwon-si (KR); **Hyoungtak Cho**, Suwon-si (KR); **Soyoung Lee**, Suwon-si (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**, Suwon-si (KR)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/573,036**

(22) Filed: **Jan. 11, 2022**

(65) **Prior Publication Data**

US 2022/0147116 A1 May 12, 2022

**Related U.S. Application Data**

(63) Continuation of application No. PCT/KR2021/016061, filed on Nov. 5, 2021.

(30) **Foreign Application Priority Data**

Nov. 6, 2020 (KR) ..... 10-2020-0147371  
Mar. 4, 2021 (KR) ..... 10-2021-0028874

(51) **Int. Cl.**  
**G06F 1/16** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **G06F 1/1698** (2013.01); **G06F 1/1624** (2013.01); **G06F 1/1652** (2013.01)

(58) **Field of Classification Search**  
CPC .... G06F 1/1624; G06F 1/1652; G06F 1/1656; G06F 1/1698

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,208,874 B1 \* 3/2001 Rudisill ..... H04M 1/0237  
455/575.4  
6,752,320 B1 \* 6/2004 Herranen ..... H01Q 1/22  
343/702

(Continued)

FOREIGN PATENT DOCUMENTS

KR 10-2006-0068926 A 6/2006  
KR 10-0606798 B1 8/2006

(Continued)

OTHER PUBLICATIONS

International Search Report dated Feb. 11, 2022, issued in International Application No. PCT/KR2021/016061.

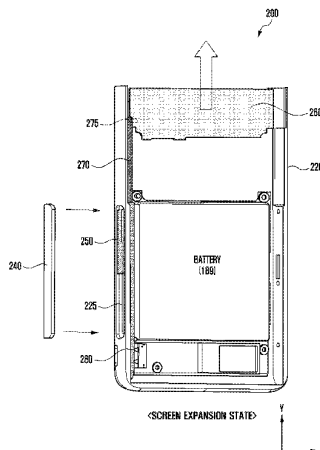
*Primary Examiner* — Adrian S Wilson

(74) *Attorney, Agent, or Firm* — Jefferson IP Law, LLP

(57) **ABSTRACT**

An electronic device is provided. The electronic device includes a first housing, a second housing, a flexible display, a printed circuit board, an antenna radiator, and a flexible printed circuit board. The second housing slides in a first direction to be pulled out of the first housing and slides in a second direction opposite to the first direction to be pulled into the inside of the first housing. The flexible display is disposed in the first housing and the second housing. The printed circuit board is disposed in the second housing and may move according to sliding of the second housing. The antenna radiator is disposed on a side surface of the first housing. The flexible printed circuit board electrically connects the printed circuit board and the antenna radiator. The first housing includes a through hole formed in a side surface thereof, and at least a portion of the antenna radiator may be inserted via the through hole into the inside of the first housing. The antenna radiator may move on the side surface of the first housing according to sliding of the second housing.

**20 Claims, 19 Drawing Sheets**





US011688927B2

(12) **United States Patent**  
**Oh et al.**

(10) **Patent No.:** **US 11,688,927 B2**  
(45) **Date of Patent:** **Jun. 27, 2023**

(54) **DISPLAY MODULE EXCITATION FOR WIRELESS COMMUNICATIONS**

(71) Applicant: **GOOGLE LLC**, Mountain View, CA (US)

(72) Inventors: **Sung Oh**, San Jose, CA (US);  
**Uei-ming Jow**, San Diego, CA (US);  
**Huan Liao**, San Jose, CA (US)

(73) Assignee: **Google LLC**, Mountain View, CA (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 327 days.

(21) Appl. No.: **16/947,222**

(22) Filed: **Jul. 23, 2020**

(65) **Prior Publication Data**

US 2021/0066781 A1 Mar. 4, 2021

**Related U.S. Application Data**

(60) Provisional application No. 62/892,068, filed on Aug. 27, 2019.

(51) **Int. Cl.**  
**H01Q 1/22** (2006.01)  
**H01Q 1/48** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/2266** (2013.01); **H01Q 1/48** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/2266; H01Q 1/243; H01Q 1/273; H01Q 1/38-48  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

10,355,344	B1	7/2019	Ruaro et al.
2010/0321325	A1	12/2010	Springer et al.
2015/0255856	A1	9/2015	Hong et al.
2017/0033439	A1*	2/2017	Liu ..... H01Q 1/243
2019/0074586	A1	3/2019	Ruaro et al.
2019/0372205	A1*	12/2019	Ruaro ..... H01Q 13/10
2020/0021008	A1*	1/2020	Yong ..... H01Q 21/005
2020/0136234	A1*	4/2020	Paulotto ..... H01Q 15/0026

FOREIGN PATENT DOCUMENTS

CN 204809404 U 11/2015

OTHER PUBLICATIONS

International Search Report and Written Opinion for PCT Application No. PCT/US2020/070309, dated Oct. 15, 2020, 11 pages.

