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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

[Continued on next page]

(54) Title: DETECTION OF ELECTROMAGNETIC RADIATION USING NONLINEAR MATERIALS

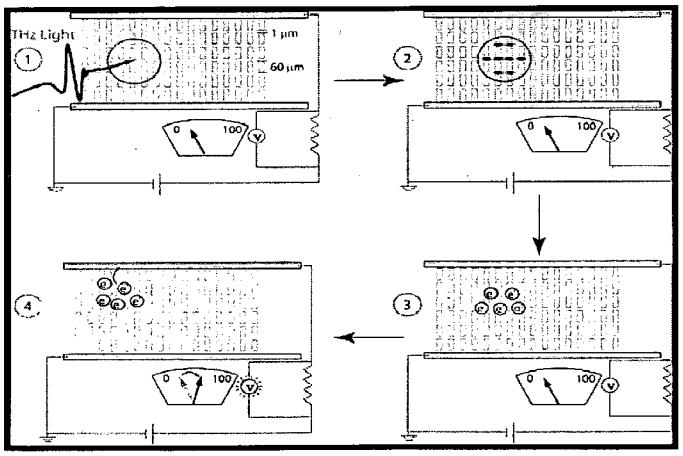

Fig. 14B

(57) Abstract: An apparatus for detecting electromagnetic radiation within a target frequency range is provided. The apparatus includes a substrate and one or more resonator structures disposed on the substrate. The substrate can be a dielectric or semiconductor material. Each of the one or more resonator structures has at least one dimension that is less than the wavelength of target electromagnetic radiation within the target frequency range, and each of the resonator structures includes at least two conductive structures separated by a spacing. Charge carriers are induced in the substrate near the spacing when the resonator structures are exposed to the target electromagnetic radiation. A measure of the change in conductivity of the substrate due to the induced charge carriers provides an indication of the presence of the target electromagnetic radiation.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/49020

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - H01L 31/00 (2014.01)
USPC - 250/208.1
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)
USPC: 250/208.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
USPC: 250/208.1; 257/440,441,443,444 (text search - see terms below)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatBase; PubWEST(USPT,PGPB,EPAB,JPAB); Google
Search Terms Used: gigahertz, ghz, terahertz, thz, resonator, conductivity, resistance, metal, split ring, wedge, bow tie, polarized, detect, sense, second, two, gap, interdigitated, cross, shape, pattern, four, vanadium, oxide

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/0093023 A1 (RASPOPIN et al.) 05 May 2005 (05.05.2005), entire document especially Figs 2-3, 8; paras [0015], [0019], [0024], [0026], [0030], [0035]	1-4, 11-14, 20-22, 24, 46/(1-4,11-14,20-22,24), 98-100, 104-109
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Y		5-10, 15-19, 23 46/(5-10,15-19, 23), 80-92, 101-103
Y	CAI et al., "A NOVEL TERAHERTZ SENSING DEVICE COMPRISING OF A PARABOLIC REFLECTIVE SURFACE AND A BI-CONICAL STRUCTURE," December 2009 (12.2009) [online] [retrieved on 07 May 2014 (07.05.2014)]. Retrieved from the Internet: URL= <http://www.jpier.org/PIER/pier97/05.09090902.pdf> pgs 67-70	5, 7-10, 46/(5,7-10), 87, 89-92, 101-103
Y	US 2010/0079217 A1 (MORTON et al.) 01 April 2010 (01.04.2010), entire document especially Fig 4; paras [0048]-[0049]	6, 46/(6), 88
Y	US 2007/0222693 A1 (POPA-SIMIL) 27 September 2007 (27.09.2007), entire document especially para [0021]	15, 46/(15)
Y	US 2010/0276597 A1 (OUVRIER-BUFFET) 04 November 2010 (04.11.2010), entire document especially para [0014]	16-19, 46/(16-19)
Y	US 2012/0091342 A1 (BERGER et al.) 19 April 2012 (19.04.2012), entire document especially para [0066]	23, 46/(23), 102, 103

