(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
3 January 2014 (03.01.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/003441 A1

(51) **International Patent Classification**:
H01L 31/042 (2006.01) ***H01L 31/0236*** (2006.01)
H01L 31/0224 (2006.01) ***H01L 31/18*** (2006.01)

(21) **International Application Number**:
PCT/KR2013/005667

(22) **International Filing Date**:
26 June 2013 (26.06.2013)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
10-2012-0070354 28 June 2012 (28.06.2012) KR

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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, 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.

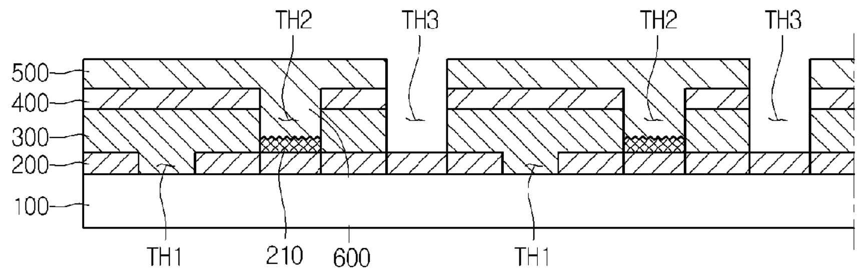
(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR,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

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))*

(54) **Title**: SOLAR CELL AND METHOD OF FABRICATING THE SAME



(57) **Abstract**: A solar cell includes: a substrate; a back electrode layer on the substrate; a light absorbing layer on the back electrode layer; a buffer layer on the light absorbing layer; and a through hole formed through the light absorbing layer and the buffer layer, wherein a metal layer is disposed on the back electrode layer exposed through the through hole.

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Description

Title of Invention: SOLAR CELL AND METHOD OF FABRICATING THE SAME

Technical Field

[1] The embodiment relates to a solar cell and a method of fabricating the same.

Background Art

[2] A method of fabricating a solar cell for solar light power generation is as follows. First, after preparing a substrate, a back electrode layer is formed on the substrate and patterned by a laser, thereby forming a plurality of back electrodes.

[3] Thereafter, a light absorbing layer, a buffer layer, and a high resistance buffer layer are sequentially formed on the back electrodes. Various schemes, such as a scheme of forming a $Cu(In,Ga)Se_2$ (CIGS) based-light absorbing layer by simultaneously or separately evaporating Cu, In, Ga, and Se and a scheme of performing a selenization process after a metallic precursor film has been formed, have been extensively used in order to form the light absorbing layer. The energy bandgap of the light absorbing layer is in the range of about 1eV to 1.8eV.

[4] Then, a buffer layer including cadmium sulfide (CdS) is formed on the light absorbing layer through a sputtering process. The energy bandgap of the buffer layer may be in the range of about 2.2eV to 2.4eV. After that, a high resistance buffer layer including zinc oxide (ZnO) is formed on the buffer layer through the sputtering process. The energy bandgap of the high resistance buffer layer is in the range of about 3.1eV to about 3.3eV.

[5] Thereafter, a hole pattern may be formed in the light absorbing layer, the buffer layer, and the high resistance buffer layer.

[6] Then, a transparent conductive material is laminated on the high resistance buffer layer, and is filled in the hole pattern. Therefore, a transparent electrode layer is formed on the high resistance buffer layer, and connection wires are formed in the hole pattern. A material constituting the transparent electrode layer and the connection wireless may include aluminum doped zinc oxide (AZO). The energy bandgap of the transparent electrode layer may be in the range of about 3.1eV to about 3.3eV.

[7] Then, the hole pattern is formed in the transparent electrode layer, so that a plurality of solar cells may be formed. The transparent electrodes and the high resistance buffers correspond to the cells, respectively. The transparent electrodes and the high resistance buffers may be provided in the form of a stripe or a matrix.

[8] The transparent electrodes and the back electrodes are misaligned from each other, so that the transparent electrodes are electrically connected to the back electrodes through

the connection wires. Accordingly, the solar cells may be electrically connected to each other in series.

[9] As described above, in order to convert the solar light into electrical energy, various solar cell apparatuses have been fabricated and used. One of the solar cell apparatuses is disclosed in Korean Unexamined Patent Publication No. 10-2008-0088744.

[10] Meanwhile, according to the process of the related art, a second through hole is formed after a high resistance buffer layer has been formed and then a front electrode layer is formed inside the high resistance buffer layer and the through hole to serially connect a plurality of cells to each other.

[11] However, when connecting the cells to each other, a thickness of the front electrode layer must be increased to reduce connection resistance, so transmittance of the front electrode layer is reduced.

[12] Accordingly, a novel solar cell capable of improving transmittance and efficiency by reducing the thickness of the front electrode layer and a method of manufacturing the same are required.

Disclosure of Invention

Technical Problem

[13] The embodiment provides a solar cell having improved photoelectric conversion efficiency and a method of fabricating the same.

