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**Declarations under Rule 4.17:**
— *as to the identity of the inventor (Rule 4.17(i))*

**(54) Title:** EFFICIENT ELECTRODES ON HOLE TRANSPORTING LAYER OF METHYL AMMONIUM METAL HALIDE PEROVSKITE SOLAR CELL

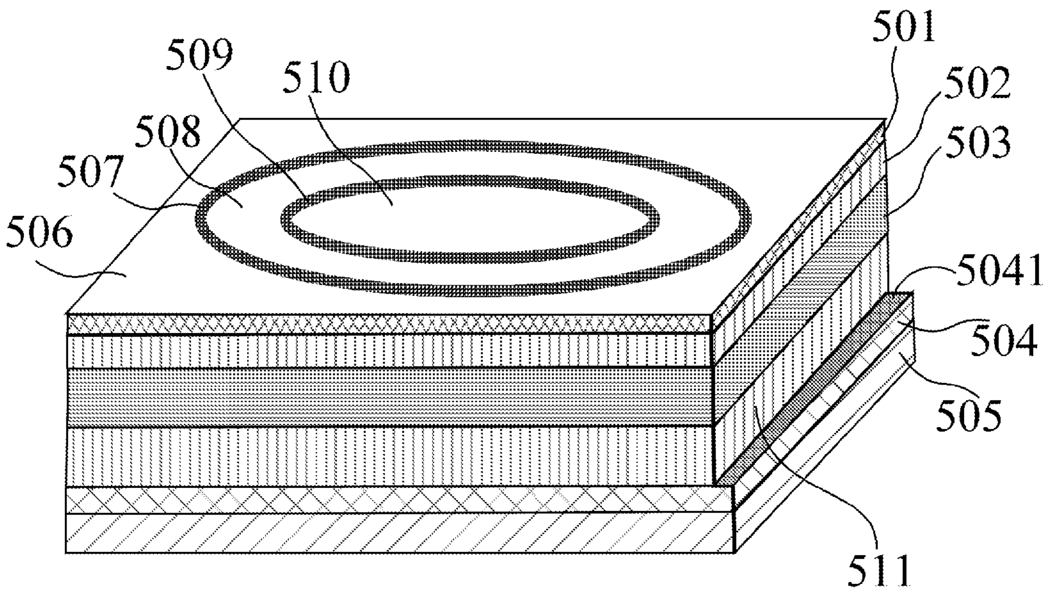


FIG. 5

**(57) Abstract:** A methyl ammonium metal halide perovskite solar cell comprises a photovoltaic conversion element, an electrically connected front electrode, back electrode that is divided into concentric and non- concentric electrodes, wherein concentric back electrode comprises two or more separate electrodes. The said photovoltaic conversion element consists of a photosensitive element, where energetic electron-hole pairs are generated due to light absorption that is disposed in between electron transporting layer or n-type layer, and hole transporting layer or p-type layer.

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[Continued on next page]

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# Efficient electrodes on hole transporting layer of methyl ammonium metal halide perovskite solar cell

ABSTRACT

A methyl ammonium metal halide perovskite solar cell comprises a photovoltaic conversion element, an electrically connected front electrode, back electrode that is divided into concentric and non-concentric electrodes, wherein concentric back electrode comprises two or more separate electrodes. The said photovoltaic conversion element consists of a photosensitive element, where energetic electron-hole pairs are generated due to light absorption that is disposed in between electron transporting layer or n-type layer, and hole transporting layer or p-type layer.

## Technical Field

The present invention relates to a solar cell device, particularly to the structure of a solar cell electrode.

## Background Art

Sun light is considered as one of the most widely available pollution free source of energy. A photovoltaic solar cell can absorb the light energy of the solar radiation and convert it to electrical energy.

There are various types of solar cells available, of which, methyl ammonium metal halide perovskite solar cell is one type of solar cell. Generally, in the solar cells, the electrodes are not concentric type, typical prior art examples are as schematically shown in FIG. 1, FIG. 2, FIG. 3. In the FIG. 1, reference numeral 101 indicates back electrode, reference numeral 102 indicates the methyl ammonium metal halide perovskite solar cell, reference numeral 103 indicates front electrode, reference numeral 104 indicates supporting material. In the FIG. 2, reference numeral 201 indicates back electrode, reference numeral 202 indicates the methyl ammonium metal halide perovskite solar cell, reference numeral 203 indicates front electrode, reference numeral 204 indicates supporting material. In the FIG. 3, reference numeral 301 indicates back electrode, reference numeral 302 indicates the methyl ammonium metal halide perovskite solar cell, reference numeral 303 indicates front electrode, reference numeral 3031 indicates exposed part of front electrode, reference numeral 304 indicates supporting material.

The problem with a conventional electrode is that if there is a non-uniform characteristics of the device over the surface, the electrodes cannot be used to differentiate them. For example, but not limited to this example, if thickness of layers vary from one point to another over the surface, the electrodes cannot be used to differentiate them.

Various types of solar cells are in development, for example, as disclosed in the US Patent No. US20160086739. This type of solar cells generally have a transparent support material, on which front electrode is fabricated. Electron transporting layer is fabricated on this electrode. Methyl ammonium metal halide type perovskite material is fabricated on the electron transporting layer by spin casting method. Then hole transporting layer is fabricated on the methyl ammonium metal halide type perovskite material. Then back electrode is fabricated. However, in many vcases, the thickness of prepared film in spin casting method is non-uniform over the film surface. In a non-uniformly thick solar cell, the generated electric current density and output voltage are non-uniform over the points of non-uniformity. Therefore, local shunting of electric current takes place. The type of electrodes, as disclosed in US Patent No. US20160086739, is not enough to address this problem.

Present invention significantly reduces this problem by electrically separating the regions of non-uniform thicknesses.

## SUMMARY OF INVENTION

Present invention provides an improved solar cell, out of the problem of non-uniformity in film-thickness in a spin casted solar cell that easily happens in spin casting on a larger surface area. Methyl ammonium lead iodide based perovskite solar cell is an example of methyl ammonium metal halide perovskite solar cell. These methyl ammonium metal halide perovskite solar cells are spin casted on a supporting substrate. Concentric electrodes are used at the back of the solar cell. The concentric electrodes are designed to divide the spin casted surface area into several smaller surface areas. Each surface area that are covered by each electrode, have reduced non-uniformity. In this invention, the part of the solar cell covered by each concentric electrodes, act like concentric solar cells with reduced shunting loss of output electrical energy of the solar cell. In this way, performance of the smaller concentric solar cells improve.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram of a prior art methyl ammonium metal halide perovskite solar cell;

FIG. 2 is a schematic diagram of a prior art methyl ammonium metal halide perovskite solar cell;

FIG. 3 is a schematic diagram of a prior art methyl ammonium metal halide perovskite solar cell;

FIG. 4 is a schematic diagram of top-view of two concentric back electrodes, as indicated by reference numerals 404, 405 that comprise gap-material Y, as indicated by reference numerals 402, 403;

FIG. 5 is a schematic diagram of two concentric electrodes, as indicated by reference numerals 508, 510 that comprise gap-material Y, as indicated by reference numerals 507, 509;

FIG. 6 is a schematic diagram of two concentric electrodes, as indicated by reference numerals 608, 610 that comprise the gap-material Y, as indicated by reference numerals 607, 609, 611, 613, extending from the back electrode to the front surface of the electron transporting layer of solar cell;