\* cited by examiner

*Primary Examiner* — Hasan Islam

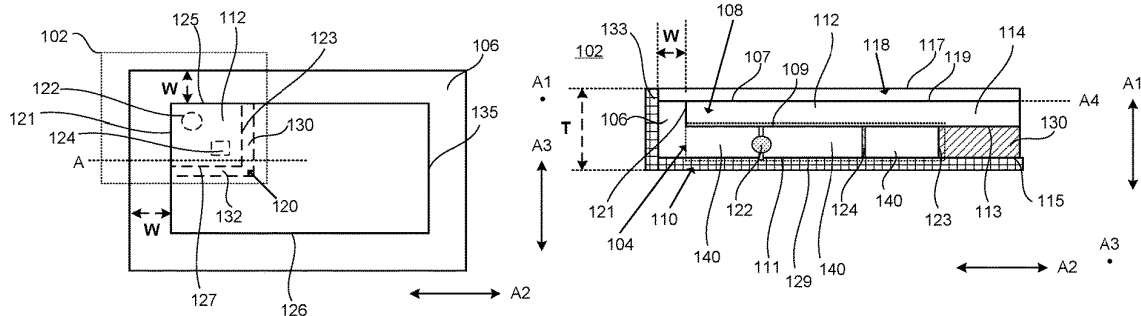
(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**

According to an aspect, a display device includes a display module including a display panel and a conductive layer, and an enclosure configured to surround the display module, where the enclosure includes a conductive portion. The display device includes an antenna having a structure formed by an air gap disposed between the conductive layer and the conductive portion of the enclosure. The antenna includes an antenna feed located within the air gap. The antenna feed is coupled to the conductive portion of the enclosure and to the conductive layer such that at least a portion of the display module is configured as a radiating element for wireless communication.

**16 Claims, 8 Drawing Sheets**

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US011688930B2

(12) **United States Patent**  
**Chang et al.**

(10) **Patent No.:** **US 11,688,930 B2**  
(45) **Date of Patent:** **Jun. 27, 2023**

(54) **ANTENNA APPARATUS AND MOBILE TERMINAL**

(58) **Field of Classification Search**  
CPC .... H01Q 1/242; H01Q 21/0006; H01Q 21/28;  
H01Q 1/243; H01Q 1/50; H01Q 5/335;  
(Continued)

(71) Applicant: **Huawei Technologies Co., Ltd.**,  
Shenzhen (CN)

(56) **References Cited**

(72) Inventors: **Chih-Hua Chang**, Taiwan (CN);  
**Chien-Ming Lee**, Shenzhen (CN);  
**Dong Yu**, Shanghai (CN); **Hanyang Wang**, Reading (GB); **Yen-Cheng Lai**,  
Shenzhen (CN)

U.S. PATENT DOCUMENTS

5,880,649 A \* 3/1999 Tai ..... H03H 7/463  
333/132  
6,249,687 B1 \* 6/2001 Thomsen ..... H01P 1/213  
375/316

(73) Assignee: **Huawei Technologies Co., Ltd.**,  
Shenzhen (CN)

(Continued)

(\*) Notice: Subject to any disclaimer, the term of this  
patent is extended or adjusted under 35  
U.S.C. 154(b) by 72 days.

FOREIGN PATENT DOCUMENTS

CN 104218306 A 12/2014  
CN 104795636 A 7/2015  
(Continued)

(21) Appl. No.: **17/053,678**

*Primary Examiner* — Ab Salam Alkassim, Jr.

(22) PCT Filed: **May 8, 2018**

*Assistant Examiner* — Bamidele A Jegede

(86) PCT No.: **PCT/CN2018/086083**

(74) *Attorney, Agent, or Firm* — Slater Matsil, LLP

§ 371 (c)(1),  
(2) Date: **Nov. 6, 2020**

(57) **ABSTRACT**

(87) PCT Pub. No.: **WO2019/213851**  
PCT Pub. Date: **Nov. 14, 2019**

An antenna apparatus includes two feeding parts, a filter matching network, and a radiator. The filter matching network includes a first port, a second port, and a third port. A first feeding part is electrically connected to the first port, a second feeding part is electrically connected to the second port, and the radiator is electrically connected to the third port. The first feeding part is configured to feed a low frequency signal and an intermediate frequency signal, the second feeding part is configured to feed a high frequency signal, the low frequency signal, the intermediate frequency signal, and the high frequency signal are respectively fed into the filter matching network by using the first feeding part and the second feeding part, and the filter matching network is configured to improve isolation between the low frequency signal and the intermediate frequency signal, and the high frequency signal.

