



US011715878B2

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

(10) **Patent No.:** **US 11,715,878 B2**
(45) **Date of Patent:** **Aug. 1, 2023**

(54) **THREE-DIMENSIONAL ELECTRONIC COMPONENT AND ELECTRONIC DEVICE**

(71) Applicant: **ASUSTeK COMPUTER INC.**, Taipei (TW)

(72) Inventors: **Zhi-Hua Feng**, Taipei (TW); **Chia-Ho Lin**, Taipei (TW); **Pin-Tang Chiu**, Taipei (TW); **Zhen-De Jiang**, Taipei (TW)

(73) Assignee: **ASUSTEK COMPUTER INC.**, Taipei (TW)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 134 days.

(21) Appl. No.: **17/476,544**

(22) Filed: **Sep. 16, 2021**

(65) **Prior Publication Data**

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(30) **Foreign Application Priority Data**

Sep. 30, 2020 (TW) 109134311

(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/48 (2006.01)
H01Q 5/357 (2015.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0457** (2013.01); **H01Q 1/48** (2013.01); **H01Q 5/357** (2015.01); **H01Q 9/0471** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 1/48; H01Q 9/0471; H01Q 5/371; H01Q 9/0421; H01Q 5/357
See application file for complete search history.

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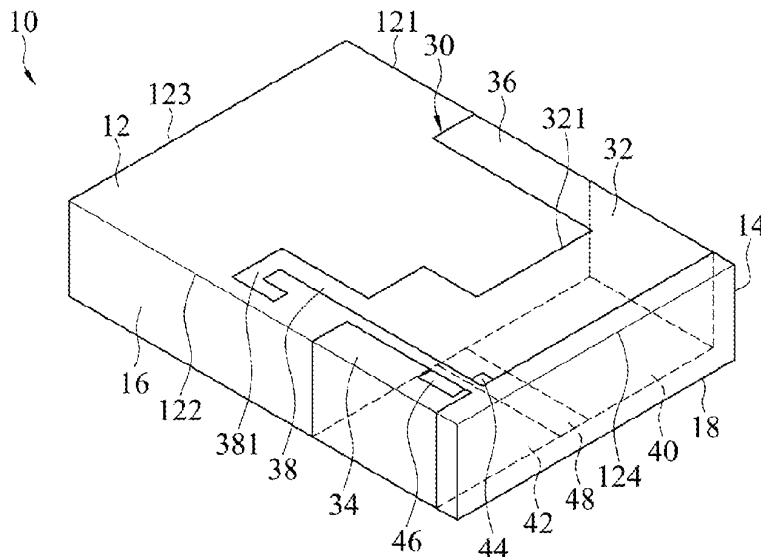
Primary Examiner — Ricardo I Magallanes

(74) Attorney, Agent, or Firm — McClure, Qualey & Rodack, LLP

(57) **ABSTRACT**

A three-dimensional electronic component includes a first surface, a second surface, a third surface, and a fourth surface, and an antenna structure. The antenna structure includes a first radiating metal portion, a second radiating metal portion, an adjusting metal branch, a first ground connection portion, a second ground connection portion, a feed point, and a ground point. The first radiating metal portion on the first surface extends to the second surface. The second radiating metal portion on the first surface extends to the third surface. A gap is between the first radiating metal portion and the second radiating metal portion. The adjusting metal branch on the first surface is connected to the first radiating metal portion. The feed point on the first radiating metal portion is close to the gap. The ground point on the second radiating metal portion is close to the gap.

21 Claims, 9 Drawing Sheets





US011721885B2

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

(10) **Patent No.:** **US 11,721,885 B2**
(45) **Date of Patent:** **Aug. 8, 2023**

(54) **ELECTRONIC DEVICE**

(71) Applicant: **SAMSUNG DISPLAY CO., LTD.**,
Yongin-si (KR)

(72) Inventors: **Seongryong Lee**, Hwaseong-si (KR);
Kiseo Kim, Yongin-si (KR);
Jae-Kyoung Kim, Hwaseong-si (KR);
Eunjin Sung, Yongin-si (KR);
Sangrock Yoon, Hwaseong-si (KR)

(73) Assignee: **SAMSUNG DISPLAY CO., LTD.**,
Yongin-si (KR)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 14 days.

(21) Appl. No.: **17/349,676**

(22) Filed: **Jun. 16, 2021**

(65) **Prior Publication Data**
US 2022/0109227 A1 Apr. 7, 2022

(30) **Foreign Application Priority Data**
Oct. 5, 2020 (KR) 10-2020-0128296

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
G06F 3/044 (2006.01)
G06F 1/16 (2006.01)
G06F 3/041 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **G06F 1/1643**
(2013.01); **G06F 3/0412** (2013.01); **G06F**
3/0446 (2019.05)

(58) **Field of Classification Search**
CPC G06F 1/1643; G06F 3/0446; G06F 1/1698
See application file for complete search history.