FIG. 7 is a schematic diagram of two concentric electrodes, as indicated by reference numerals 708, 710 that comprise the gap-material Y, as indicated by reference numerals 707, 709, 711, 713 where the gap-material Y extends from the back electrode to the front surface of the absorber layer of solar cell;

FIG. 8 is a schematic diagram of two concentric electrodes, as indicated by reference numerals 808, 810 that comprise the gap-material Y, as indicated by reference numerals 807, 809, 811, 813 where the gap-material Y extends from the back electrode to the front surface of the hole transporting layer of solar cell ;

FIG. 9 is a schematic diagram of two concentric electrodes, as indicated by reference numerals 908, 910 that comprise the gap-material Y, as indicated by reference numerals 907, 909, 911, 913 where the gap-material Y extends from the back electrode to the front surface of the concentric electrodes;

FIG. 10 is a schematic diagram of one circular electrode, as indicated by reference numeral 1007 that comprise the gap-material Y, as indicated by reference numerals 1006, 1008 where the gap-material Y extends from the back surface of the electrode to the back surface of the front electrode of solar cell;

FIG. 11 is a schematic diagram of one circular electrode, as indicated by reference numeral 1107 that comprise the gap-material Y, as indicated by reference numerals 1106, 1108 where the gap-material Y extends from the back electrode to the front surface of the absorber layer of solar cell;

FIG. 12 is a schematic diagram of one circular electrode, as indicated by reference numeral 1207 that comprise the gap-material Y, as indicated by reference numerals 1206, 1208 where the gap-material Y extends from the back electrode to the front surface of the hole transporting layer of solar cell;

FIG. 13 is a schematic diagram of one circular electrode, as indicated by reference numeral 1307 that comprise the gap-material Y, as indicated by reference numerals 1306, 1308 where the gap-material Y extends from the back electrode to the front surface of the concentric electrodes.

In all the above figures the supporting material side of the solar cell is considered as front side while the concentric electrode side of the solar cell is considered as back side.

## DETAILED DESCRIPTION

Detailed description and embodiments of this invention is given in the following. Referring to FIG. 4, FIG. 5, both of these figures show the back surface of the one of the embodiments of the invented device, indicating two concentric electrodes. In FIG. 4, reference numeral 401 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 402, 403 indicate gap-material Y, reference numeral 404 indicates one of the concentric electrodes, reference numeral 405 indicates a central disk-type electrode. Here the gap-material Y separates the electrodes. In FIG. 5, a different view of the device in FIG.4 is shown in addition to a part of the exposed front electrode as indicated by reference numeral 5041. In FIG. 5, reference numeral 501, 506 indicate part of the back electrode layer that is disposed on the hole transporting layer of the solar cell, reference numerals 507, 509 indicate gap-material Y, reference numeral 508 indicates one of the concentric electrodes, reference numeral 510 indicates a central disk-type electrode, reference numeral 502 indicates hole transporting layer, reference numeral 503 indicates absorber layer, reference numeral 511 indicates electron transporting layer, reference numeral 504 indicates front electrode, reference numeral 505 indicates supporting material. Here the gap-material Y separates the electrodes.

A clearer schematic diagram of one of the embodiments, as shown in FIG. 4, FIG. 5, is shown in FIG.6 as cross-sectional schematic diagram. In this cross-sectional schematic diagram, and in FIG. 7, FIG. 8, FIG. 9, FIG. 10, FIG. 11, FIG. 12, FIG, 13, various detailed embodiments of the present investigation is shown. Referring to the FIG. 6, FIG. 7, FIG. 8, FIG. 9, FIG. 10, FIG. 11, FIG. 12, FIG, 13, various sizes of the gap-material Y, is shown indicating various embodiments of the invention with various levels of electrical isolations of the concentric solar cells.

In FIG. 6, reference numeral 601 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 607, 609, 611, 613 indicate gap-material Y, reference numerals 608, 610 indicate the concentric electrodes, where reference numerals 608 and 612 are part of the same electrode. In FIG. 6, reference numeral 604 indicates front electrode, reference numeral 614 indicates electron transporting layer, reference numeral 605 indicates a support material. Here the gap-material Y penetrates through all the layers of the solar cell except the front electrode.

In FIG. 7, reference numeral 701 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 707, 709, 711, 713 indicate gap-material Y, reference numerals 708, 710 indicate the concentric electrodes, where reference numerals 708 and 712 are part of the same electrode. In FIG. 7, reference numeral 704 indicates front electrode, reference numeral 705 indicates a support material, reference numeral 714 indicates electron transporting layer. Here the gap-material Y penetrates through the back electrodes, hole transporting layer and absorber layer of the solar cell.

In FIG. 8, reference numeral 801 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 807, 809, 811, 813 indicate gap-material Y, reference numerals 808, 810 indicate the concentric electrodes, where reference numerals 808 and 812 are part of the same electrode. In FIG. 8 reference numeral 805 indicates a support material, reference numeral 814 indicates electron transporting layer. Here the gap-material Y penetrates through the back electrodes and hole transporting layer of the solar cell.

In FIG. 9, reference numeral 901 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 907, 909, 911, 913 indicate gap-material Y, reference numerals 908, 910 indicate the concentric electrodes, where reference numerals 908 and 912 are part of the same electrode. In FIG. 9 reference numeral 905 indicates a support material, reference numeral 914 indicates electron transporting layer. Here the gap-material Y penetrates through the back electrodes of the solar cell.

FIG. 10 shows another embodiment of the present invention, in which only one disk-type electrode is demonstrated. In FIG. 10, reference numeral 1001 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 1006, 1008 indicate gap-material Y, reference numeral 1007 indicates a disk-type electrode. In FIG. 10 reference numeral 1005 indicates a support material, reference numeral 1002 indicates hole transport layer, reference numeral 1003 indicates absorber layer, reference numeral 1010 indicates electron transporting layer, reference numeral 1004 indicates front electrode, 10041 indicates exposed front electrode. Here the gap-material Y penetrates through all the layers of the solar cell except the front electrode of the solar cell.

FIG. 11 shows another embodiment of the present invention, in which only one disk-type electrode is demonstrated. In FIG. 11, reference numeral 1101 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 1106, 1108 indicate gap-material Y, reference numeral 1107 indicates a disk-type electrode. In FIG. 11 reference numeral 1105 indicates a support material, reference numeral 1102 indicates hole transport layer, reference numeral 1103 indicates absorber layer, reference numeral 1110 indicates electron transporting layer, reference numeral 1104 indicates front electrode, 11041 indicates exposed front electrode. Here the gap-material Y penetrates through the back electrodes, hole transporting layer, absorber layer of the solar cell.

FIG. 12 shows another embodiment of the present invention, in which only one disk-type electrode is demonstrated. In FIG. 12, reference numeral 1201 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 1206, 1208 indicate gap-material Y, reference numeral 1207 indicates a disk-type electrode. In FIG. 12 reference numeral 1205 indicates a support material, reference numeral 1202 indicates hole transport layer, reference numeral 1203 indicates absorber layer, reference numeral 1210 indicates electron transporting layer, reference numeral 1204 indicates front electrode, 12041 indicates exposed front electrode. Here the gap-material Y penetrates through the back electrodes, hole transporting layer of the solar cell.

FIG. 13 shows another embodiment of the present invention, in which only one disk-type electrode is demonstrated. In FIG. 13, reference numeral 1301 indicates a part of the layer that is disposed on the hole transporting layer as back electrode of the solar cell, reference numerals 1306, 1308 indicate gap-material Y, reference numeral 1307 indicates a disk-type electrode. In FIG. 13 reference numeral 1305 indicates a support material, reference numeral 1302 indicates hole transport layer, reference numeral 1303 indicates absorber layer, reference numeral 1310 indicates electron transporting layer, reference numeral 1304 indicates front electrode, 13041 indicates exposed front electrode. Here the gap-material Y penetrates through the back electrodes of the solar cell.