Solution to Problem

[14] According to the embodiment, there is provided a solar cell including: a substrate; a back electrode layer on the substrate; a light absorbing layer on the back electrode layer; a buffer layer on the light absorbing layer; and a through hole formed through the light absorbing layer and the buffer layer, wherein a metal layer is disposed on the back electrode layer exposed through the through hole.

[15] According to one embodiment, there is provided a method of fabricating a solar cell, including: forming a back electrode layer on a substrate; forming a light absorbing layer on the back electrode layer; forming a buffer layer on the light absorbing layer; forming through holes through the light absorbing layer and the buffer layer; and forming a metal layer on the back electrode layer exposed through the through holes.

Advantageous Effects of Invention

[16] The solar cell and the method of fabricating the same according to the embodiment may enlarge a surface area of a contact surface where a front electrode and a back electrode are connected. That is, a concavo-convex pattern and a metal layer having a predetermined surface roughness are formed on the back electrode exposed through through holes so that the surface area of the contact surface can be enlarged.

[17] Accordingly, a contact area between the front electrode and the back electrode is

enlarged so that contact resistance can be reduced.

[18] Therefore, it is not necessary to thickly form the front electrode to reduce the contact resistance, so the solar cell and the method of fabricating the same according to the embodiment can provide a thin front electrode.

[19] Accordingly, since the solar cell and the method of fabricating the same according to the embodiment can provide the front electrode having a thin thickness, transmittance of the front electrode can be improved and efficiency of the solar cell can be improved due to the improvement of the transmittance.

Brief Description of Drawings

[20] FIG. 1 is a plan view showing a solar cell according to the embodiment.

[21] FIG. 2 is a sectional view showing one section of a solar cell according to the embodiment.

[22] FIGS. 3 to 10 are views showing a method of fabricating a solar cell according to the embodiment.

Mode for the Invention

[23] In the description of the embodiments, it will be understood that, when a layer (film), a region, a pattern or a structure is referred to as being "on" or "under" another layer (film), another region, another pattern, or another structure, it can be "directly" or "indirectly" on the other layer (film), region, pattern, or structure, or one or more intervening layers may also be present. Such a position of the layer has been described with reference to the drawings.

[24] The size or the thickness of the layer (film), the region, the pattern or the structure may be modified exaggerated for the purpose of explanation and clarity. The size may not utterly reflect the actual size.

[25] Hereinafter, an embodiment will be described with reference to the accompanying drawings.

[26] Hereinafter, the solar cell according to the embodiment will be described in detail. FIG. 1 is a plan view showing a solar cell according to the embodiment, and FIG. 2 is a sectional view showing one section of a solar cell according to the embodiment.

[27] Referring to FIGS. 1 and 2, the photovoltaic apparatus according to the embodiment includes a support substrate 100, a back electrode layer 200, a light absorbing layer 300, a buffer layer 400, a front electrode layer 500, and a plurality of connecting parts 600.

[28] The support substrate 100 has a plate shape and supports the back electrode layer 200, the light absorbing layer 300, the buffer layer 400, the front electrode layer 500, and the connecting parts 700.

[29] The support substrate 100 may include an insulator. The support substrate 100 may

be a glass substrate, a plastic substrate such as polymer or a metal substrate. Meanwhile, the support substrate 100 may include soda lime glass. The support substrate 100 may be transparent, flexible or rigid.

[30] The back electrode layer 200 is provided on a top surface of the support substrate 100. The back electrode layer 200 is a conductive layer. For example, a material used for the back electrode layer 200 may include metal such as molybdenum (Mo).

[31] The back electrode layer 200 may include at least two layers. In this case, at least two layers may be formed by using the same metal or different metals.

[32] The back electrode layer 200 is provided therein with first through holes TH1. The first through holes TH1 are an open region to expose the top surface of the support substrate 100. When viewed in a plan view, the first through holes TH1 may have a shape extending in a first direction.

[33] A width of each of the first through holes TH1 may be in the range of about 80 ㎛ to 200 ㎛.

[34] The back electrode layer 200 is divided into a plurality of back electrodes by the first through holes TH1. That is, the back electrodes are defined by the first through holes TH1.

[35] The back electrodes may be spaced apart from each other by the first through holes TH1. The back electrodes are provided in the form of a stripe.

[36] Alternatively, the back electrodes may be provided in the form of a matrix. In this case, the first through holes may be formed in the form of a lattice when viewed in a plan view.

[37] The light absorbing layer 300 is provided on the back electrode layer 200. Further, a material included in the light absorbing layer 300 is filled in the first through holes TH1.

[38] The light absorbing layer 300 may include group I-III-VI compounds. For instance, the light absorbing layer 300 may include the $Cu(In,Ga)Se_2$ (CIGS) crystal structure, the $Cu(In)Se_2$ crystal structure, or the $Cu(Ga)Se_2$ crystal structure.

[39] The energy bandgap of the light absorbing layer 300 is in the range of about 1 eV to 1.8 eV.