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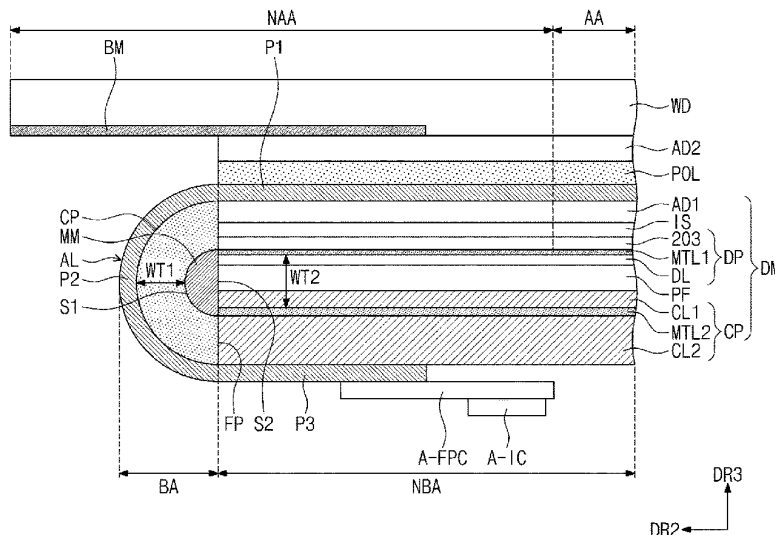
Primary Examiner — Robin J Mishler

(74) *Attorney, Agent, or Firm* — F. Chau & Associates,
LLC

(57) **ABSTRACT**

An electronic device includes a display module including a
display area and a non-display area. An antenna layer is
disposed on the display module, including a bending area at
least partially overlapping the non-display area and a non-
bending area adjacent to the bending area, and including a
first portion disposed in the non-bending area and a second
portion disposed in the bending area, and bent, and a spacer
disposed between the second portion and the display module
and including a metal plate that is bent.

24 Claims, 13 Drawing Sheets





US011721902B2

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

(10) **Patent No.:** **US 11,721,902 B2**
(45) **Date of Patent:** **Aug. 8, 2023**

(54) **WIDE BAND LOOP TYPE GROUND
RADIATING ANTENNA**

2018/0062254 A1 3/2018 Rahikkala et al.
2020/0127628 A1* 4/2020 Zolomy H01Q 7/005
2022/0131271 A1* 4/2022 Hänninen H01Q 7/00

(71) Applicant: **Silicon Laboratories Inc.**, Austin, TX
(US)

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(72) Inventors: **Pasi Rahikkala**, Vihti (FI); **Tuomas
Hänninen**, Helsinki (FI); **Attila
Zólmoy**, Budapest (HU)

Hassan et al., "A Wideband Loop-type Ground Radiation Antenna
Using Ground Mode Tuning and Optimum Impedance Level",
Microwave and Optical Technology Letters, pp. 1-6, 2019.

(73) Assignee: **Silicon Laboratories Inc.**, Austin, TX
(US)

Liu et al., "Excitation Techniques of Loop Current Mode of Ground
Antenna", IEEE Proceedings of 2011 Cross Strait Quad-Regional
Radio Science and Wireless Technology Conference, Jul. 2011.

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

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(21) Appl. No.: **17/325,548**

Primary Examiner — Hai V Tran

Assistant Examiner — Michael M Bouizza

(22) Filed: **May 20, 2021**

(74) *Attorney, Agent, or Firm* — Nields, Lemack &
Frame, LLC

(65) **Prior Publication Data**

US 2022/0376395 A1 Nov. 24, 2022

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 1/48 (2006.01)
H01Q 7/00 (2006.01)

A loop type ground radiating antenna having dual resonance is disclosed. The antenna including a feeding path that traverses the ground clearance, creating a first portion and a second portion. One or more first capacitors are disposed along a first conductive path between the ground clearance and the edge of the ground layer, proximate the first portion, while one or more second capacitors are disposed along a second conductive path between the ground clearance and the edge of the ground layer, proximate the second portion. An input capacitor is used to feed the feeding path. The values of the input capacitor and the first capacitors determine a resonant frequency of the first feeding loop, while the values of the input capacitor and the second capacitors determine a resonant frequency of the second feeding loop. By proper selection of the capacitor values, a wide bandwidth may be created.

(52) **U.S. Cl.**
CPC **H01Q 7/00** (2013.01); **H01Q 1/48**
(2013.01)

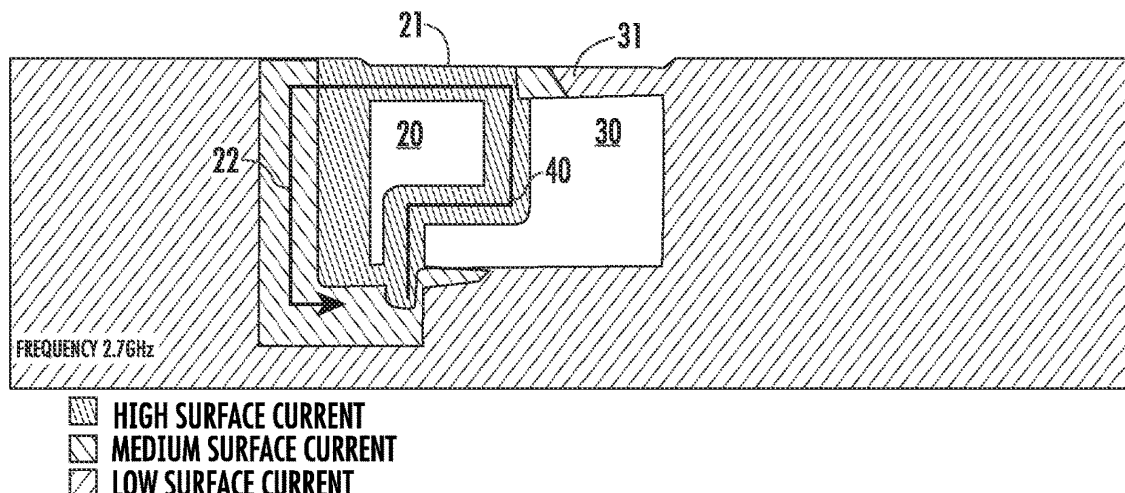
(58) **Field of Classification Search**
CPC H01Q 7/00; H01Q 1/48; H01Q 7/005
See application file for complete search history.