What is claimed is:

1. A solar cell, comprising: a front electrode; an electron transporting layer connected to the front electrode; an absorber layer connected to the electron transporting layer; a hole transporting layer connected to the absorber layer; a back electrode connected to the hole transporting layer; wherein the improvement comprise dividing the back electrode into concentric and non-concentric electrodes connected to the hole transporting layer; wherein the concentric electrodes are separated from its neighboring electrode or electrodes.

2. A solar cell, as recited in claim 1, wherein the said electrodes comprise at least one annular electrode or at least one disk-type electrode.

3. A solar cell, as recited in claim 2, wherein thickness of the said electrodes are more than 5 nm and separated from its neighboring electrode (or electrodes) by a gap-material Y that is different in composition from the composition of the said electrodes.

4. The invention of claim 3, wherein the said electrodes are separated, by the gap-material Y, by more than 100 nm from neighboring electrode or electrodes.
5. The invention of claim 4, wherein the said gap-material Y comprises a material of lower electrical conductivity than the electrical conductivity of the said electrodes.
6. The invention of claim 5, wherein the said gap-material Y provides a means of reducing flow of electric charge between the neighboring electrodes.
7. The invention of claim 6, wherein the said gap-material Y is distributed parallel to the plane of the said electrodes.
8. The invention of claim 7, wherein the said gap-material Y comprises a material of lower electrical conductivity.
9. The invention of claim 8, wherein thickness, of the said gap-material Y, is more than the local thickness of the said electrodes but less than the distance between the top surface of the electron transporting layer and bottom surface of the said electrodes.
10. The invention of claim 9, wherein the said gap-material Y provides a means of reducing flow of electric charge across the gap-material Y.
11. The invention of claim 10 wherein the said electrodes comprise Au.
12. The invention of claim 10 wherein said electrodes comprise Ag.
13. The invention of claim 10 wherein said electrodes comprise Al.
14. The invention of claim 10 wherein said electrodes comprise aluminum doped zinc oxide (AZO).
15. The invention of claim 10 wherein said electrodes comprise indium tin oxide.
16. The invention of claim 10 wherein said electrodes comprise Au/Ag.
17. The invention of claim 10 wherein said electrodes comprise Au/Al.
18. The invention of claim 10 wherein said electrodes comprise AZO/Au.
19. The invention of claim 10 wherein said electrodes comprise indium tin oxide.
20. The invention of claim 10 wherein said electrodes comprise graphene.
21. The invention of claim 1-20 wherein the back electrodes comprise the electrodes, residual parts of the electrode that are not concentric.

22. A solar cell, as recited in claim 21, wherein the said absorber layer comprises methyl ammonium metal halide perovskite material.
23. A solar cell, as recited in claim 21, wherein the said absorber layer comprises hydrogenated thin film silicon alloy.
24. A solar cell, as recited in claim 21, wherein the said absorber layer comprises crystalline silicon.

What is claimed is:

1. A solar cell, comprising: a front electrode; an electron transporting layer connected to the front electrode; an absorber layer connected to the electron transporting layer; a hole transporting layer connected to the absorber layer; a back electrode connected to the hole transporting layer; wherein the improvement comprise dividing the back electrode into concentric and non-concentric electrodes connected to the hole transporting layer; wherein the concentric electrodes are separated from its neighboring electrode or electrodes.
2. A solar cell, as recited in claim 1, wherein the said electrodes comprise at least one annular electrode or at least one disk-type electrode.
3. A solar cell, as recited in claim 2, wherein thickness of the said electrodes are more than 5 nm and separated from its neighboring electrode (or electrodes) by a gap-material Y that is different in composition from the composition of the said electrodes.
4. The invention of claim 3, wherein the said electrodes are separated, by the gap-material Y, by more than 100 nm from neighboring electrode or electrodes.
5. The invention of claim 4, wherein the said gap-material Y comprises a material of lower electrical conductivity than the electrical conductivity of the said electrodes.
6. The invention of claim 5, wherein the said gap-material Y provides a means of reducing flow of electric charge between the neighboring electrodes.
7. The invention of claim 6, wherein the said gap-material Y is distributed parallel to the plane of the said electrodes.
8. The invention of claim 7, wherein the said gap-material Y comprises a material of lower electrical conductivity.
9. The invention of claim 8, wherein thickness, of the said gap-material Y, is more than the local thickness of the said electrodes but less than the distance between the top surface of the electron transporting layer and bottom surface of the said electrodes.
10. The invention of claim 9, wherein the said gap-material Y provides a means of reducing flow of electric charge across the gap-material Y.
11. The invention of claim 10 wherein the said electrodes comprise Au.
12. The invention of claim 10 wherein said electrodes comprise Ag.
13. The invention of claim 10 wherein said electrodes comprise Al.
14. The invention of claim 10 wherein said electrodes comprise aluminum doped zinc oxide (AZO).
15. The invention of claim 10 wherein said electrodes comprise indium tin oxide.
16. The invention of claim 10 wherein said electrodes comprise Au/Ag.
17. The invention of claim 10 wherein said electrodes comprise Au/Al.
18. The invention of claim 10 wherein said electrodes comprise AZO/Au.
19. The invention of claim 10 wherein said electrodes comprise indium tin oxide.
20. The invention of claim 10 wherein said electrodes comprise graphene.
21. The invention of claim 1-20 wherein the back electrodes comprise the electrodes, residual parts of the electrode that are not concentric.
22. A solar cell, as recited in claim 21, wherein the said absorber layer comprises methyl ammonium metal halide perovskite material.
23. A solar cell, as recited in claim 21, wherein the said absorber layer comprises hydrogenated thin film silicon alloy.
24. A solar cell, as recited in claim 21, wherein the said absorber layer comprises crystalline silicon.

AMENDED CLAIMS
received by the International Bureau on 26 October 2018

| | |
|---|---|
| [Claim 1] | [Amended] An improved photovoltaic device for converting optical energy to electrical energy, of the type having an electrode-A (504), an electrical charge transporting layer (511) disposed on the electrode-A, an energy conversion layer(503) disposed on the electrical charge transporting layer, an opposite charge transporting layer (502) disposed on the energy conversion layer (503), an electrode-B (501) disposed on the opposite charge transporting layer (502), wherein the improvement comprises: a plurality of concentric electrodes (506, 508,510) disposed on the opposite charge transporting layer; wherein the concentric electrodes are mutually separated. |
| [Claim 2] | [Amended] The improved photovoltaic device according to claim 1 wherein the said concentric electrodes comprise at least one annular electrode (508) or at least one disk-type electrode (510). |
| [Claim 3] | [Amended] The improved photovoltaic device according to claim 2 wherein the said concentric electrodes (506,508,510) are mutually separated by a gap-material Y(507,509) that is different in composition from the composition of the said concentric electrodes (506,508,510). |
| [Claim 4] | [Amended] The improved photovoltaic device according to claim 3 wherein the said concentric electrodes (506,508,510) are mutually separated, by the gap-material Y (507,509), by more than 100 nm. |
| [Claim 5] | [Amended] The improved photovoltaic device according to claim 4 wherein the said gap-material Y (507,509) comprises a material of lower electrical conductivity than the electrical conductivity of the electrodes (506,508,510). |
| [Claim 6] | [Amended] The improved photovoltaic device according to claim 5 wherein the said gap-material Y (507,509) provides a means of reducing flow of electric charge between the neighboring electrodes (506, 508), (508,510). |
| [Claim 7] | [Cancelled] |
| [Claim 8] | [Amended] The improved photovoltaic device according to claim 6 wherein the said gap-material Y (507,509) comprises a material of lower electrical conductivity. |
| [Claim 9] | [Amended] The improved photovoltaic device according to claim 7 wherein thickness, of the said gap-material Y (507,509), is more than the local thickness of the concentric electrodes (506,508,510) but less than or equal to the distance between the supporting material (505) and |

the surface of the concentric electrodes (506,508,510) that the surface of the concentric electrodes is at the opposite side to that of the supporting material (505).