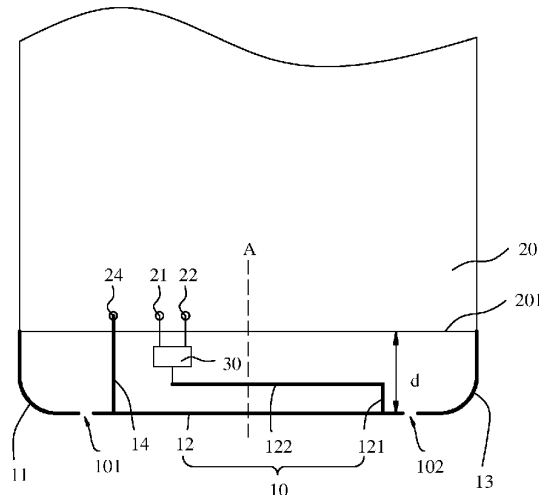
(65) **Prior Publication Data**

US 2021/0075089 A1 Mar. 11, 2021

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 21/00** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/242**  
(2013.01); **H01Q 21/0006** (2013.01); **H01Q**  
**21/28** (2013.01); **H01Q 5/335** (2015.01)

**20 Claims, 10 Drawing Sheets**





US011688953B2

(12) **United States Patent**  
**Huang et al.**

(10) **Patent No.:** **US 11,688,953 B2**  
(45) **Date of Patent:** **Jun. 27, 2023**

(54) **TERMINAL DEVICE**  
(71) Applicant: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)  
(72) Inventors: **Huan-chu Huang**, Dongguan (CN); **Yijin Wang**, Dongguan (CN); **Xianjing Jian**, Dongguan (CN)  
(73) Assignee: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)  
(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 281 days.

(21) Appl. No.: **17/213,898**

(22) Filed: **Mar. 26, 2021**

(65) **Prior Publication Data**  
US 2021/0218155 A1 Jul. 15, 2021

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2019/101512, filed on Aug. 20, 2019.

(30) **Foreign Application Priority Data**

Sep. 28, 2018 (CN) ..... 201811142574.7

(51) **Int. Cl.**  
**H01Q 21/06** (2006.01)  
**H01Q 9/04** (2006.01)  
**H01Q 21/00** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/065** (2013.01); **H01Q 9/045** (2013.01); **H01Q 21/0031** (2013.01)

(58) **Field of Classification Search**  
CPC ... H01Q 21/065; H01Q 9/045; H01Q 21/0031  
See application file for complete search history.

(56) **References Cited**  
U.S. PATENT DOCUMENTS  
4,401,988 A \* 8/1983 Kaloj ..... H01Q 19/005 343/700 MS  
4,403,221 A 9/1983 Lamberg et al.  
(Continued)

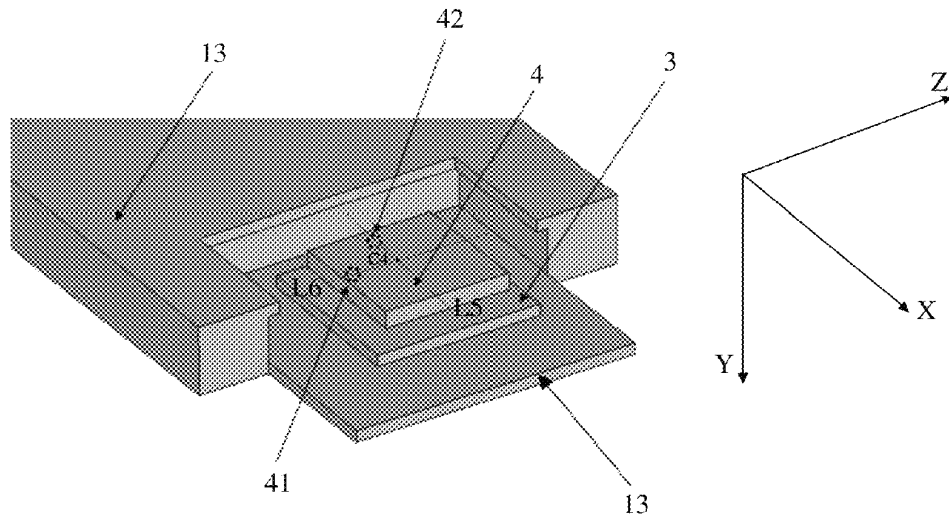
FOREIGN PATENT DOCUMENTS  
CN 2938452 Y 8/2007  
CN 102117962 A 7/2011  
(Continued)

OTHER PUBLICATIONS  
Supplementary European Search Report for Application No. 19867529.0-1205/3859880—PCT/CN2019/101512, dated Oct. 14, 2021.  
(Continued)

*Primary Examiner* — Dieu Hien T Duong  
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**  
A terminal device includes feed sources, a metal frame, coupling patches, and radiating patches, where at least two grooves are formed in the outer side surface of the metal frame, two first through holes are formed in each groove, a coupling patch and a radiating patch are arranged in each groove; the coupling patch in each groove is arranged between the radiating patch and the bottom of the groove, and two second through holes are formed in the coupling patch; two antenna feed points are arranged on each radiating patch, each feed source is connected to one antenna feed point through one first through hole and one second through hole; and the metal frame, the coupling patch, and the radiating patch are not in contact with one another, and an area of the radiating patch is less than an area of the coupling patch.