(56) **References Cited**

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343/702
2011/0309985 A1* 12/2011 He H01Q 5/371
343/700 MS

14 Claims, 6 Drawing Sheets





US011721904B2

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

(10) **Patent No.:** **US 11,721,904 B2**
(45) **Date of Patent:** **Aug. 8, 2023**

(54) **ANTENNA AND WIRELESS
COMMUNICATION DEVICE**

(71) Applicant: **Realtek Semiconductor Corp.,**
HsinChu (TW)

(72) Inventors: **Ching-Wei Ling, HsinChu (TW);**
Chih-Pao Lin, HsinChu (TW)

(73) Assignee: **Realtek Semiconductor Corp.,**
HsinChu (TW)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 24 days.

(21) Appl. No.: **17/349,864**

(22) Filed: **Jun. 16, 2021**

(65) **Prior Publication Data**
US 2022/0029299 A1 Jan. 27, 2022

(30) **Foreign Application Priority Data**
Jul. 21, 2020 (TW) 109124589

(51) **Int. Cl.**
H01Q 9/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/42** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 9/42; H01Q 1/20
See application file for complete search history.

(56) **References Cited**

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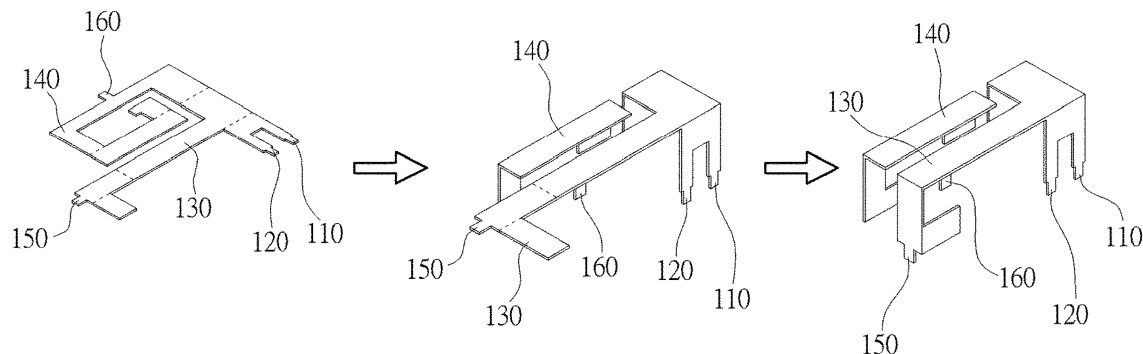
TW 201203698 A1 1/2012
* cited by examiner

Primary Examiner — Hai V Tran
Assistant Examiner — Michael M Bouizza
(74) *Attorney, Agent, or Firm* — Winston Hsu

(57) **ABSTRACT**

An antenna includes a radiation body and a feed pin. The radiation body includes a first radiation branch and a second radiation branch. The first radiation branch extends along a first direction. The second radiation branch extends along a second direction. The feed pin extends outward from the radiation body along a third direction. The first direction is perpendicular to the second direction and the third direction.

16 Claims, 10 Drawing Sheets





US011721912B2

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

(10) **Patent No.:** **US 11,721,912 B2**
(45) **Date of Patent:** **Aug. 8, 2023**

(54) **ANTENNA DEVICE**

(56) **References Cited**

(71) Applicant: **Murata Manufacturing Co., Ltd.**,
Nagaokakyo (JP)

U.S. PATENT DOCUMENTS

(72) Inventors: **Dai Futagami**, Nagaokakyo (JP);
Takaya Nemoto, Nagaokakyo (JP)

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343/700 MS
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343/785

(73) Assignee: **MURATA MANUFACTURING CO., LTD.**,
Nagaokakyo (JP)

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 305 days.

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(Continued)

(21) Appl. No.: **17/213,245**

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

(65) **Prior Publication Data**

US 2021/0226345 A1 Jul. 22, 2021

Written Opinion of the International Searching Authority dated Oct.
21, 2019, received for PCT Application PCT/JP2019/033975, Filed
on Aug. 29, 2019, 5 pages. (Previously filed; submitting English
translation only.).

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Related U.S. Application Data

(63) Continuation of application No.
PCT/JP2019/033975, filed on Aug. 29, 2019.