[Claim 10] [Amended] The improved photovoltaic device according to claim 8 wherein the said gap-material Y (507,509) provides a means of reducing flow of electric charge across the gap-material Y (507,509).

[Claim 11] [Amended] The improved photovoltaic device according to claim 9 wherein the said concentric electrodes (506, 508,510) comprise gold.

[Claim 12] [Amended] The improved photovoltaic device according to claim 9 wherein said concentric electrodes (506, 508,510) comprise silver.

[Claim 13] [Amended] The improved photovoltaic device according to claim 9 wherein said concentric electrodes (506, 508,510) comprise aluminum.

[Claim 14] [Amended] The improved photovoltaic device according to claim 9 wherein said concentric electrodes (506, 508,510) comprise aluminum doped zinc.

[Claim 15] [Amended] The improved photovoltaic device according to claim 9 wherein said concentric electrodes (506, 508,510) comprise indium tin oxide.

[Claim 16] [Cancelled] .

[Claim 17] [Cancelled] .

[Claim 18] [Cancelled] .

[Claim 19] [Cancelled] .

[Claim 20] [Amended] The improved photovoltaic device according to claim 9 wherein said concentric electrodes (506, 508,510) comprise graphene.

[Claim 21] [Cancelled] .

[Claim 22] [Amended] The improved photovoltaic device according to any one of claim 11 to claim 15 wherein the said energy conversion layer (503) comprises methyl ammonium metal halide perovskite material.

[Claim 23] [Cancelled]

[Claim 24] [Cancelled]

[Claim 25] [Added] The improved photovoltaic device according to claim 16 wherein the improved photovoltaic device comprises plurality of smaller photovoltaic devices those are disposed between the concentric electrodes (506, 508,510) and the supporting material (505).

[Claim 26] [Added] The improved photovoltaic device according to claim 17 wherein the improved photovoltaic device comprises a solar cell, or a photodiode, or a photo detector, or a photosensor.

# Statement under Article 19(1)

The Inventor/Applicant hereby makes the following statements. The applicant hereby requests to incorporate changes in the application document, keeping subject matter of the application unchanged:

1. Drawing will have no impact, so no change in drawing is required at this stage.
2. Title to be changed to "Efficient electrodes for methyl ammonium metal halide perovskite photovoltaic device"
3. Abstract to be changed to "A methyl ammonium metal halide perovskite photovoltaic device comprises a plurality of photovoltaic conversion elements (502,503,511), an electrically connected electrode-A (504), electrode-B (501) that is divided into concentric electrodes (506, 508, 510), wherein concentric electrode-B's comprise two or more separate electrodes (506, 508, 510). The said photovoltaic conversion element consists of an energy conversion layer (503), where energetic electric charge carriers are generated due to light absorption. The said energy conversion layer (503) is disposed in between electrical charge transporting layer (511), and opposite charge transporting layer (502). In this invention, the part of the photovoltaic device covered by each of the concentric electrodes, act like concentric smaller photovoltaic devices."
4. Please allow to include the following:

ACKNOWLEDGMENT OF GOVERNMENT SUPPORT

This invention was made with government support under Grant No. NRF-2016R1D1A1B03935259 of Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education. The government has certain rights in the invention.

5. Some amendments in the description in the application document are required. These amendments are based on improving text for better presentation. The Applicant hereby requests for an opportunity to incorporate the changes in the text of the application document.

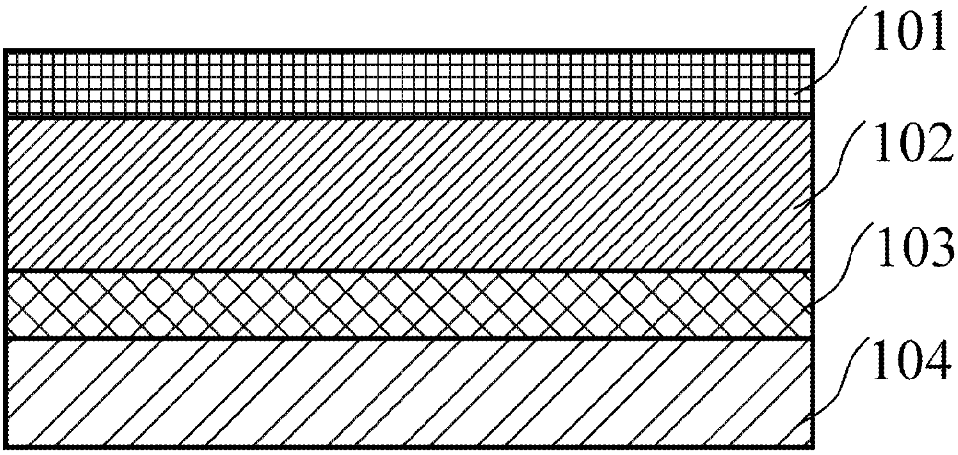



FIG. 1
(Prior Art)

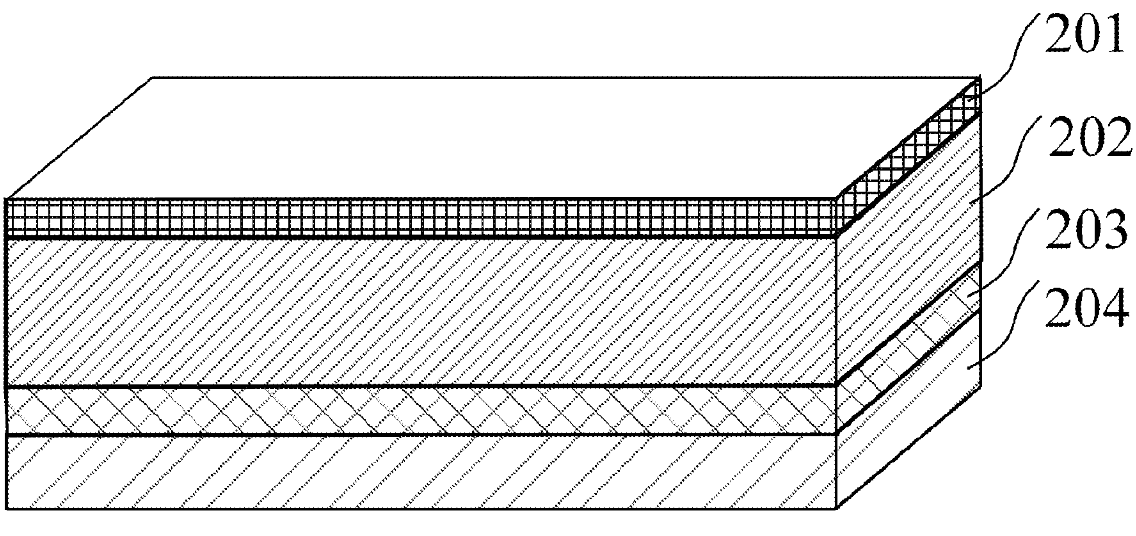



FIG. 2
(Prior Art)