**10 Claims, 5 Drawing Sheets**





US011695199B2

(12) **United States Patent**  
**Lai et al.**

(10) **Patent No.:** **US 11,695,199 B2**  
(45) **Date of Patent:** **Jul. 4, 2023**

(54) **ANTENNA DEVICE AND MANUFACTURING METHOD THEREOF**

(71) Applicant: **XINTEC INC.**, Taoyuan (TW)

(72) Inventors: **Jiun-Yen Lai**, Taoyuan (TW);  
**Ming-Chung Chung**, Taoyuan (TW);  
**Wei-Luen Suen**, Taoyuan (TW)

(73) Assignee: **XINTEC INC.**, Taoyuan (TW)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 169 days.

(21) Appl. No.: **17/407,068**

(22) Filed: **Aug. 19, 2021**

(65) **Prior Publication Data**

US 2022/0069454 A1 Mar. 3, 2022

**Related U.S. Application Data**

(60) Provisional application No. 63/070,056, filed on Aug. 25, 2020.

(51) **Int. Cl.**  
**H01Q 1/38** (2006.01)  
**H01Q 1/52** (2006.01)  
**H01Q 23/00** (2006.01)  
**H01Q 1/24** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/38** (2013.01); **H01Q 1/526** (2013.01); **H01Q 1/243** (2013.01); **H01Q 23/00** (2013.01)

(58) **Field of Classification Search**

CPC ..... H01Q 1/38; H01Q 1/526; H01Q 1/243; H01Q 23/00; H01Q 1/2283; H01Q 1/36  
See application file for complete search history.

(56) **References Cited**

**U.S. PATENT DOCUMENTS**

8,134,180 B2 3/2012 Otake et al.  
2011/0079903 A1\* 4/2011 Liu ..... H01L 24/03 257/E23.068  
2017/0186797 A1\* 6/2017 Long ..... H01L 27/14636  
2017/0301986 A1 10/2017 Nguyen et al.  
2021/0398921 A1\* 12/2021 Chen ..... H01Q 1/38

**FOREIGN PATENT DOCUMENTS**

CN 107958896 A 4/2018  
CN 109155303 B 5/2020  
TW 201622503 A 6/2016

\* cited by examiner

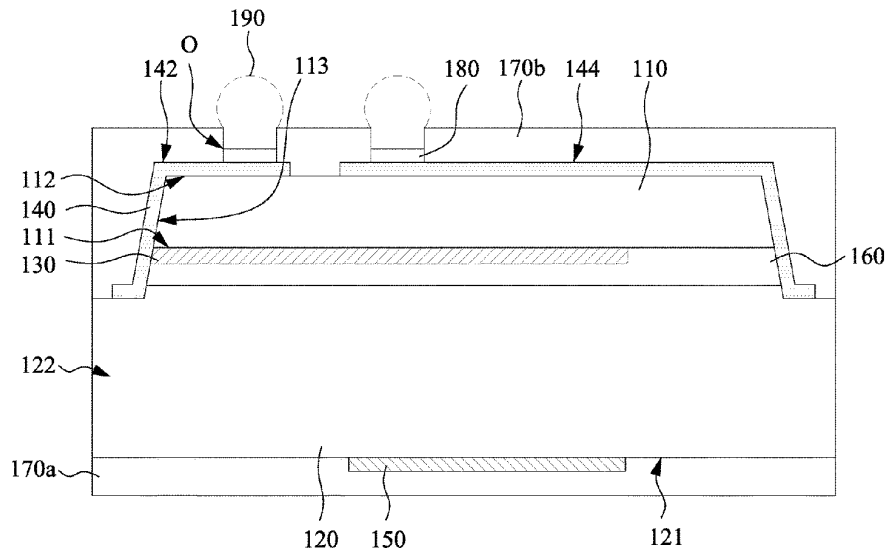
*Primary Examiner* — David E Lotter

(74) *Attorney, Agent, or Firm* — Liu & Liu

(57) **ABSTRACT**

An antenna device includes a first substrate, a second substrate, an antenna layer, and a redistribution layer. The first substrate has a first surface, a second surface opposite to the first surface, and an inclined sidewall adjoining the first and second surfaces. The second substrate is below the first substrate. The first surface of the first substrate faces toward the second substrate. The antenna layer is located on the first surface of the first substrate. The redistribution layer extends from the second surface of the first substrate to the second substrate along the inclined sidewall of the first substrate, and the redistribution layer has a first section in contact with an end of the antenna layer.