Primary Examiner — Hasan Islam
(74) *Attorney, Agent, or Firm* — Xsensus LLP

(30) **Foreign Application Priority Data**

Sep. 27, 2018 (JP) 2018-181165

(57) **ABSTRACT**

(51) **Int. Cl.**
H01Q 19/06 (2006.01)
H01Q 21/06 (2006.01)
(Continued)

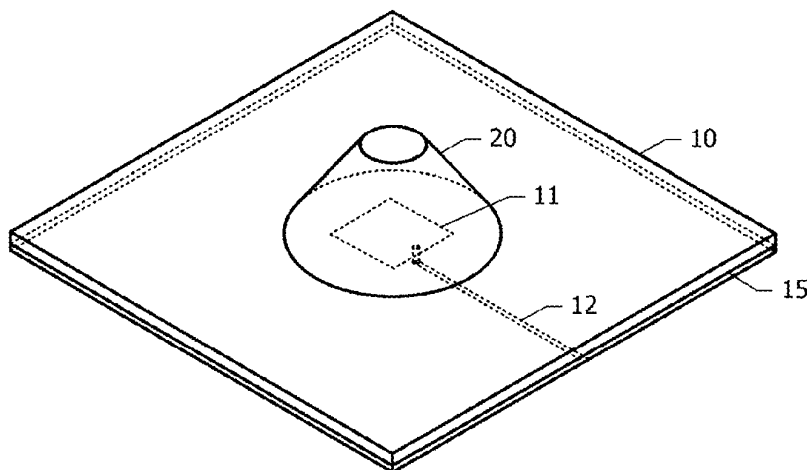
A patch antenna is constituted by a radiation element dis-
posed on a substrate and a ground conductor disposed in the
substrate. A dielectric member is disposed to at least par-
tially cover the radiation element as viewed from above. The
dielectric member is disposed on a side opposite a side on
which the ground conductor is disposed as viewed from the
radiation element. When a direction of a normal line to the
radiation element is assumed as a height direction and when
an imaginary plane perpendicular to the height direction is
assumed as a reference plane, the dielectric member has a
side surface which tilts with respect to the reference plane.
The dielectric member has no focal point for a radio wave
entering the dielectric member in parallel with the height
direction.

(52) **U.S. Cl.**
CPC **H01Q 21/065** (2013.01); **H01Q 9/0407**
(2013.01); **H01Q 19/06** (2013.01); **H01Q**
21/0075 (2013.01)

(58) **Field of Classification Search**
CPC H01Q 19/06; H01Q 1/38; H01Q 9/0407;
H01Q 13/08; H01Q 21/065; H01Q
21/0075

See application file for complete search history.

20 Claims, 8 Drawing Sheets





US011728559B2

(12) **United States Patent**
Kim

(10) **Patent No.:** **US 11,728,559 B2**
(45) **Date of Patent:** **Aug. 15, 2023**

(54) **POLYMER COMPOSITION FOR USE IN AN ANTENNA SYSTEM**

(71) Applicant: **Ticona LLC**, Florence, KY (US)

(72) Inventor: **Young Shin Kim**, Cincinnati, OH (US)

(73) Assignee: **Ticona LLC**, Florence, KY (US)

(*) 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.: **17/178,318**

(22) Filed: **Feb. 18, 2021**

(65) **Prior Publication Data**
US 2022/0263226 A1 Aug. 18, 2022

(51) **Int. Cl.**
C08K 3/00 (2018.01)
H01Q 1/24 (2006.01)
H01Q 21/06 (2006.01)
C08K 7/14 (2006.01)
C08K 3/04 (2006.01)
C08K 3/30 (2006.01)
C08L 67/04 (2006.01)
C08K 7/06 (2006.01)
(52) **U.S. Cl.**
CPC **H01Q 1/241** (2013.01); **C08K 3/04** (2013.01); **C08K 3/30** (2013.01); **C08K 7/06** (2013.01); **C08K 7/14** (2013.01); **C08L 67/04** (2013.01); **H01Q 21/065** (2013.01); **C08K 2003/3045** (2013.01)

(58) **Field of Classification Search**
CPC ... C08K 3/04; C08K 3/30; C08K 7/06; C08K 7/14; C08K 67/03; C08K 67/04; C08K 2003/3045; C08K 3/00; H01Q 1/24; H01Q 1/241; H01Q 1/2283; H01Q 1/38; H01Q 21/065; H01Q 1/243; C08L 67/03; C08L 67/04

See application file for complete search history.