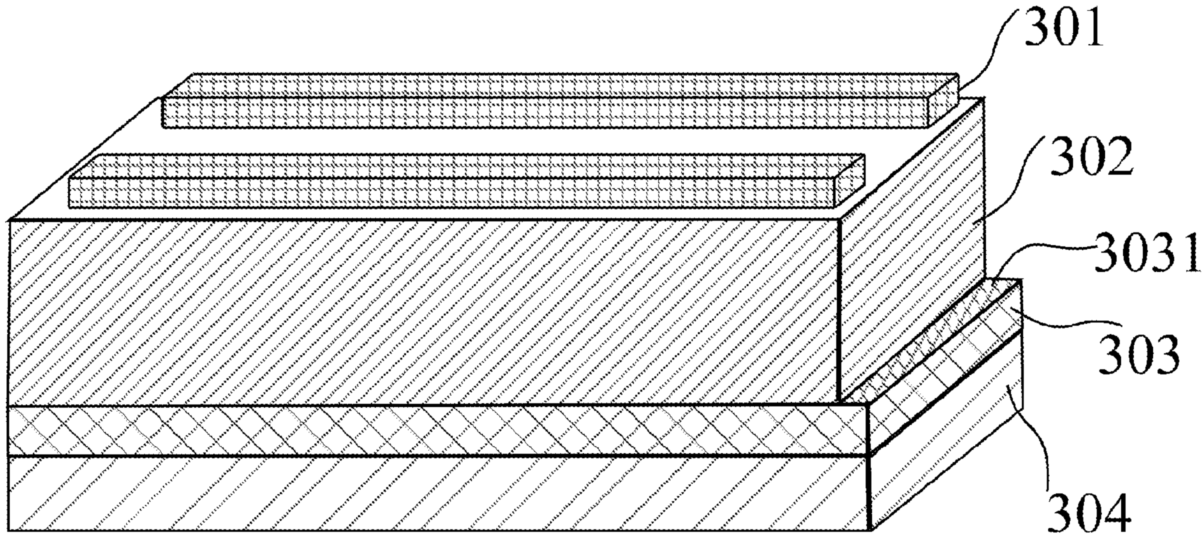



FIG. 3
(Prior Art)

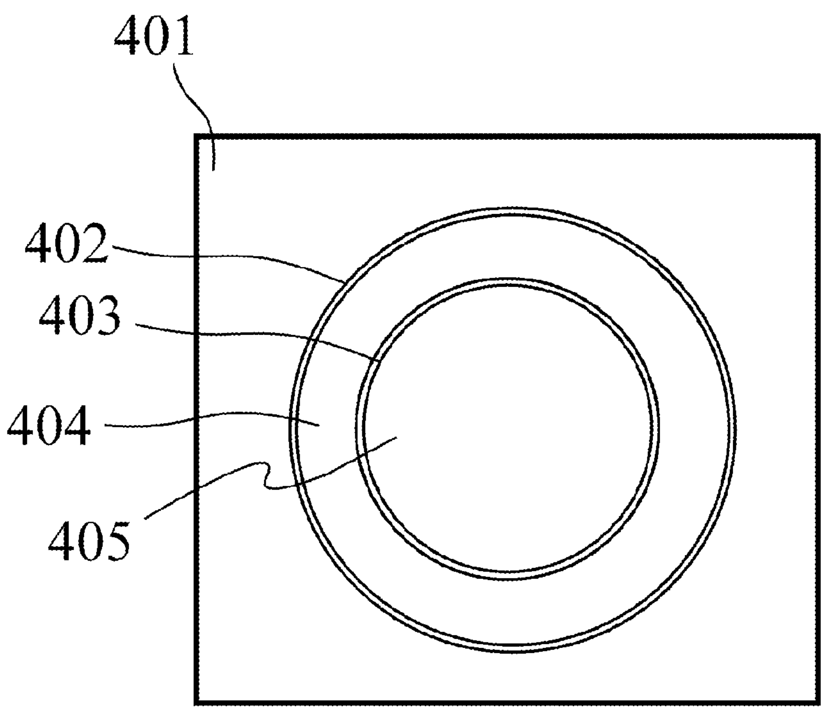
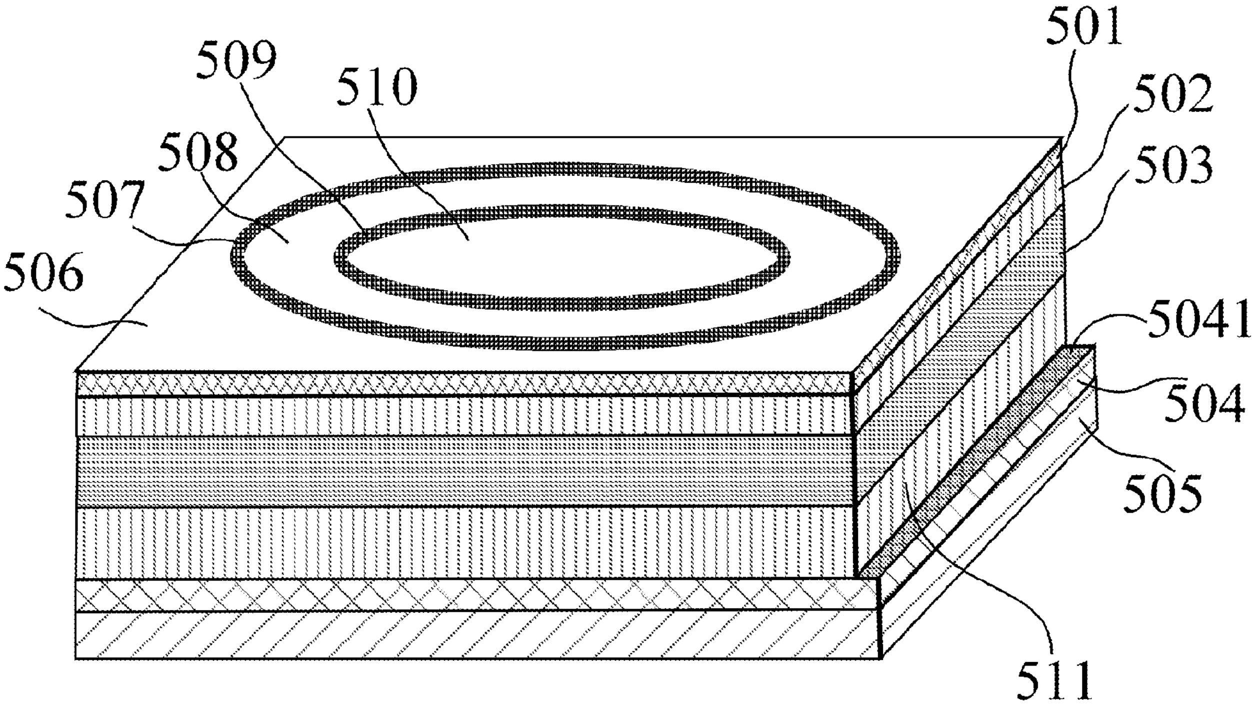



FIG. 4


501
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507
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505
511