**18 Claims, 11 Drawing Sheets**







US011695210B2

(12) **United States Patent**  
**Huang et al.**

(10) **Patent No.:** **US 11,695,210 B2**  
(45) **Date of Patent:** **Jul. 4, 2023**

- (54) **TERMINAL DEVICE**
- (71) Applicant: **VIVO MOBILE COMMUNICATION CO., LTD.**, Guangdong (CN)
- (72) Inventors: **Huan-Chu Huang**, Chang'an Dongguan (CN); **Yijin Wang**, Chang'an Dongguan (CN); **Xianjing Jian**, Chang'an Dongguan (CN)
- (73) Assignee: **VIVO MOBILE COMMUNICATION CO., LTD.**, Chang'an Dongguan (CN)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 196 days.

(21) Appl. No.: **17/214,613**

(22) Filed: **Mar. 26, 2021**

(65) **Prior Publication Data**

US 2021/0218143 A1 Jul. 15, 2021

**Related U.S. Application Data**

(63) Continuation of application No. PCT/CN2019/101510, filed on Aug. 20, 2019.

(30) **Foreign Application Priority Data**

Sep. 28, 2018 (CN) ..... 201811142604.4

(51) **Int. Cl.**  
**H01Q 9/04** (2006.01)

(52) **U.S. Cl.**  
CPC ..... **H01Q 9/0414** (2013.01); **H01Q 9/045** (2013.01); **H01Q 9/0435** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 9/0414; H01Q 9/0435; H01Q 9/045  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

- 2007/0132642 A1 6/2007 Iluz et al.
- 2008/0218418 A1\* 9/2008 Gillette ..... H01Q 9/045  
343/700 MS
- 2013/0278468 A1\* 10/2013 Yehezky ..... H01Q 1/2266  
343/702

(Continued)

FOREIGN PATENT DOCUMENTS

- CN 2938452 Y 8/2007
- CN 201910487 U 7/2011

(Continued)

OTHER PUBLICATIONS

CN Office Action dated Nov. 27, 2019 as received in Application No. 201811142604.4.

(Continued)

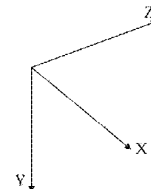
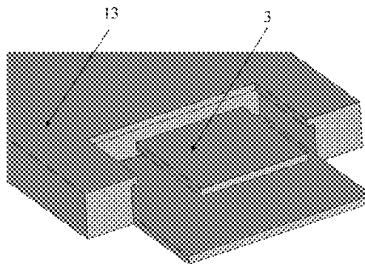
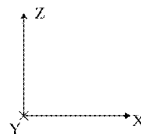
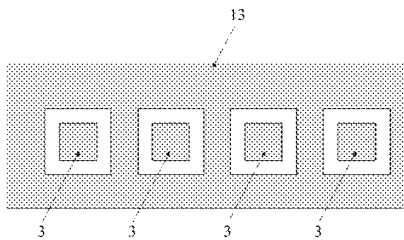
*Primary Examiner* — Dieu Hien T Duong

(74) *Attorney, Agent, or Firm* — Maschoff Brennan

(57) **ABSTRACT**

A terminal device is provided. The terminal device includes a feed, a metal frame, and a radiating patch. At least two grooves are disposed on an outer surface of the metal frame, two through-holes are disposed in each groove, the radiating patch is disposed in each groove, the metal frame is grounded, two antenna feeding points are disposed on each radiating patch, the feed is connected to one feeding point through one through-hole, the antenna feeding points in each groove are in a one-to-one correspondence with the through-holes, and each radiating patch is insulated from the groove by using a non-conducting material.

**12 Claims, 6 Drawing Sheets**





US011695219B2

(12) **United States Patent**  
**Govoni et al.**

(10) **Patent No.:** **US 11,695,219 B2**  
(45) **Date of Patent:** **Jul. 4, 2023**

(54) **BROADBAND STACKED PATCH ANTENNA ARRAY**

(71) Applicant: **U.S. Army DEVCOM Army Research Laboratory, Adelphi, MD (US)**

(72) Inventors: **Mark A. Govoni, Abingdon, MD (US); Seth A. McCormick, Arlington, VA (US)**

(73) Assignee: **America as represented by the Secretary of the Army, Washington, DC (US)**

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **17/322,317**

(22) Filed: **May 17, 2021**

(65) **Prior Publication Data**  
US 2022/0368028 A1 Nov. 17, 2022

(51) **Int. Cl.**  
**H01Q 21/06** (2006.01)  
**H01Q 1/42** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 21/065** (2013.01); **H01Q 1/38** (2013.01); **H01Q 1/422** (2013.01); **H01Q 9/0414** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 21/065; H01Q 1/38; H01Q 1/422; H01Q 9/0414  
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,317,084 B1 \* 11/2001 Chen ..... H01Q 1/38 343/700 MS

9,184,504 B2 11/2015 Zhang  
(Continued)

