



(51) International Patent Classification:
G01S 7/481 (2006.01)

(21) International Application Number:
PCT/US2019/060524

(22) International Filing Date:
08 November 2019 (08.11.2019)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
16/185,495 09 November 2018 (09.11.2018) US

(71) Applicant: **CONTINENTAL AUTOMOTIVE SYSTEMS, INC.** [US/US]; 1 Continental Drive, Auburn Hills, Michigan 48326 (US).

(72) Inventors: **ROSS, Sean H**; 6307 Carpinteria Avenue, Suite A, Carpinteria, California 93101 (US). **DUERNER, Andrew**; 6307 Carpinteria Avenue, Suite A, Carpinteria, California 93101 (US). **BERGAM, Jacob Alexander**; 6307 Carpinteria Avenue, Suite A, Carpinteria, California 93101

(US). **SHORT, Bradley**; 6307 Carpinteria Avenue, Suite A, Carpinteria, California 93101 (US).

(74) Agent: **BINKOWSKI, Matthew** et al.; 1 Continental Drive, Auburn Hills, Michigan 48326 (US).

(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, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, 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, SA, 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.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK,

(54) Title: LIDAR SENSOR ASSEMBLY WITH OPTIC FOR LIGHT DIFFUSION AND FILTERING

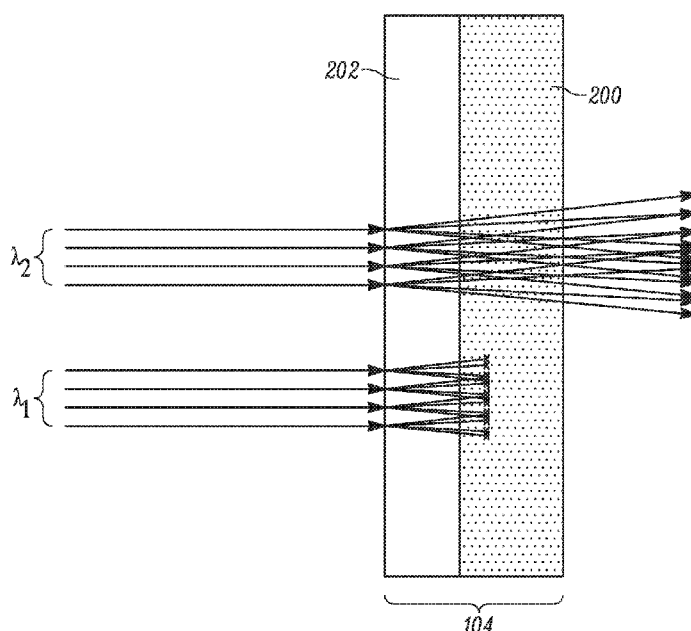


FIG. 2

(57) Abstract: A lidar sensor assembly (100) includes a laser light source (102) configured to generate light. The lidar sensor assembly (100) also includes a filter element (200) configured to receive light from the laser light source (102). The filter element (200) absorbs light at a first wavelength while allowing light at a second wavelength to pass therethrough. The lidar sensor assembly (100) further includes a diffuser element (202) formed integrally with the filter element (200) and configured to scatter the light generated by the laser light source.



EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV,
MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM,
TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW,
KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to the identity of the inventor (Rule 4.17(i))*
- *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))*

Published:

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

LIDAR SENSOR ASSEMBLY WITH OPTIC FOR LIGHT DIFFUSION AND FILTERING

TECHNICAL FIELD

[0001] The technical field relates generally to lidar sensors and more particularly to flash lidar sensors.

BACKGROUND

[0002] Flash lidar systems often include a laser which generates multiple pulses of insense, focused light. These pulses are then diffused to spread these light pulses over a wider area. A filter element may be utilized to block undesirable wavelengths of light. Unfortunately, use of multiple elements to diffuse and filter light increases cost, complexity, size, energy use.

[0003] As such, it is desirable to present a lidar sensor assembly which does not require multiple filter and diffusion elements. In addition, other desirable features and characteristics will become apparent from the subsequent summary and detailed description, and the appended claims, taken in conjunction with the accompanying drawings and this background.