FIG. 5

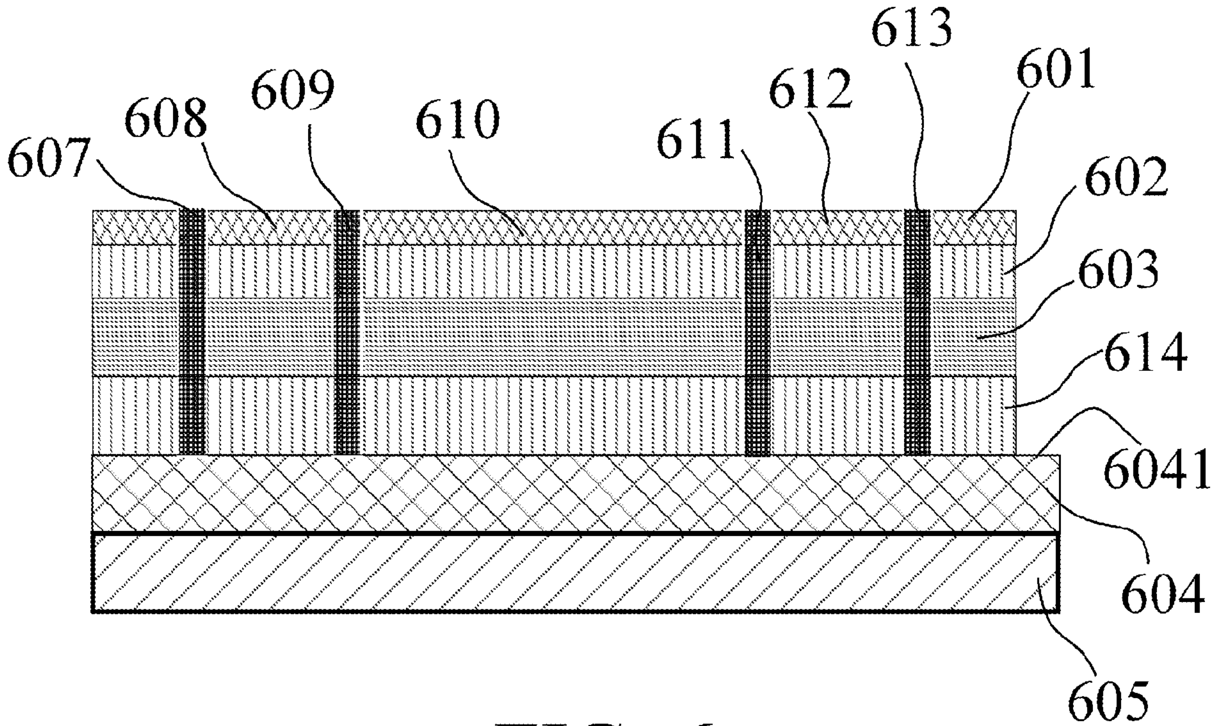
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FIG. 6

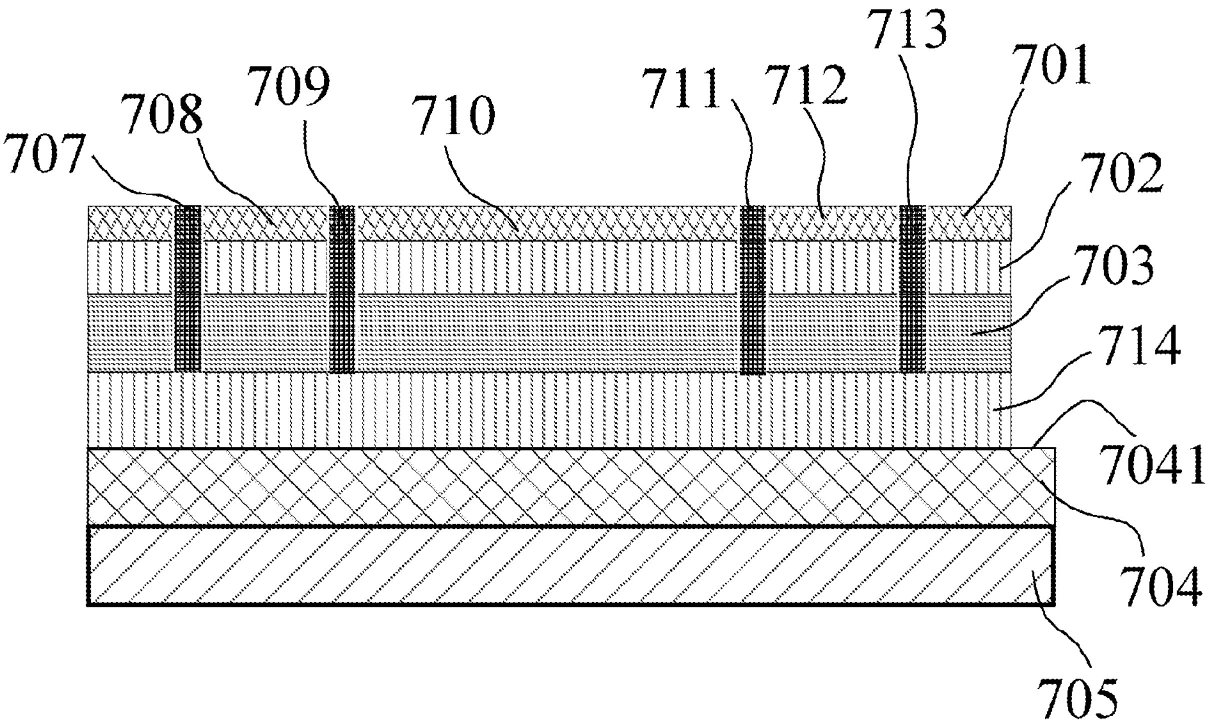
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FIG. 7

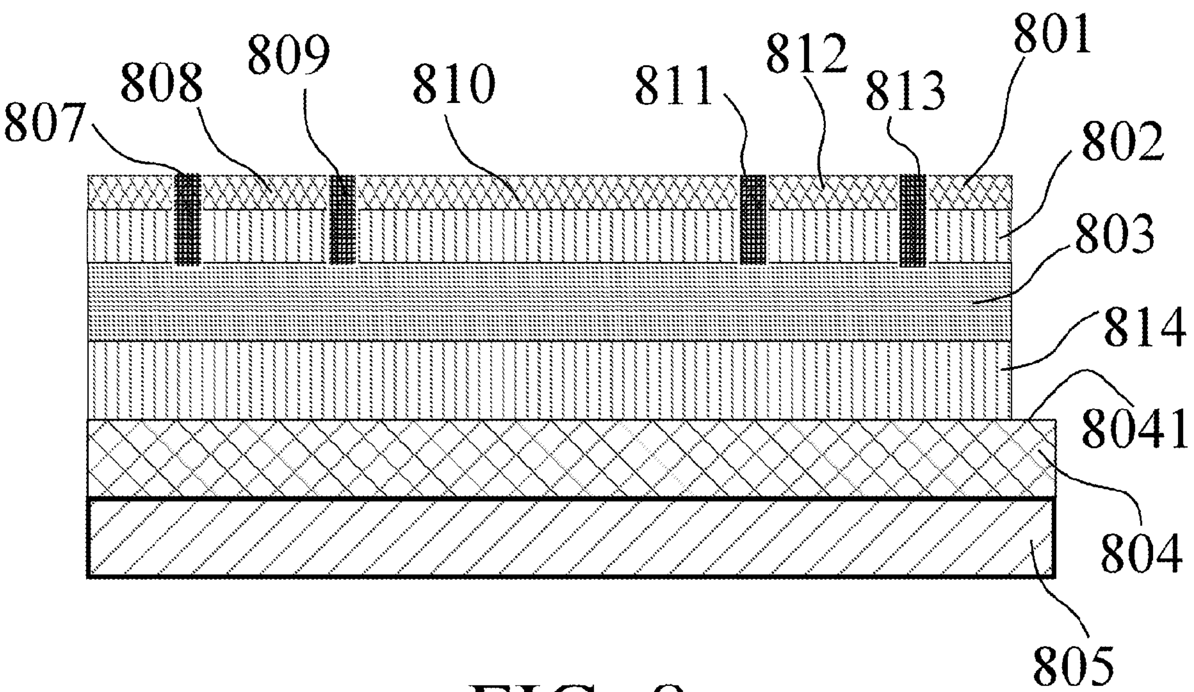
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FIG. 8