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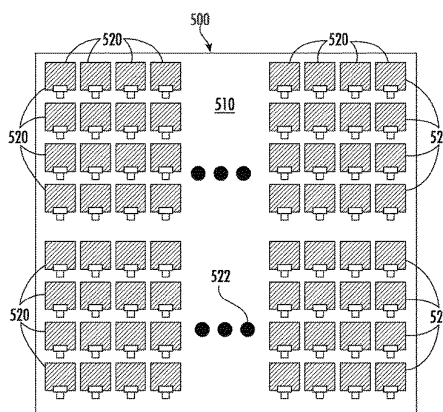
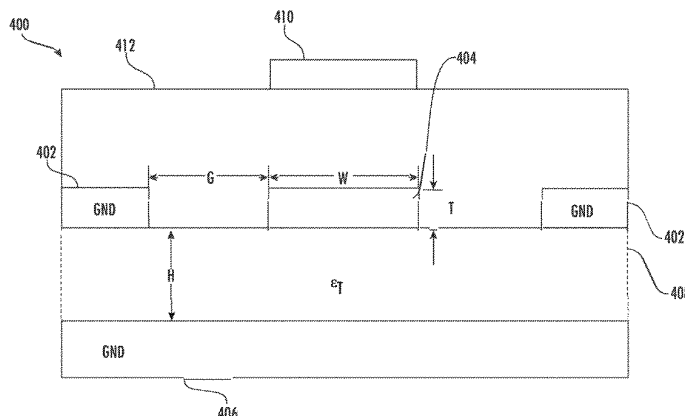
Primary Examiner — Thai Pham

(74) Attorney, Agent, or Firm — Dority & Manning, P.A.

(57) **ABSTRACT**

A polymer composition comprising a semiconductive material distributed within a polymer matrix is provided. The semiconductive material includes inorganic particles and an electrically conductive material, the inorganic particles having an average particle size of from about 0.1 to about 100 μm and an electrical conductivity about 500 $\mu\text{S}/\text{cm}$ or less. The polymer matrix contains at least one thermoplastic high performance polymer having a deflection under load of about 40° C. or more. The polymer composition exhibits a dielectric constant of about 4 or more and a dissipation factor of about 0.3 or less, as determined at a frequency of 2 GHz.

35 Claims, 10 Drawing Sheets





US011728561B2

(12) **United States Patent**
Nyström

(10) **Patent No.:** **US 11,728,561 B2**
(45) **Date of Patent:** **Aug. 15, 2023**

(54) **SUBSTRATE INTEGRATED MULTI BAND
INVERTED F ANTENNA**

(71) Applicant: **ASCOM (SWEDEN) AB**, Gothenburg
(SE)

(72) Inventor: **Mikael Nyström**, Gothenburg (SE)

(73) Assignee: **ASCOM (SWEDEN) AB**, Gothenburg
(SE)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 380 days.

(21) Appl. No.: **17/077,415**

(22) Filed: **Oct. 22, 2020**

(65) **Prior Publication Data**

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Oct. 23, 2019 (EP) 19204929

(51) **Int. Cl.**
H01Q 1/24 (2006.01)
H01Q 1/38 (2006.01)
H01Q 1/22 (2006.01)
H01Q 7/02 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/2225**
(2013.01); **H01Q 1/38** (2013.01); **H01Q 7/02**
(2013.01)

(58) **Field of Classification Search**
CPC .. H01Q 1/24; H01Q 1/22; H01Q 1/38; H01Q
7/02; H01Q 5/328; H01Q 5/364; H01Q
9/42; H01Q 9/0421; H01Q 5/307
See application file for complete search history.

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2020, pp. 1-9.

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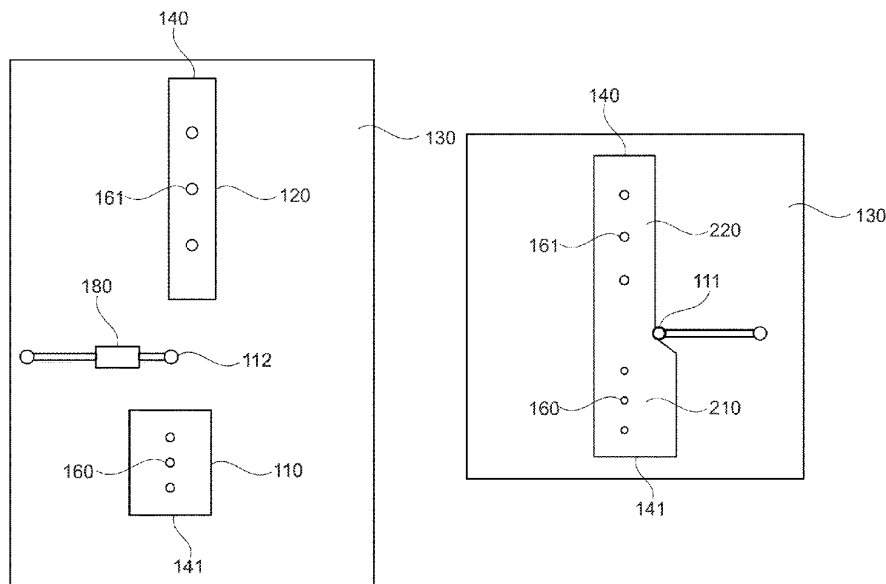
Primary Examiner — Ricardo I Magallanes

(74) *Attorney, Agent, or Firm* — Hamilton, Brook, Smith
& Reynolds, P.C.

(57) **ABSTRACT**

The present disclosure provides an antenna for wireless
communication that includes a first planar conductor, which
is adapted to resonate at frequencies of a first frequency
range; and a second planar conductor, which is adapted to
resonate at frequencies of a second frequency range that
spans lower frequencies than the first frequency range. Thus,
a compact and efficient antenna layout is provided that
enables reception and transmission of radio signals on
multiple frequency bands.