BRIEF SUMMARY

[0004] In one exemplary embodiment, a lidar sensor assembly includes a laser light source configured to generate light. The lidar sensor assembly also includes a filter element configured to receive light from the laser light source. The filter element absorbs light at a first wavelength while allowing light at a second wavelength to pass therethrough. The lidar sensor assembly further includes a diffuser element formed integrally with the filter element and configured to scatter the light generated by the laser light source.

[0005] In one exemplary embodiment, a method of forming a optic for a lidar sensor assembly includes providing a filter element configured to receive light from a laser light source. The filter element absorbs light at a first wavelength while allowing light at a second wavelength to pass therethrough. The method also includes forming a diffuser element integrally with the filter element and configured to scatter the light generated by the laser light source.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Other advantages of the disclosed subject matter will be readily appreciated, as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

[0007] Figure 1 is a perspective view of a lidar sensor assembly according to one exemplary embodiment;

[0008] Figure 2 is cross-sectional side view of an optic of the lidar sensor assembly according to one exemplary embodiment;

[0009] Figure 3 is a cross-sectional side view of the optic of the lidar sensor assembly according to another exemplary embodiment; and

[0010] Figure 4 is a flowchart of a method of forming the optic according to one exemplary embodiment.

DETAILED DESCRIPTION

[0011] Referring to the Figures, wherein like numerals indicate like parts throughout the several views, a lidar sensor assembly 100 is shown and described herein.

[0012] Referring to Figure 1, the lidar sensor assembly 100, also referred to simply as the assembly 100, includes a laser light source 102 configured to generate light. The laser light source 102 may generate light at one or more wavelengths, e.g., at a first wavelength λ_1 and a second wavelength λ_2 . In the exemplary embodiment, the laser light source 102 is a Nd:YAG laser system which generates light at a first wavelength λ_1 of about 808 nanometers ("nm") and at a second wavelength λ_2 of about 1064 nm. Due to component protection and safety concerns, it is desirable to filter, i.e., block, light at the first wavelength λ_1 . It should be appreciated, however, that in other embodiments, the laser light source 102 may generate light at other wavelengths besides and/or in addition to the particular wavelengths described above.

[0013] The lidar sensor assembly 100 includes an optic 104 configured to filter and scatter light of certain wavelengths. Said another way, the optic 104 transmits and scatters light at one wavelength and blocks, i.e., absorbs, light at another wavelength.

[0014] Referring now to Figures 2 and 3, the optic 104 includes a filter element 200. The filter element 200 is configured to receive light from the laser light source 102. The filter element 200 absorbs light at the first wavelength λ_1 . That is, the filter element 200 blocks light oscillating at the first wavelength λ_1 from passing through. However, the filter element 200 allows light at a second wavelength λ_2 , which is different from the first wavelength λ_1 , to pass through. The filter element 200 may be made of glass, plastic, and/or any other suitable material, as appreciated by those skilled in the art.

[0015] In the exemplary embodiment, the filter element 200 may be implemented using the model No. RG850 filter manufactured by SCHOTT AG, headquartered in Mainz, Germany. This filter generally blocks wavelengths of light under 830 nm. However, it should be appreciated that other filters may be implemented as the filter element 200.

[0016] The optic 104 also includes a diffuser element 202. The diffuser element 202 is configured to scatter the light generated by the laser light source 102. That is, the diffuser element 202 disperses the focused light into a wider field-of-view. In the exemplary embodiment shown in Figure 1, the light is dispersed into a generally rectangular field-of-view.

[0017] Referring again to Figures 2 and 3, the diffuser element 202 is integrally formed with the filter element 200. In one exemplary embodiment, the diffuser element 202 is refractive. As such, the direction of light wave propagation is changed due to a change in the transmission medium.

[0018] This diffuser element 202 may be formed by stamping small-feature, three-dimensional patterns on the filter element 200. That is, in one exemplary embodiment, the filter element 200 is pressed against a stamping mold (not shown) to generate the patterns of the diffuser element 202. For example, the stamped patterns may have features sized between about 1 μm and 100 μm .