OTHER PUBLICATIONS

F. Rostan, E. Heidrich and W. Wiesbeck, "Design of aperture-coupled patch antenna arrays with multiple dielectric layers," 1993 23rd European Microwave Conference, 1993, pp. 917-919, doi: 10.1109/EUMA.1993.336749. (Year: 1993).\*

(Continued)

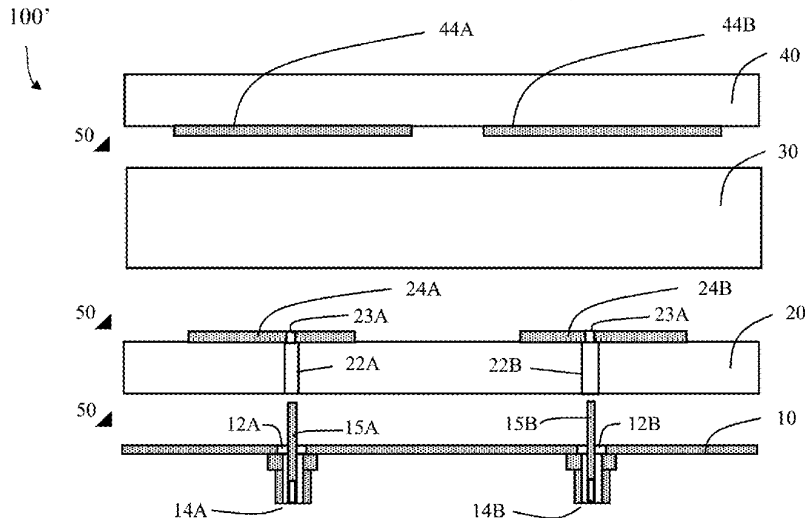
*Primary Examiner* — David E Lotter  
(74) *Attorney, Agent, or Firm* — Eric B. Compton

(57) **ABSTRACT**

A stacked patch antenna array includes: a conductive ground plane configured to connect to a plurality of electrical transmission lines for transmitting and/or receiving electrical signals; a driven layer adjacent to the conductive ground plane formed of a dielectric material and comprising a plurality of first resonant circular patches, each electrically connecting to a respective electrical transmission line such that a received electrical signal excites and generates an electromagnetic signal and/or a received electromagnetic signal excites and generates an electrical signal; an electrically insulating spacer adjacent to the driven layer; and a coupled layer adjacent to the electrically insulating spacer formed of a dielectric material and comprising a plurality of second resonant circular patches which are symmetrically positioned with respect to the first circular resonant patches of the driven layer and excited by the electromagnetic waves generated by the first resonant circular patches, wherein the electrically insulating spacer electrically separates the driven layer and the coupled layer having a thickness such that the resonances of the first and second resonant circular patches constructively combine.

**14 Claims, 7 Drawing Sheets**

**SIDE VIEW (UNASSEMBLED)**







US011699844B2

(12) **United States Patent**  
**Zhao**

(10) **Patent No.:** **US 11,699,844 B2**  
(45) **Date of Patent:** **Jul. 11, 2023**

- (54) **ANTENNA STRUCTURE AND WEARABLE DEVICE**
- (71) Applicant: **Anhui Huami Information Technology Co., Ltd.**, Anhui FTZ (CN)
- (72) Inventor: **Anping Zhao**, Anhui FTZ (CN)
- (73) Assignee: **Anhui Huami Information Technology Co., Ltd.**, Anhui FTZ (CN)
- (\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

- (21) Appl. No.: **17/954,074**
- (22) Filed: **Sep. 27, 2022**

- (65) **Prior Publication Data**  
US 2023/0022192 A1 Jan. 26, 2023

- Related U.S. Application Data**
- (63) Continuation of application No. PCT/CN2021/098121, filed on Jun. 3, 2021.

- (30) **Foreign Application Priority Data**  
Jun. 10, 2020 (CN) ..... 202010525769.0  
Jun. 10, 2020 (CN) ..... 202021058390.5