20 Claims, 7 Drawing Sheets





US011728563B2

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

(10) **Patent No.:** **US 11,728,563 B2**
(45) **Date of Patent:** **Aug. 15, 2023**

(54) **ANTENNA FOR WIRELESS COMMUNICATION AND ELECTRONIC DEVICE INCLUDING THE SAME**

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

(72) Inventors: **Nak Chung Choi**, Seoul (KR); **Gyu Sub Kim**, Seoul (KR); **Hyung Joo Lee**,
Gyeonggi-do (KR)

(73) Assignee: **Samsung Electronics Co., Ltd.**

(*) 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.: **17/363,843**

(22) Filed: **Jun. 30, 2021**

(65) **Prior Publication Data**
US 2021/0328330 A1 Oct. 21, 2021

Related U.S. Application Data

(63) Continuation of application No. 16/871,492, filed on May 11, 2020, now Pat. No. 11,075,447, which is a
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(30) **Foreign Application Priority Data**

Sep. 7, 2016 (KR) 10-2016-0114921

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

(52) **U.S. Cl.**
CPC **H01Q 1/243** (2013.01); **H01Q 1/24**
(2013.01); **H01Q 1/245** (2013.01); **H01Q 3/24**
(2013.01);
(Continued)

(58) **Field of Classification Search**

CPC H01Q 1/243; H01Q 1/24; H01Q 1/48;
H01Q 3/247; H01Q 5/364; H01Q 5/35;
(Continued)

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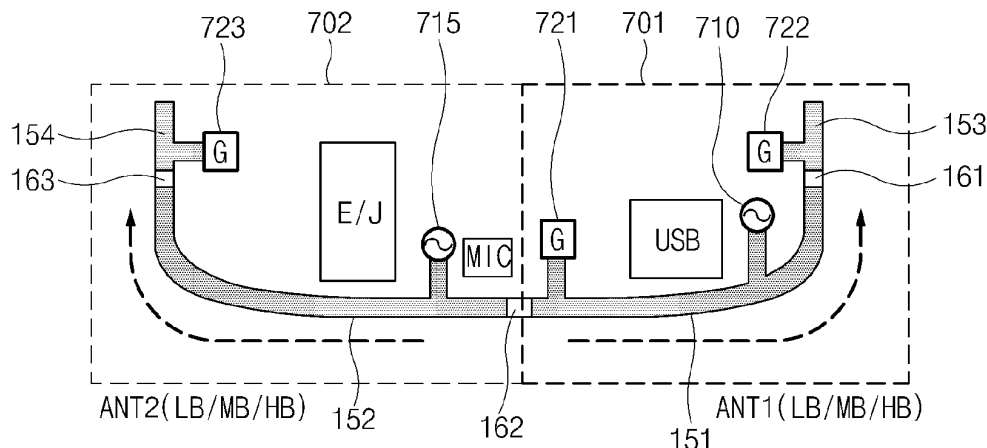
European Search Report dated Jan. 22, 2018 issued in counterpart application No. 17189699.6-1205, 10 pages.
(Continued)

Primary Examiner — Hai V Tran

(74) *Attorney, Agent, or Firm* — The Farrell Law Firm, P.C.

(57) **ABSTRACT**

An electronic device is provided, which includes a housing; a conductive member forming at least a part of the housing; first to third nonconductive members separating the conductive member, wherein the conductive member includes a first conductive pattern disposed between the first nonconductive member and the second nonconductive member, and a second conductive pattern disposed between the second nonconductive member and the third nonconductive member; a first feeding part connected to the first conductive pattern; a second feeding part connected to the second conductive pattern; a first ground part connected to the first conductive pattern at a point adjacent to the second non-
(Continued)





US011728569B2

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

(10) **Patent No.:** **US 11,728,569 B2**
(45) **Date of Patent:** **Aug. 15, 2023**

(54) **ELECTRONIC DEVICES WITH DIELECTRIC RESONATOR ANTENNAS**

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

(72) Inventors: **Bilgehan Avser**, San Bruno, CA (US);
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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 283 days.

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(22) Filed: **Dec. 3, 2020**

(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**
H01Q 9/04 (2006.01)
H01Q 1/24 (2006.01)
H01Q 21/00 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 9/0485** (2013.01); **H01Q 1/243** (2013.01); **H01Q 21/0075** (2013.01)

(58) **Field of Classification Search**
None

See application file for complete search history.

(56) **References Cited**

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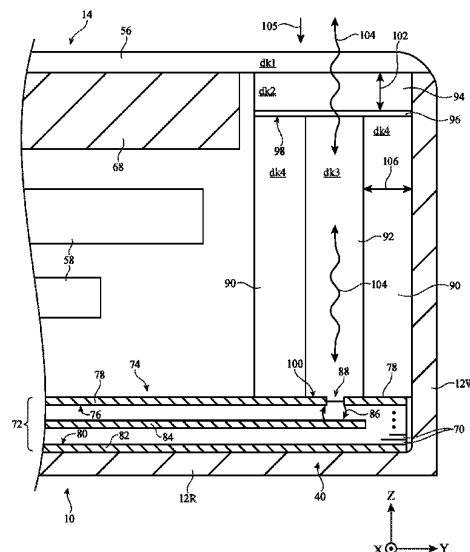
Primary Examiner — Crystal L Hammond