[0019] In another exemplary embodiment, the refractive diffuser element is generated by the patterns being deposited on the filter element 202. In yet another exemplary embodiment, the refractive diffuser element is generated by the patterns being etched on the filter element 202.

[0020] In another exemplary embodiment, the diffuser element 202 is reflective. As such, the direction of light wave propagation is changed due to the reflective nature of the

patterns of the diffuser element 202. Numerous techniques may be employed to generate the reflective diffuser element 202, including, but not limited to disposition of mirror elements onto the filter element 200.

[0021] In another exemplary embodiment, the diffuser element 202 is diffractive. As such, the diffuser element 202 includes obstacles and/or apertures which result in the bending and/or spreading of the light waves. Numerous techniques may be employed to generate the diffractive diffuser element 202, including, but not limited to disposition of a film and subsequent etching of the film to generate apertures.

[0022] In the embodiment shown in Figure 2, the diffuser element 202 is formed on the side of the filter element 200 closer to the light source 102. In the embodiment shown in Figure 3, the diffuser element 204 is formed on the opposite side of the filter element 200 than the embodiment of Figure 2.

[0023] The optic 104 described above has numerous advantages over the prior art. For instance, by integrally forming the diffuser element 202 with the filter element 200, the optic 104 has less material-air interfaces than the prior art. This improves energy efficiency, which means that less energy is utilized and less heat is generated. Furthermore, the optic 104 requires less anti-reflective coatings than are typically commonplace in the prior art due to less Fresnel loss. As such, overall cost and complexity of the optic 104 is reduced.

[0024] The lidar sensor assembly 100 described above is ideally suited for use in a motor vehicle (not shown), such as an automobile. However, it should be appreciated that the lidar sensor assembly 100 and/or optic 104 shown and described herein may be utilized in many other non-vehicular applications.

[0025] One exemplary embodiment of a method 400 of forming the optic 104 for the lidar sensor assembly 100 is shown in Figure 4. The method 400 includes, at 402, providing a filter element configured to receive light from a laser light source wherein the filter element absorbs light at a first wavelength while allowing light at a second wavelength to pass therethrough. The method 400 also includes, at 404, forming a diffuser element integrally with the filter element and configured to scatter the light generated by the laser light source.

[0026] The present invention has been described herein in an illustrative manner, and it is to be understood that the terminology which has been used is intended to be in the

nature of words of description rather than of limitation. Obviously, many modifications and variations of the invention are possible in light of the above teachings. The invention may be practiced otherwise than as specifically described within the scope of the appended claims.

CLAIMS

What is claimed is:

1. A lidar sensor assembly (100) comprising:
a laser light source (102) configured to generate light;
5 a filter element (200) configured to receive light from said laser light source (102)
wherein said filter element (200) absorbs light at a first wavelength while allowing light at
a second wavelength to pass therethrough; and
a diffuser element (202) formed integrally with said filter element (200) and
configured to scatter the light generated by said laser light source (102).

10 2. The lidar sensor assembly (100) as set forth in claim 1 wherein said diffuser
element (202) is refractive.

15 3. The lidar sensor assembly (100) as set forth in claim 2 wherein said diffuser
element (202) is formed of small-feature, three-dimensional patterns of a transparent
material.

20 4. The lidar sensor assembly (100) as set forth in claim 3 wherein said patterns
are stamped on said filter element (200).

5. The lidar sensor assembly (100) as set forth in claim 3 wherein said patterns
are deposited on said filter element (200).

25 6. The lidar sensor assembly (100) as set forth in claim 3 wherein said patterns
are etched on said filter element (200).

7. The lidar sensor assembly (100) as set forth in claim 1 wherein said diffuser
element (202) is reflective.

30 8. The lidar sensor assembly (100) as set forth in claim 1 wherein said diffuser
element (202) is diffractive.

9. A method of forming a optic for a lidar sensor assembly (100), comprising:
providing a filter element (200) configured to receive light from a laser light source
(102) wherein the filter element (200) absorbs light at a first wavelength while allowing
5 light at a second wavelength to pass therethrough; and
forming a diffuser element (202) integrally with the filter element (200) and
configured to scatter the light generated by the laser light source (102).