☒ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 May 2014 (08.05.2014)	27 MAY 2014
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-3201	Authorized officer: Lee W. Young PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4,264,881 A (DERONDE) 28 April 1981 (28.04.1981), entire document especially col 5, lns 41-47	80-92
Y	US 4,600,906 A (BLIGHT) 15 July 1986 (15.07.1986), entire document especially Figs 11-12; col 10, lns 50-63; col 12, lns 25-44	9, 46/(9), 91

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 13/49020

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: claims 1-24, 46/(1-24), 80-92, 98-109: drawn to an apparatus, image sensor, and method for detecting radiation within a frequency range which includes a substrate having one or more resonator structures disposed on the substrate wherein the resonator structures include at least two conductive structures separated by a spacing such that the charge carriers are generated near the spacing based on an enhanced electric field induced by a resonant response to the electromagnetic radiation and based on a measure of conductivity an indication of the presence of the electromagnetic radiation is provided. Claims 98-103 are specifically drawn to a method for detecting a polarization of target electromagnetic radiation through use of the above apparatus for detecting radiation within a frequency range.

-- Please See Continuation Sheet --

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:
1-24, 46/(1-24), 80-92, 98-109

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

Continuation of BOX III -- Observations where unity of invention is lacking

Group II: claims 25-45, 46/(25-45): drawn to an apparatus for detecting radiation within a frequency range which includes a substrate having a first conductive structure and a second conductive structure which are separated by a spacing and wherein the apparatus detects the electromagnetic radiation of different polarizations.

Group III: claims 47-67, 93-97: drawn to an apparatus for detecting radiation with a frequency range which includes a substrate having a resonator structure and a coupling structure which is not in physical contact with the resonator structure.

Group IV: claims 68-79: drawn to an apparatus for detecting radiation within a frequency range which includes a substrate, a first conductive structure and a second conductive structure alined in a longitudinal antenna arrangement with a spacing separating the first conductive structure from the second conductive structure and first and second electrodes.

The inventions listed as Groups I-IV do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

Special technical features:

Group I requires measurement of a conductivity based on generated charge carriers and said measurement of conductivity providing an indication of the presence of the target electromagnetic radiation, not found in the other groups.

Group II requires detecting target electromagnetic radiation of different polarizations, not found in the other groups.

Group III requires a first coupling structure disposed on the substrate and which is not in physical contact with a first resonator structure, not found in the other groups.

Group IV requires the conductive structures alined in a longitudinal antenna arrangement along a z-direction of the substrate wherein a spacing separate an end of the first conductive structure from an end of the second conductive structure, and first and second electrodes, not found in the other groups.

Shared Features:

The only technical features shared by Groups I-IV that would otherwise unify the groups are an apparatus and method for detecting electromagnetic radiation within a target frequency range; the apparatus having a substrate comprising a dielectric material or a semiconductor material; at least one resonator structure, first and second conductive structures with a spacing separating a first end of the first conductive structure form a first end of the second conductive structure and a polarization.

However, these shared technical features do not represent a contribution over prior art, because the shared technical features are disclosed by US 2005/0093023 A1 to Raspopin et al. (hereinafter Raspopin), 05 May 2005 (05.05.2005), which discloses an apparatus and method for detecting electromagnetic radiation within a target frequency range (Abstract, para [0018], [0023]; Fig 8) with a substrate (4) comprising a dielectric material or a semiconductor material (insulating layer 6; semiconductor superlattice 8), at least one resonator structure (para [0024], [0026]) disposed on the substrate, each of the resonator structures comprising at least two conductive structures (metal mirrors 2, 14) separated by a spacing (para [0024], [0026], resonator formed by first and second metal mirrors) and a polarization (para [0024]).

As the shared technical features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

Groups I-IV therefore lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.