

Notice of Allowability

Application No. 17/532,831	Applicant(s) WANG et al.	
Examiner Eduardo A Rodela	Art Unit 2893	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

- 1. This communication is responsive to interview 2/9/2022.
 A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.
- 2. An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
- 3. The allowed claim(s) is/are 1-30. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
- 4. Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

- a) All b) Some* c) None of the:
 - 1. Certified copies of the priority documents have been received.
 - 2. Certified copies of the priority documents have been received in Application No. _____.
 - 3. Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.

THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

- 5. CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
 including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.
- Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).**
- 6. DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

- 1. Notice of References Cited (PTO-892)
- 2. Information Disclosure Statements (PTO/SB/08),
Paper No./Mail Date 2/10/2022.
- 3. Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.
- 4. Interview Summary (PTO-413),
Paper No./Mail Date. 2/9/2022.
- 5. Examiner's Amendment/Comment
- 6. Examiner's Statement of Reasons for Allowance
- 7. Other _____.

/EDUARDO A RODELA/
Primary Examiner, Art Unit 2893

DETAILED ACTION

This correspondence is in response to the communications received November 22, 2021.

Claims 1-30 are pending.

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Priority

Applicant has made no claim to the benefit of an earlier foreign priority filing date.

Applicant has pointed out that support for the entirety of the content claimed can find parentage back to the provisional application US 61/834,873, dated June 13, 2013. This is connected to this instant application by US 14/947,718. Accordingly the effective filing date of this instant application has been determined to be the June 13, 2013 date. Further explanation of parentage can be found in Applicant's arguments and comments dated November 22, 2021, on page 12.

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it **MUST** be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in an interview with Applicant's Representative, Ivan Kavrukov on February 9, 2022.

The application has been amended as follows:

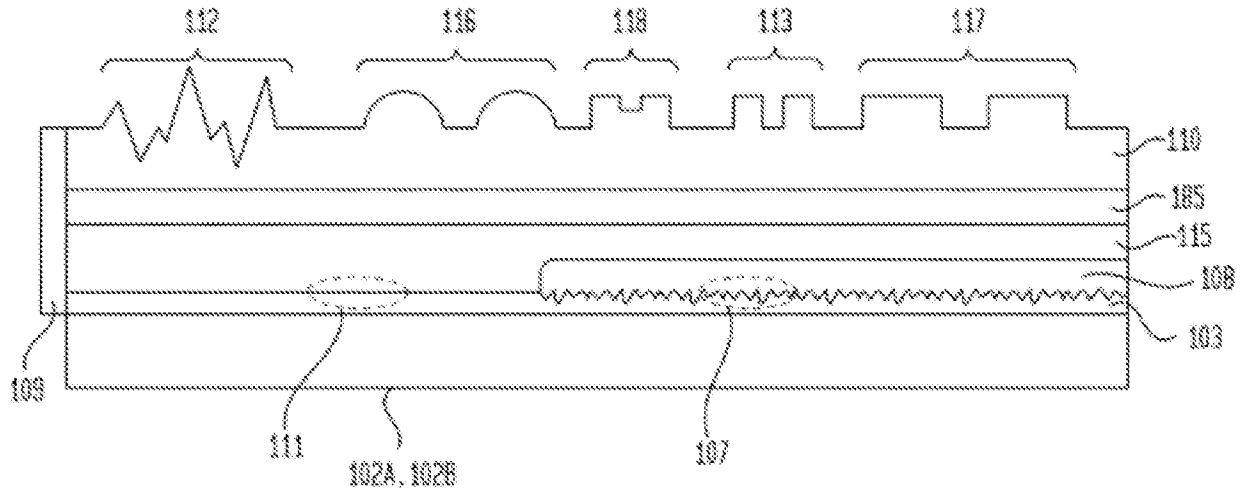
In the Claims:

Please amend claim 9, to replace "holes" with "regions".

Relevant Prior Art

Lowenthal et al. (US 2015/0349206) Fig. 25, shown below.

FIG. 25



Hsu et al. (US 7,525,170) which shows P-I-N diode pillars, but lacks many of the further claimed features including the “in-pillar holes”, see Fig. 5H below.

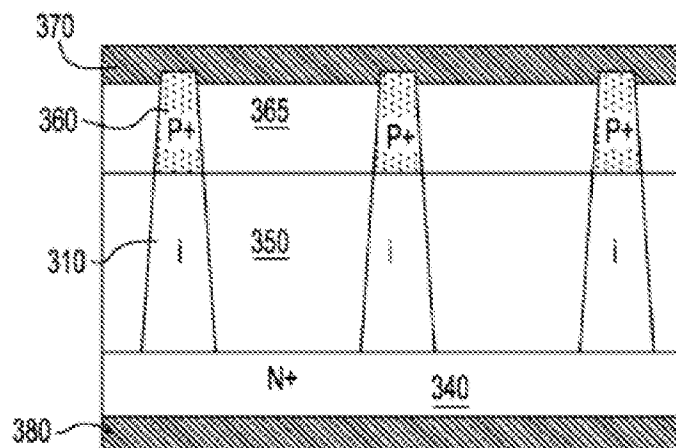


FIG. 5H

Applicant's Claim to Figure Comparison

It is noted that this comparison is merely for the benefit of reviewers of this office action during prosecution, to allow for an understating of the examiner's interpretation of the Applicant's independent claims as compared to disclosed embodiments in Applicant's Figures. No response or comments are necessary from Applicant.