10. The method as set forth in claim 9 wherein forming the diffuser element
10 (202) comprises stamping small-feature, three-dimensional patterns of a transparent
material on the filter element (200) such that the diffuser element (202) is refractive.

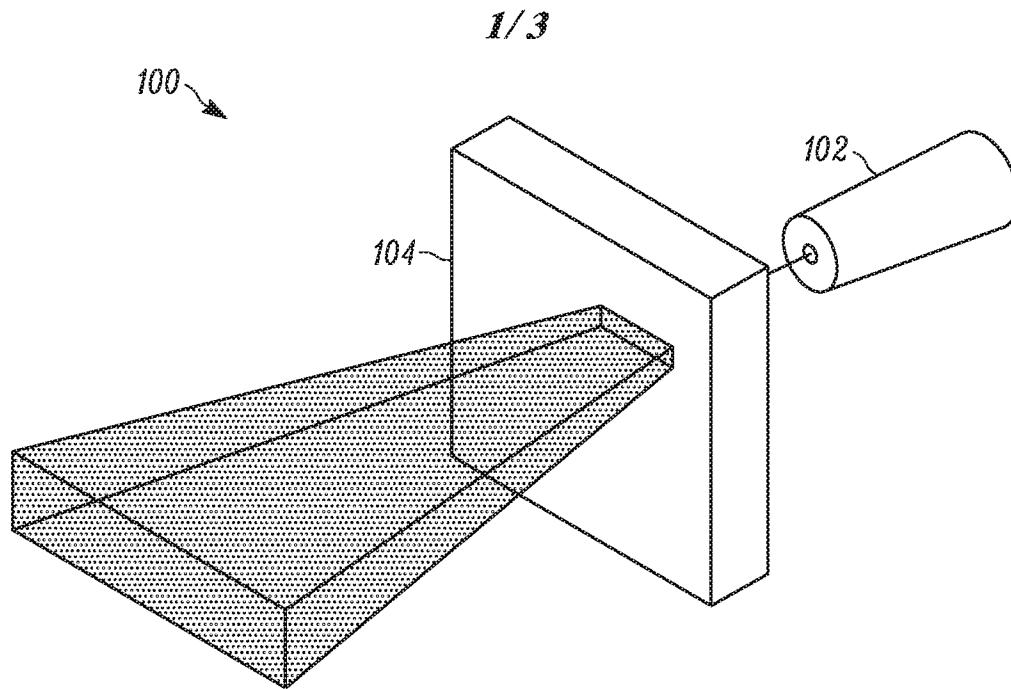


FIG. 1

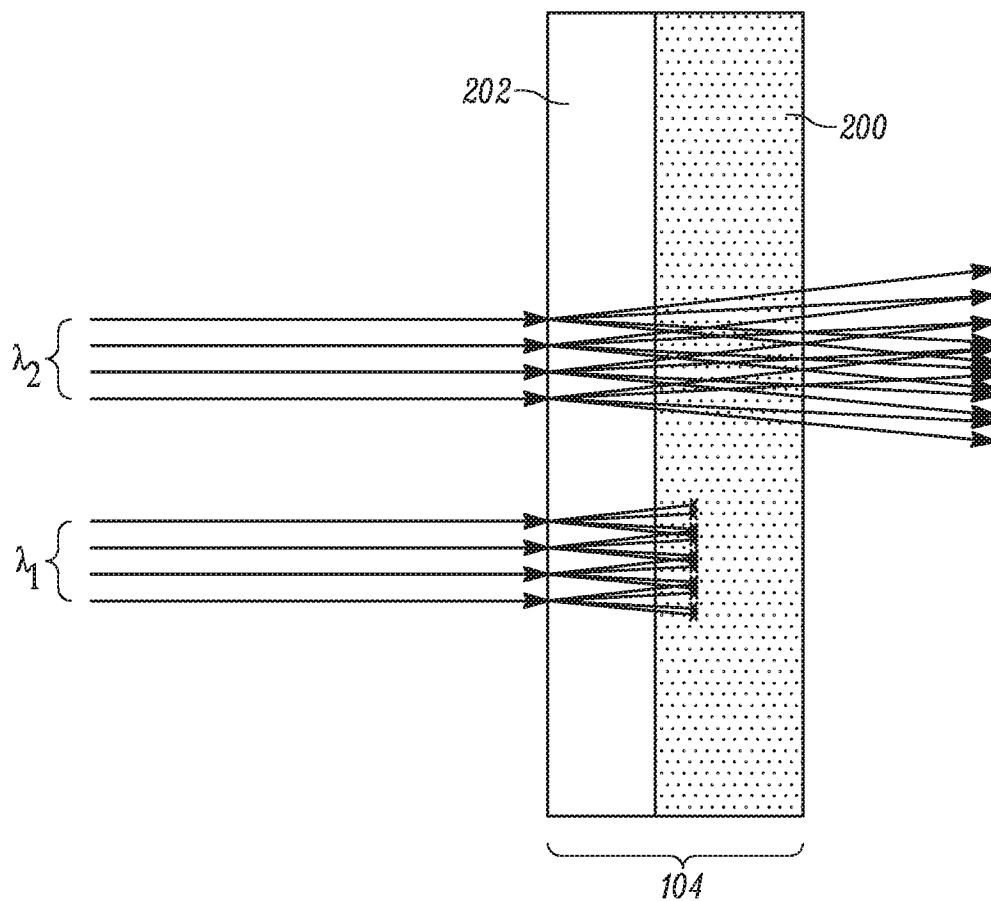


FIG. 2

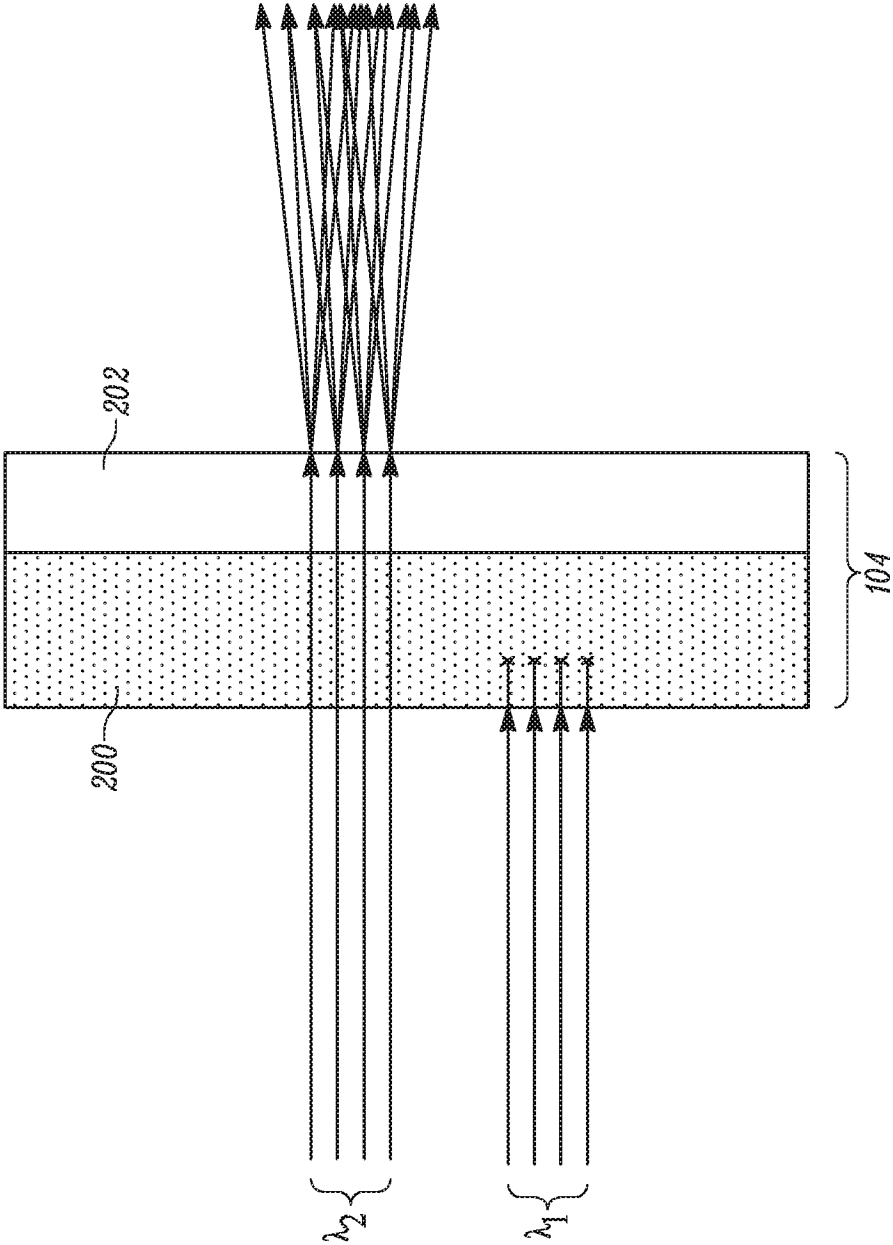


FIG. 3

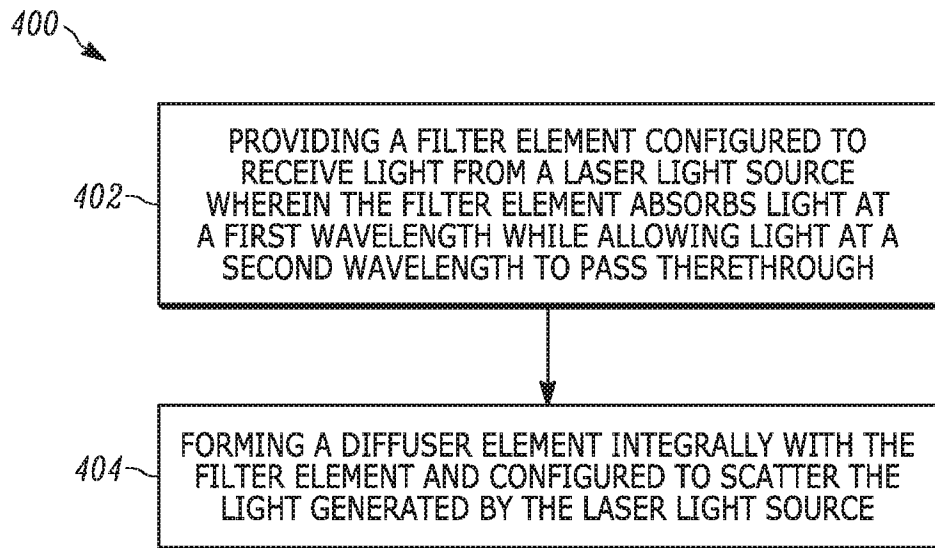
3/3

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2019/060524

A. CLASSIFICATION OF SUBJECT MATTER
INV. G01S7/481
ADD.

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)
G01S