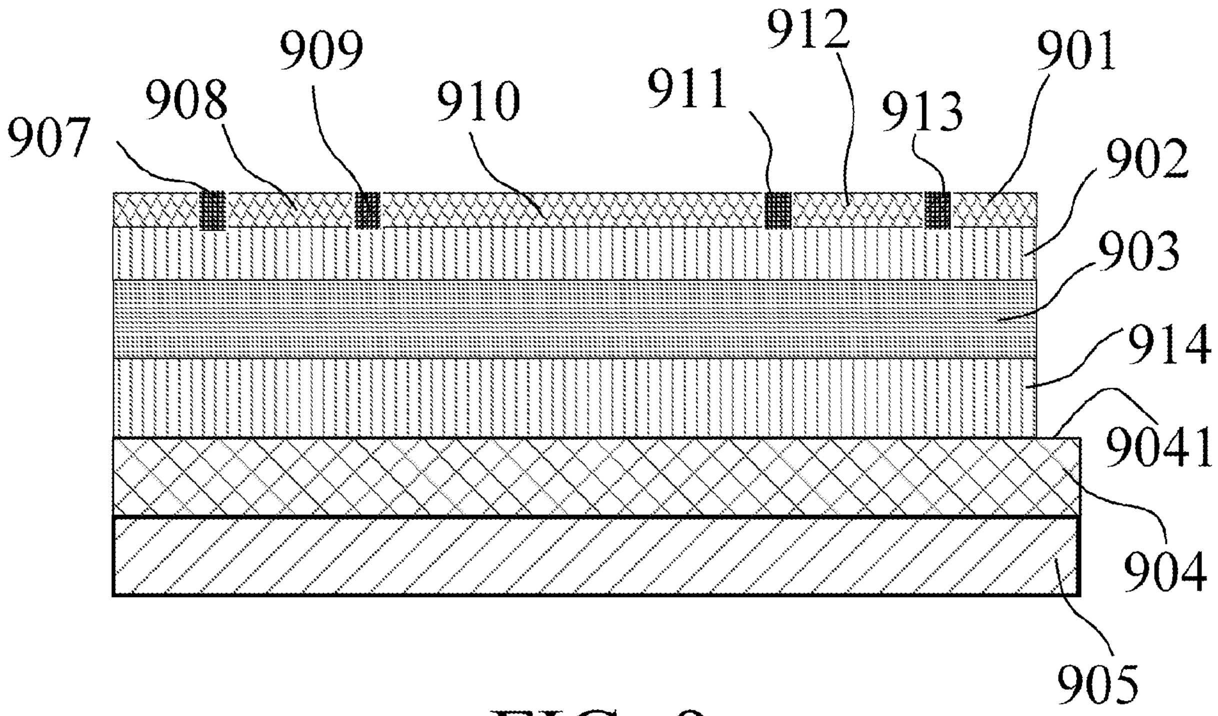
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FIG. 9

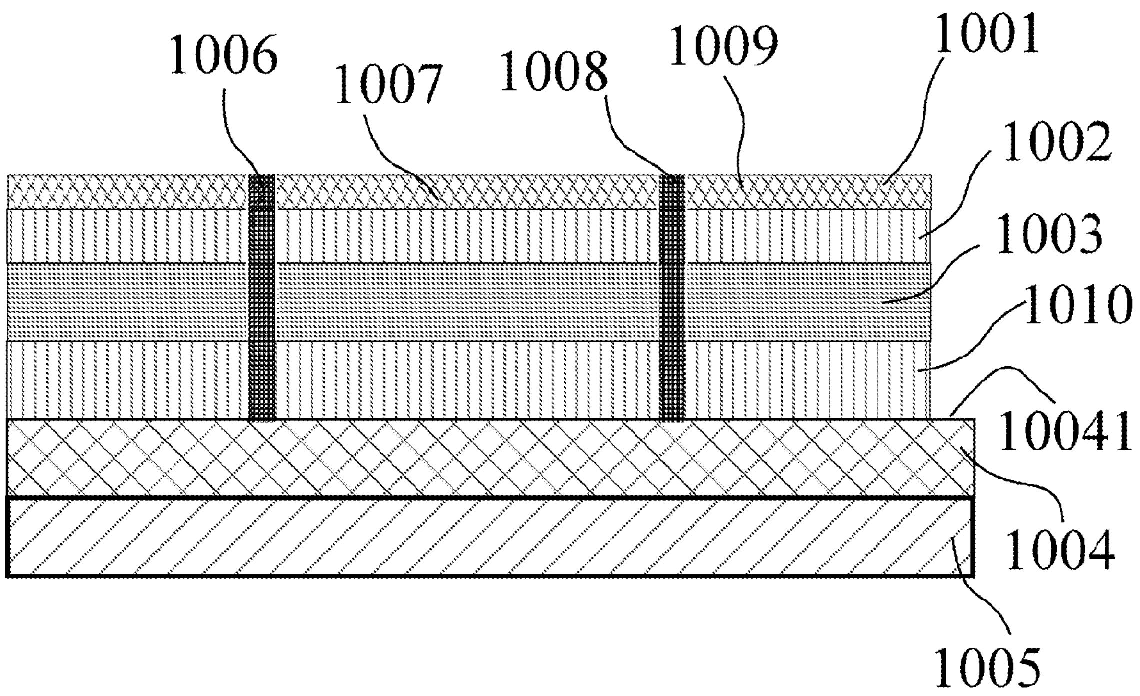
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FIG. 10