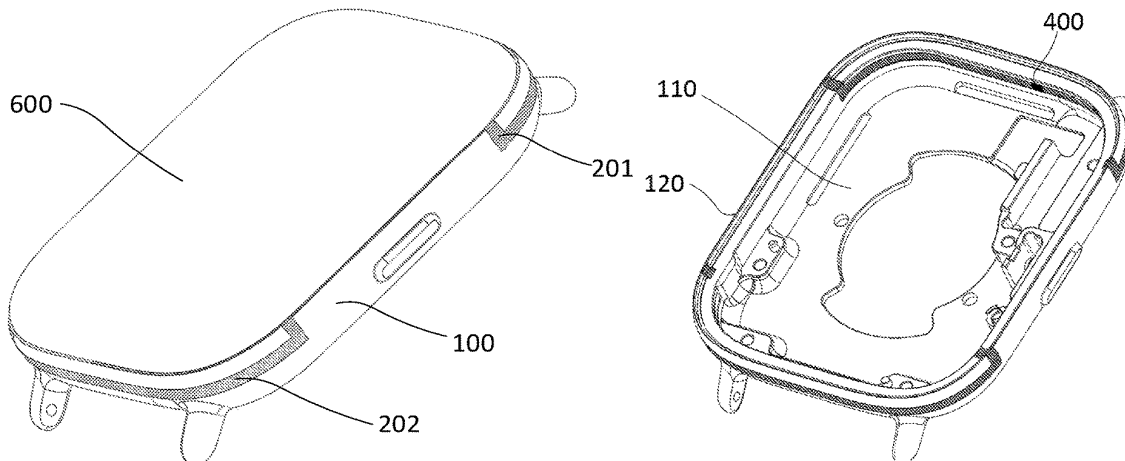
- (51) **Int. Cl.**  
**H01Q 1/27** (2006.01)  
**H01Q 5/30** (2015.01)  
**H01Q 1/48** (2006.01)
- (52) **U.S. Cl.**  
CPC ..... **H01Q 1/273** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/30** (2015.01)
- (58) **Field of Classification Search**  
CPC ..... H01Q 1/241–243; H01Q 1/273; H01Q 1/38–52; H01Q 5/30–50; H01Q 13/10  
See application file for complete search history.

- (56) **References Cited**  
U.S. PATENT DOCUMENTS  
9,379,445 B2 \* 6/2016 Zhu ..... H01Q 1/2266  
10,797,382 B2 \* 10/2020 Wu ..... H01Q 1/2283  
(Continued)  
FOREIGN PATENT DOCUMENTS  
CN 104538741 A 4/2015  
CN 108666739 A 10/2018  
(Continued)

- OTHER PUBLICATIONS**  
International Search Report with English translation for International Application No. PCT/CN2021/098121 dated Aug. 12, 2021.  
*Primary Examiner* — Hasan Islam  
(74) *Attorney, Agent, or Firm* — Young Basile Hanlon & MacFarlane, P.C.

- (57) **ABSTRACT**  
Provided are electronic devices, an antenna structure and a wearable device. The wearable device includes a metal casing including a bottom casing and a side frame surrounding an edge of the bottom casing and integrally connected with the bottom casing, the antenna structure includes a slot in the side frame, and the slot has a first end and a second end opposite to the first end in the first direction. The first direction is the direction surrounding the edge of the bottom casing; the slot is provided with an opening at the first end, and the opening faces the side away from the bottom casing; in the first direction, length from the first end to the grounding end of the slot is 1/4 of operating wavelength; and a feeding terminal is arranged between the first end and the grounding end of the slot, and is close to the grounding end.

**20 Claims, 5 Drawing Sheets**





US011700035B2

(12) **United States Patent**  
**Rajagopalan et al.**

(10) **Patent No.:** **US 11,700,035 B2**  
(45) **Date of Patent:** **Jul. 11, 2023**

(54) **DIELECTRIC RESONATOR ANTENNA MODULES**

(71) Applicant: **Apple Inc.**, Cupertino, CA (US)

(72) Inventors: **Harish Rajagopalan**, San Jose, CA (US); **Bilgehan Avser**, Mountain View, CA (US); **David Garrido Lopez**, Campbell, CA (US); **Forhad Hasnat**, Cupertino, CA (US); **Mattia Pascolini**, San Francisco, CA (US); **Mikal Askarian Amiri**, Tempe, AZ (US); **Rodney A. Gomez Angulo**, Santa Clara, CA (US); **Thomas W. Yang**, Sunnyvale, CA (US); **Jiechen Wu**, Santa Clara, CA (US); **Eric N. Nyland**, Santa Clara, CA (US); **Simone Paulotto**, Redwood City, CA (US); **Jennifer M. Edwards**, San Francisco, CA (US); **Matthew D. Hill**, Santa Clara, CA (US); **Ihtesham H. Chowdhury**, Los Altos, CA (US); **David A. Hurrell**, San Mateo, CA (US); **Siwen Yong**, San Francisco, CA (US); **Jiangfeng Wu**, San Jose, CA (US); **Daniel C. Wagman**, Scotts Valley, CA (US); **Soroush Akbarzadeh**, San Jose, CA (US); **Robert Scritzky**, Sunnyvale, CA (US); **Subramanian Ramalingam**, Sunnyvale, CA (US)

(73) Assignee: **Apple Inc.**, Cupertino, CA (US)

(\* ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/920,297**

(22) Filed: **Jul. 2, 2020**

(65) **Prior Publication Data**

US 2022/0006486 A1 Jan. 6, 2022

(51) **Int. Cl.**  
**H01Q 9/04** (2006.01)  
**H04B 3/52** (2006.01)  
(Continued)

(52) **U.S. Cl.**  
CPC ..... **H04B 3/52** (2013.01); **G01R 31/2822** (2013.01); **H01Q 1/2283** (2013.01); **H01Q 13/24** (2013.01); **H04B 3/54** (2013.01)