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)

EPO-Internal, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2007/188735 A1 (BRAUNECKER BERNHARD [CH] ET AL) 16 August 2007 (2007-08-16) paragraphs [0001], [0002], [0011], [0025] - [0027]; figures 1,3 -----	1-10
A	US 2017/082733 A1 (SCHWARZ HANS-JOCHEN [DE]) 23 March 2017 (2017-03-23) paragraphs [0023] - [0024]; figures 2,3 -----	1-10
A	US 2012/069421 A1 (FU ZHENGHUA [CN]) 22 March 2012 (2012-03-22) paragraphs [0026] - [0029]; figures 1-2 -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* 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

27 April 2020

Date of mailing of the international search report

06/05/2020

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Metz, Carsten

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2019/060524

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2007188735 A1	16-08-2007	AU 2005229207 A1 CA 2561838 A1 CN 1942780 A EP 1730546 A1 JP 2007530964 A US 2007188735 A1 WO 2005096009 A1	13-10-2005 13-10-2005 04-04-2007 13-12-2006 01-11-2007 16-08-2007 13-10-2005
US 2017082733 A1	23-03-2017	DE 102015217910 A1 US 2017082733 A1	23-03-2017 23-03-2017
US 2012069421 A1	22-03-2012	CN 101930121 A EP 2428830 A1 US 2012069421 A1 WO 2010148910 A1	29-12-2010 14-03-2012 22-03-2012 29-12-2010