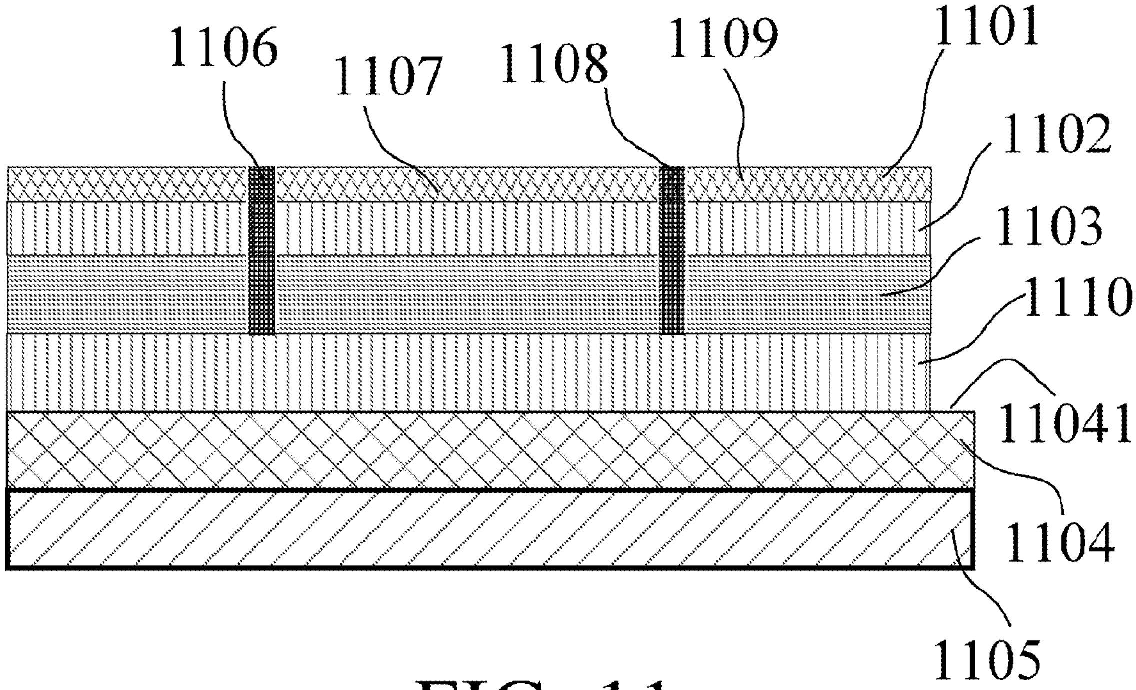


FIG. 11

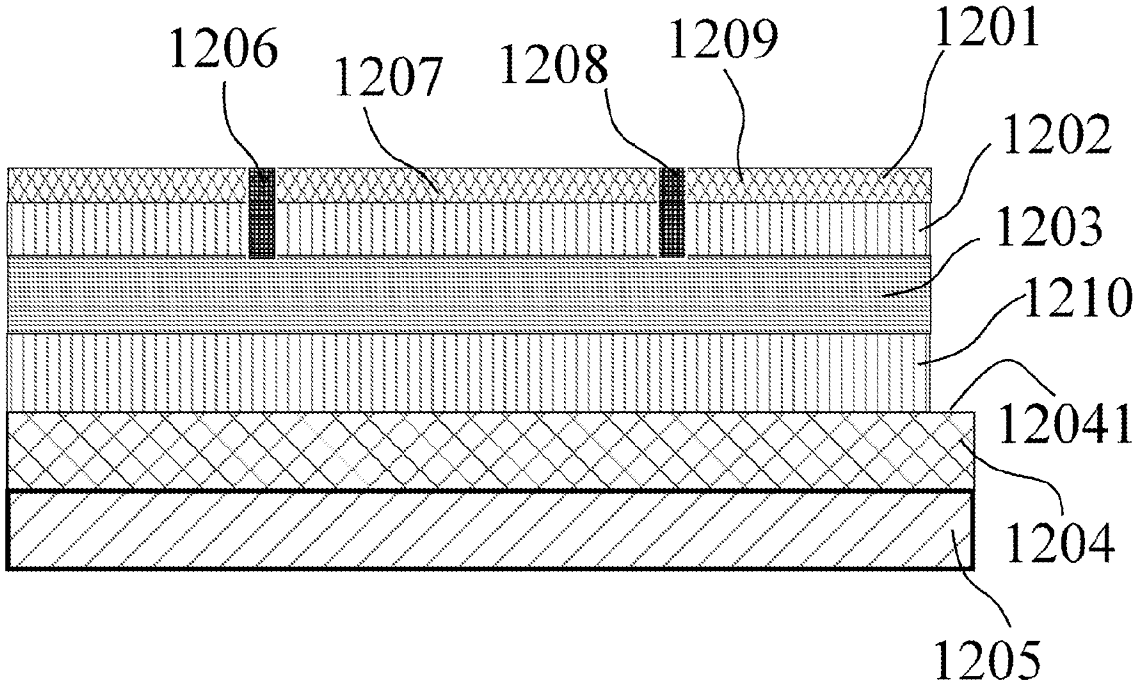
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FIG. 12

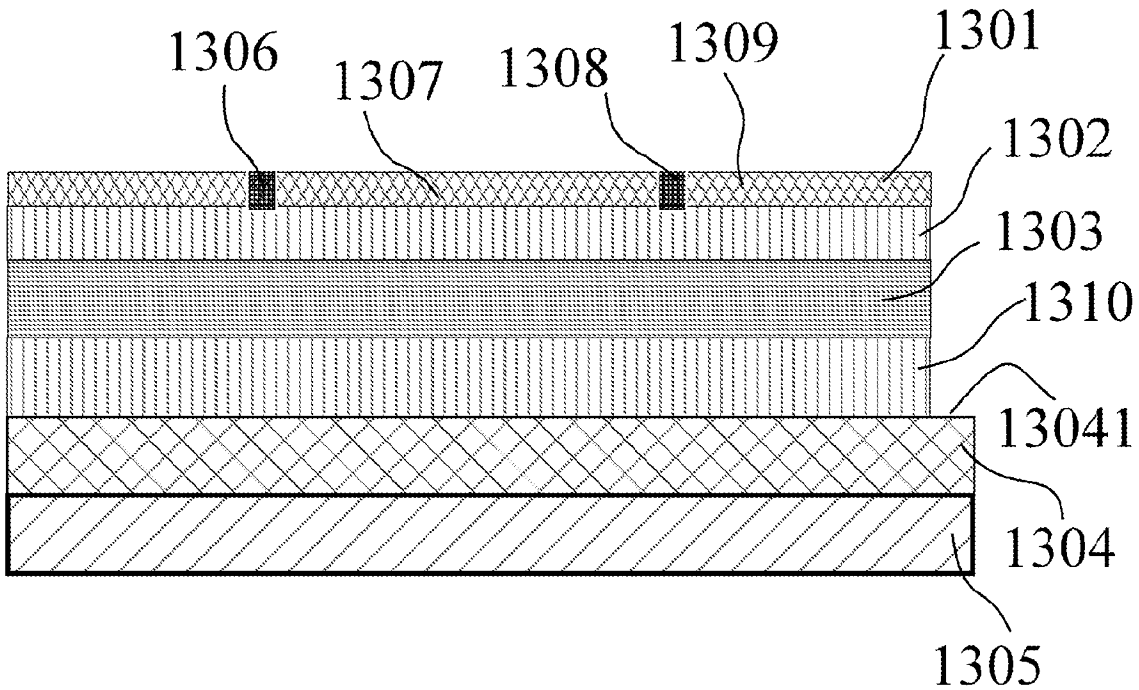
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FIG. 13

## INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2018/054896

**A. CLASSIFICATION OF SUBJECT MATTER**
A61B8/00,A61B18/00 Version=2018.01

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)

H01L, A61B

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)

Databases: TotalPatent One, IPO Internal Database.
Keywords: solar cell, perovskite, segmented electrode.

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | WO 2013171520 A1 (ISIS INNOVATION LIMITED) 21 November 2013 (21-11-2013). Entire document. | 1-24 |
| Y | WO 2015092397 A1 (ISIS INNOVATION LIMITED) 25 June 2015 (25-06-2015). Entire document. | 1-24 |
| Y | US 6846984 B2 (UNIVERSITAT KONSTANZ) 25 January 2005 (25-01-2005). Entire document. | 1-24 |

☐ 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

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"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 |
|---|---|
| 27-08-2018 | 27-08-2018 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| Indian Patent Office<br>Plot No.32, Sector 14,Dwarka,New Delhi-110075<br>Facsimile No. | Dr. Santanu Acharya<br>Telephone No. +91-1125300200 |

**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
PCT/IB2018/054896

| Citation | Pub.Date | Family | Pub.Date |
|---|---|---|---|
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| | | EP 2850669 B1 | 24-02-2016 |
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| | | DE 10020541 A1 | 08-11-2001 |
| | | WO 2001082383 A1 | 01-11-2001 |