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 9/0485; H01Q 1/38; H01Q 1/48; H01Q 21/28; H01Q 3/24;  
(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,453,754 A \* 9/1995 Fray ..... H01Q 9/0485  
343/873  
5,952,972 A \* 9/1999 Ittipiboon ..... H01Q 9/0485  
343/873

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2000278039 A 10/2000  
JP 2002524954 A 8/2002

(Continued)

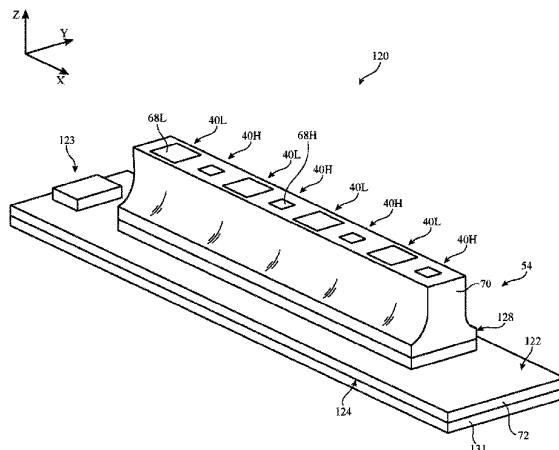
*Primary Examiner* — Linh V Nguyen

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.; Michael H. Lyons

(57) **ABSTRACT**

An electronic device may be provided with an antenna module having a substrate. A phased antenna array of dielectric resonator antennas and a radio-frequency integrated circuit for the array may be mounted to one or more surfaces of the substrate. The dielectric resonator antennas may include dielectric columns excited by feed probes. The feed probes may be printed onto sidewalls of the dielectric columns or may be pressed against the sidewalls by biasing structures. A plastic substrate may be molded over each dielectric column and each of the feed probes in the array. The feed probes may cover multiple polarizations. The array

(Continued)





US011705619B2

(12) **United States Patent**  
**Park et al.**

(10) **Patent No.:** **US 11,705,619 B2**  
(45) **Date of Patent:** **Jul. 18, 2023**

(54) **ANTENNA AND ELECTRONIC DEVICE INCLUDING THE SAME**

(58) **Field of Classification Search**  
CPC ..... H01Q 1/243; H01Q 1/38; H01Q 3/36; H01Q 5/378

(71) Applicant: **Samsung Electronics Co., Ltd.**,  
Gyeonggi-do (KR)

See application file for complete search history.

(72) Inventors: **Seongjin Park**, Gyeonggi-do (KR);  
**Dongyeon Kim**, Gyeonggi-do (KR);  
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**Sumin Yun**, Gyeonggi-do (KR);  
**Woomin Jang**, Gyeonggi-do (KR);  
**Myunghun Jeong**, Gyeonggi-do (KR);  
**Jaehoon Jo**, Gyeonggi-do (KR)

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,310,584 B1 10/2001 Reece et al.  
2013/0207869 A1 8/2013 Han et al.  
(Continued)

FOREIGN PATENT DOCUMENTS

KR 10-1288381 B1 7/2013  
KR 10-1954819 B1 2/2019  
(Continued)

(73) Assignee: **Samsung Electronics Co., Ltd.**,  
Suwon-si (KR)

OTHER PUBLICATIONS

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 124 days.

International Search Report dated Feb. 18, 2021.

(21) Appl. No.: **17/094,916**

*Primary Examiner* — Dieu Hien T Duong

(22) Filed: **Nov. 11, 2020**

(74) *Attorney, Agent, or Firm* — Cha & Reiter, LLC

(65) **Prior Publication Data**

US 2021/0151859 A1 May 20, 2021

(30) **Foreign Application Priority Data**

Nov. 18, 2019 (KR) ..... 10-2019-0147902

(51) **Int. Cl.**  
**H01Q 1/24** (2006.01)  
**H01Q 3/36** (2006.01)

(Continued)

(52) **U.S. Cl.**  
CPC ..... **H01Q 1/243** (2013.01); **H01Q 1/38** (2013.01); **H01Q 3/36** (2013.01); **H01Q 5/378** (2015.01)

(57) **ABSTRACT**

In an embodiment, an electronic device may include a housing having an inner space and an antenna structure disposed in the inner space of the housing. The antenna structure may include a printed circuit board (PCB) and at least one antenna disposed in the PCB. The PCB may have a plurality of insulating layers and a ground layer. The at least one antenna may include a conductive line disposed on a first insulating layer among the plurality of insulating layers, a conductive via extended from the conductive line in a first direction, and at least one conductive pattern branched at a right angle from the conductive line on the first insulating layer. The wireless communication circuit may be configured to transmit and/or receive a radio signal in a range of about 3 GHz to about 100 GHz through the at least one antenna.

**9 Claims, 42 Drawing Sheets**