(74) *Attorney, Agent, or Firm* — Treyz Law Group, P.C.;
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(57) **ABSTRACT**

An electronic device may be provided with a phased antenna array and a display cover layer. The phased antenna array may include a dielectric resonator antenna. The dielectric resonator antenna may include a dielectric resonating element embedded in a lower permittivity dielectric substrate. The substrate and the resonating element may be mounted to a flexible printed circuit. A slot may be formed in ground traces on the flexible printed circuit and aligned with the resonating element. The slot may excite resonant modes of the resonating element. The resonating element may convey corresponding radio-frequency signals through the cover layer. A dielectric matching layer may be interposed between the resonating element and the cover layer. If desired, the slot may radiate additional radio-frequency signals and the matching layer may have a tapered shape. Dielectric resonator antennas for covering different polarizations and frequencies may be interleaved across the array.

20 Claims, 17 Drawing Sheets





US011728577B2

(12) **United States Patent**
Haziza

(10) **Patent No.:** **US 11,728,577 B2**
(45) **Date of Patent:** **Aug. 15, 2023**

(54) **MULTI-LAYERED ANTENNA HAVING
DUAL-BAND PATCH**

H01Q 9/0414; H01Q 9/0457; H01Q
21/00; H01Q 1/36; H01Q 1/48; H01Q
1/50; H01Q 21/0006; H01Q 9/0407;
H01Q 13/08; H01Q 19/005

See application file for complete search history.

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(56)

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(*) Notice: Subject to any disclaimer, the term of this
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(21) Appl. No.: **17/092,618**

(22) Filed: **Nov. 9, 2020**

Primary Examiner — David E Lotter

(65) **Prior Publication Data**

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(74) *Attorney, Agent, or Firm* — Womble Bond Dickinson
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15, 2019.

(57)

ABSTRACT

An array antenna is provided with a plurality of radiating
patches, wherein each of the patches, operates in one fre-
quency band along one direction and in a different frequency
band along a second direction orthogonal to the first direc-
tion. The signals from each radiating patch are coupled to
two delay lines, which traverse over a variable dielectric
constant plate. A voltage potential is controllably applied to
each delay line to change the dielectric constant of the VDC
plate in the vicinity of that delay line, thereby introducing
delay in signal travel. In order to isolate the voltage potential
from the two orthogonal delay lines applied to each radiating
patch, at least one of the delay lines is connected to a
coupling patch, which capacitively couples the RF energy to
the radiating patch.

(51) **Int. Cl.**

H01Q 21/06 (2006.01)
H01Q 5/342 (2015.01)
H01Q 5/392 (2015.01)
H01Q 1/38 (2006.01)

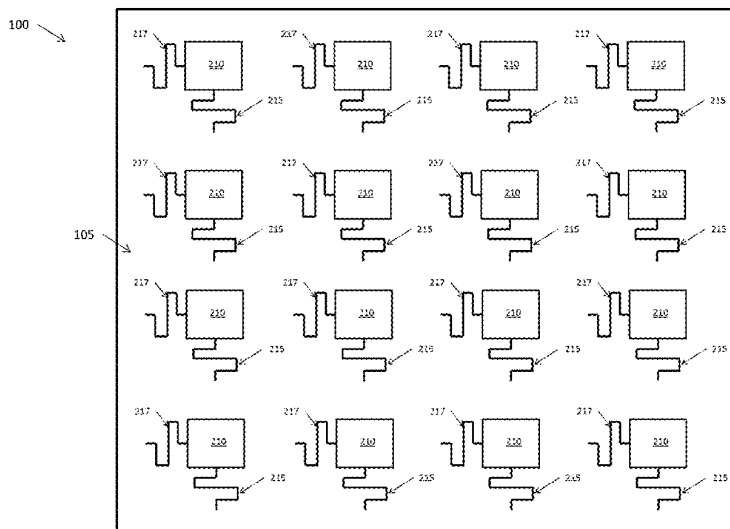
(52) **U.S. Cl.**

CPC **H01Q 21/065** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 5/342** (2015.01); **H01Q**
5/392 (2015.01)

(58) **Field of Classification Search**

CPC H01Q 21/065; H01Q 1/38; H01Q 5/342;
H01Q 5/392; H01Q 3/44; H01Q 5/35;

20 Claims, 7 Drawing Sheets





US011728578B2

(12) **United States Patent**
Flores-Cuadras

(10) **Patent No.:** **US 11,728,578 B2**
(45) **Date of Patent:** **Aug. 15, 2023**

(54) **QUAD 5G NR MIMO ANTENNA ARRAY
WITH SLANTED FORMATION**

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(73) Assignee: **2J ANTENNAS USA,
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patent is extended or adjusted under 35
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(65) **Prior Publication Data**
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Related U.S. Application Data

(60) Provisional application No. 62/892,350, filed on Aug.
27, 2019.