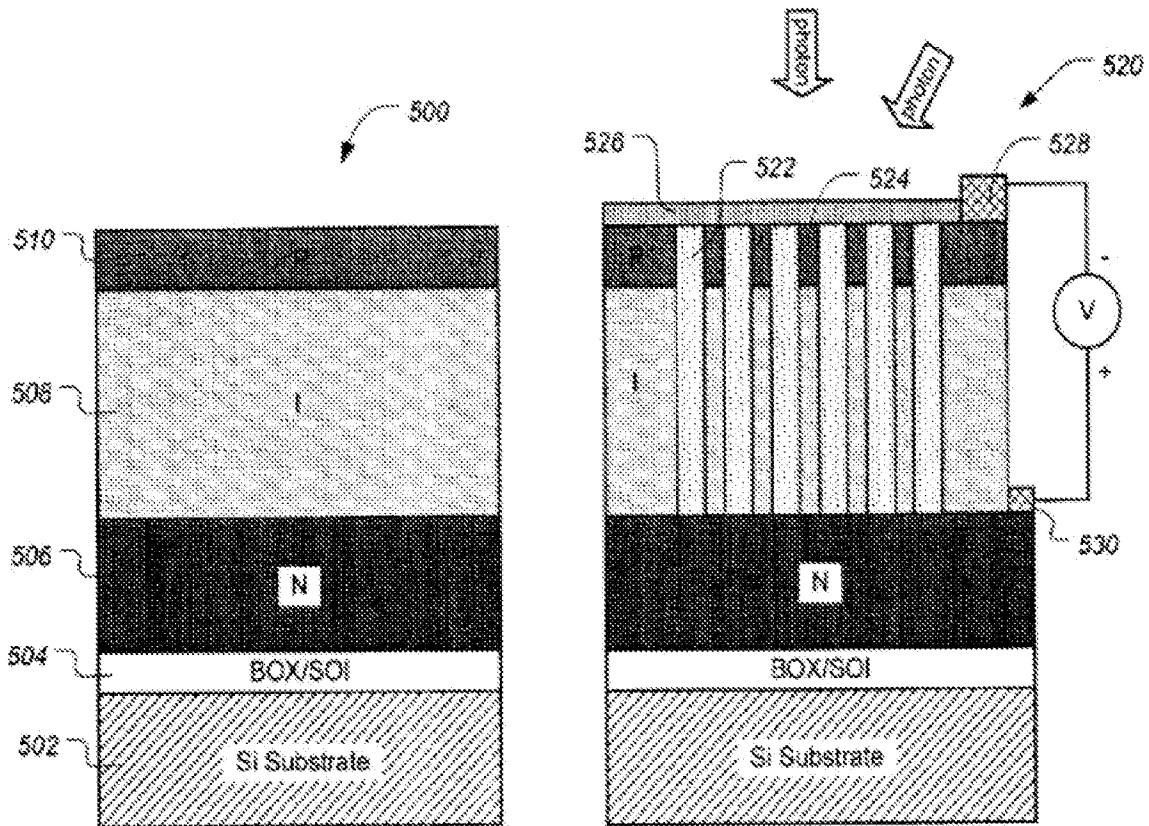


FIG. 5A

FIG. 5B

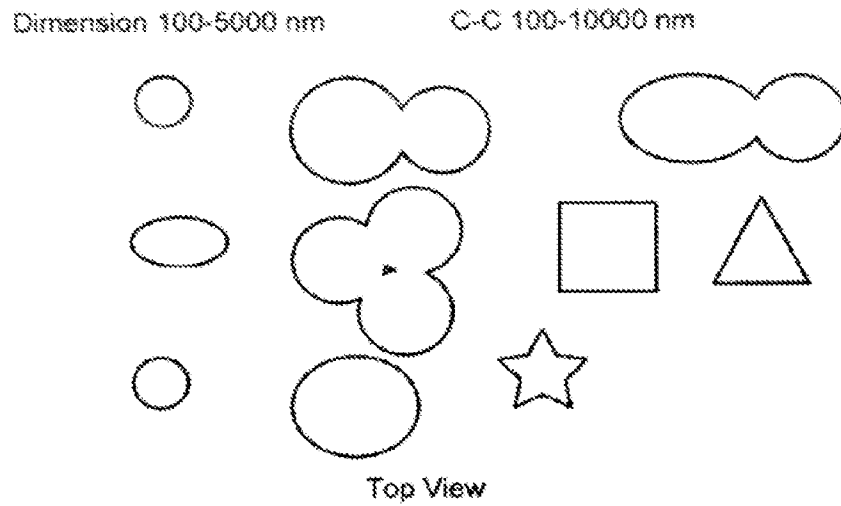


FIG. 46

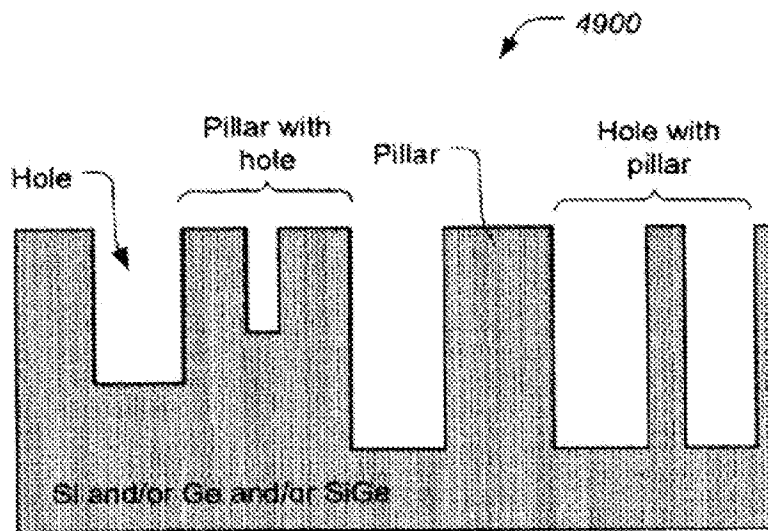


FIG. 49

Regarding claim 1, the Applicant discloses in Figs. 5A, 5B, 46 and 49, a device converting light photons to electrons, comprising:

a silicon (Si) substrate and a laterally extending array of pillars (524) formed therein that are elongated in up-down directions (as can be seen in Fig. 5B, the “substrate” is the silicon layer of the S-O-I substrate);

wherein each of a plurality of the pillars in the array:

has a rectangular laterally extending cross-section (this can be seen in Fig. 46, and discussed in ¶ 0132, 0228, 0232);

comprises an undoped or low-doped Si absorption region (508), an upper doped Si region over the Si absorption region (510), and a lower doped Si region (506) under the Si absorption region (506 is under 508);

has one or more dielectric-filled, pyramid-shaped, in-pillar holes extending down into the pillar from a top surface of said upper doped Si region of the pillar (this can be seen in Fig. 49 as the element labeled “Pillar with hole”, discussed in ¶ 0232, 0234);

has a top electrical contact (528) electrically coupled with said upper doped Si region of the pillar (528 on 510); and

has a bottom electrical contact (530) electrically coupled with the lower doped Si region of the pillar (530 electrically connects to 506);

wherein said top and bottom electrical contacts are configured to provide reverse-bias from an external source to said pillar for operation of said device in a photodetector mode to convert light photons incident on said pillar to electrons (shown as schematic voltage symbol in Fig. 5B, discussed in ¶ 0116);

pillar-separating regions filled with dielectric that surround and laterally separate at least portions of said pillars from each other;

a dielectric region under said Si substrate (the oxide region of the S-O-I substrate, otherwise known as the BOX buried oxide region);

wherein said pillars:

are laterally spaced from each other, center to center, by 100-2,000 nanometers (¶ 0132);
and

have up-down lengths of said absorption Si regions in the range of 100-5000 nanometers (¶ 0231):

wherein said pillars, in-pillar holes, and pillar-separating regions:

increase photon absorption of said device by a factor of 1.1 or more at infrared wavelength of incident light compared to a like device lacking said one or more in-pillar holes (discussed in ¶ 0095); and

facilitate operation of said device with infrared incident light (¶ 0004); and

wherein said device is CMOS compatible for mass production using CMOS foundries (¶ 0082).

Regarding claim 12, the claim differs from claim 1 in that the “in-pillar holes” are not limited to the shape of being “pyramid-shaped”.

Regarding claim 19, the claim differs from claim 1 in that the “in-pillar holes” are further described as, “has one or more in-pillar holes that extend down into the pillar and at least one is elongated in a lateral cross section”. It is noted that “elongated in lateral cross section” can be seen in Fig. 46 and is discussed in ¶ 0228.

Regarding claim 28, the claim differs from claim 1 in that the “in-pillar holes” are further described as, “has one or more dielectric-filled, in-pillar holes extending down into the pillar from a top surface of said upper doped Si region of the pillar”.

REASONS FOR ALLOWANCE

Claims 1-30 are allowed.

The following is an Examiner's statement of reasons for allowance: The device converting light photons into electrons as recited in the claims of the instant invention fail to be taught by the prior art cited of interest.

Regarding claims 1, 12, 19 and 28, the prior art discloses a P-I-N diode device for converting light photons into electrons but fails to disclose the specific characteristic recited in the claims of the instant invention e.g. the combination of claimed features in conjunction with the dielectric filled "in-pillar holes", the particularly claimed pillar pitch and pillar dimensions.

Contact Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Eduardo A Rodela whose telephone number is (571)272-8797. The examiner can normally be reached M-F, 8:30-5:00pm ET.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Yara B Green can be reached on (571) 270-3035. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: <https://patentcenter.uspto.gov>. Visit <https://www.uspto.gov/patents/apply/patent-center> for more information about Patent Center and <https://www.uspto.gov/patents/docx> for information about filing in DOCX format. For additional questions, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

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