(51) **Int. Cl.**
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H01Q 1/38 (2006.01)
H01Q 21/28 (2006.01)
H01Q 3/26 (2006.01)
H01Q 21/12 (2006.01)
H01Q 5/47 (2015.01)
H01Q 1/42 (2006.01)

(52) **U.S. Cl.**
CPC **H01Q 21/26** (2013.01); **H01Q 1/38**
(2013.01); **H01Q 1/42** (2013.01); **H01Q**
3/2617 (2013.01); **H01Q 5/47** (2015.01);
H01Q 21/12 (2013.01); **H01Q 21/28** (2013.01)

(58) **Field of Classification Search**
CPC H01Q 21/26; H01Q 1/38; H01Q 1/42;
H01Q 3/2617; H01Q 5/47; H01Q 21/12;
H01Q 21/28
See application file for complete search history.

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Primary Examiner — Ricardo I Magallanes

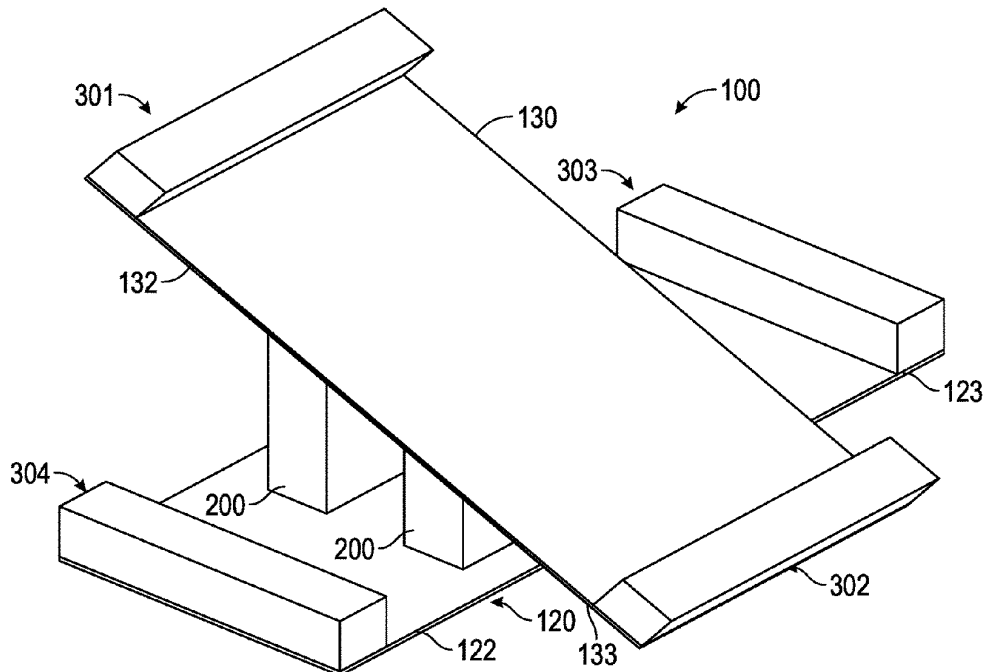
Assistant Examiner — Yonchan J Kim

(74) *Attorney, Agent, or Firm* — CP Law Group PC; Cy
Bates

(57) **ABSTRACT**

An antenna array includes one or more substrates and four individual antennas in a slant formation to improve radiation pattern independence. In various embodiments, a novel slanted antenna array configuration is disclosed where one of the four antennas is orthogonal to two of the remaining three antennas. In some embodiments, two separate substrates and a tapered dielectric spacer are used to provide a larger variety of slant formations.

9 Claims, 7 Drawing Sheets





US011729301B2

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

(10) **Patent No.:** **US 11,729,301 B2**
(45) **Date of Patent:** ***Aug. 15, 2023**

(54) **WIRELESS COMMUNICATION DEVICE
AND CASE ASSEMBLY**

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(73) Assignee: **HTC CORPORATION**, Taoyuan (TW)

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patent is extended or adjusted under 35
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This patent is subject to a terminal dis-
claimer.

(21) Appl. No.: **17/396,918**

(22) Filed: **Aug. 9, 2021**

(65) **Prior Publication Data**

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Related U.S. Application Data

(63) Continuation of application No. 16/897,438, filed on
Jun. 10, 2020, now Pat. No. 11,115,508.

(51) **Int. Cl.**
H04M 1/02 (2006.01)

(52) **U.S. Cl.**
CPC **H04M 1/0202** (2013.01)

(58) **Field of Classification Search**
CPC .. H04M 1/0202; H04M 1/0249; H04M 1/026;
H04M 1/18; H01Q 1/243

See application file for complete search history.

(56) **References Cited**

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Primary Examiner — Kenneth T Lam

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(57) **ABSTRACT**

A case assembly and a wireless communication device are provided. The case assembly includes a metal case and a plastic cladding body. The metal case includes an inner side and an outer side, the inner side is opposite to the outer side, the metal case includes a hollow portion and an antenna portion, the hollow portion is adjacent to a side of the antenna portion. The plastic cladding body is disposed on the metal case, and completely covers the outer side of the metal case, partially covers the inner side of the metal case, and fills the hollow portion. The wireless communication device includes a case assembly and a radio frequency signal module. The radio frequency signal module is electrically connected to the antenna portion of the case assembly. Thus, the structural rigidity of the wireless communication device and its case assembly is kept, and the production cost is reduced.

10 Claims, 7 Drawing Sheets