[40] The buffer layer 400 is provided on the light absorbing layer 300. The buffer layer 400 directly makes contact with the light absorbing layer 300.

[41] A high resistance buffer layer may be further provided on the buffer layer 400. The high resistance buffer layer includes i-ZnO which is not doped with impurities. The energy bandgap of the high resistance buffer layer may be in the range of about 3.1 eV to about 3.3 eV.

[42] The buffer layer 400 is provided therein with second through holes TH2. The second through holes TH2 are an open region to expose the top surface of the support

substrate 100 and a top surface of the back electrode layer 200. When viewed in a plan view, the second through holes TH2 may have a shape extending in one direction. For example, a width of each of the second through holes TH2 may be in the range of about 80 ㎛ to about 200 ㎛, but is not limited thereto.

[43] The buffer layer 400 is defined by a plurality of buffers by the second through holes TH2. That is, the buffer layer 400 is divided into a plurality of buffers by the second through holes TH2.

[44] A metal layer 210 may be disposed on the back electrode layer 200 exposed through the second through holes TH2. The metal layer 210 may include various metals. For example, the metal layer 210 may include molybdenum (Mo), nickel (Ni), or silver (Ag). Preferably, the metal layer 210 may include molybdenum (Mo).

[45] The metal layer 210 may directly contact with the back electrode layer 200 exposed through the second through holes TH2. Further, the metal layer 210 may directly make contact with an inner side of the light absorbing layer 300 exposed through the second through holes TH2.

[46] A surface of the metal layer 210 may has a predetermined pattern. In detail, a concavo-convex pattern may be formed on the surface of the metal layer 210. The concavo-convex pattern may have a random height and shape. That is, the concavo-convex pattern may be formed on the metal layer 210 with various heights and shapes.

[47] A surface roughness of the back electrode layer 200 exposed through the second through holes TH2 may be increased due to the metal layer. That is, the metal layer 210 on which the concavo-convex pattern is formed has a predetermined surface roughness, and a surface roughness of the back electrode layer 200 exposed through the second through holes TH2 may be increased due to the metal layer 210. For instance, a surface roughness of the metal layer 210 disposed on the back electrode layer 200 may be 0.1 ㎚ or above. Preferably, the surface roughness of the metal layer 210 may be in the range of 0.1 ㎚ to 1 ㎚.

[48] A surface area of the back electrode layer 200 exposed through the second through holes TH2 may be increased due to the metal layer 210 disposed on the back electrode layer 200. That is, the surface roughness is increased due to the metal layer 210 so that a surface area of the back electrode layer 200 exposed through the second through holes TH2 can be increased.

[49] The front electrode layer 500 is provided on the buffer layer 400. In detail, the front electrode layer 500 is provided on the high resistance layer. The front electrode layer 500 is transparent and conductive. Further, resistance in the front electrode layer 500 is greater than resistance of the back electrode layer 500.

[50] The front electrode layer 500 includes an oxide. For example, a material used for the front electrode layer 500 may include an Al doped zinc oxide (AZO), an indium zinc

oxide (IZO), or an indium tin oxide (ITO).

[51] A thickness of the front electrode layer 500 may be in the range of about 500 nm to about 1.5 µm. The front electrode layer 500 includes the AZO, the aluminum (Al) may be doped at the amount of about 2.5wt% to about 3.5wt%.

[52] The front electrode layer 500 includes the connecting parts 600 disposed inside the second through holes TH2. Further, the front electrode layer 500 directly makes contact with the metal layer 210 disposed in the second through holes TH2.

[53] Third through holes TH3 are formed through the buffer layer 400 and the front electrode layer 500. The third through holes TH3 may be formed through all or a part of the buffer layer 400, the high resistance buffer layer, and the front electrode layer 500. That is, the third through holes TH3 may expose a top surface of the back electrode layer 200.

[54] The third through holes TH3 are formed close to the second through holes TH2. In detail, the third through holes TH3 are disposed aside the second through holes TH2. That is, when viewed in a plan view, the third through holes TH3 are disposed aside the second through hole TH2 in parallel. The third through holes TH3 may have a shape extending in the first direction.

[55] The third through holes TH3 are formed through the front electrode layer 500. In detail, the third through holes TH3 may be formed through all or part of the light absorbing layer 300, the buffer layer 400, and/or the high resistance buffer layer.

[56] The front electrode layer 600 is divided into a plurality of front electrodes by the third through holes TH3. That is, the front electrodes are defined by the third through holes TH3.

[57] The front electrodes may have shapes corresponding to the back electrodes, respectively. That is, the front electrodes are provided in the form of a stripe. Alternatively, the front electrodes may be provided in the form of a matrix.

[58] In addition, a plurality of solar cells C1, C2..., and CN are defined by the third through holes TH3. In detail, the solar cells C1, C2..., and CN are defined by the second through holes TH2 and the third through holes TH3. That is, the solar cell according to the embodiment is divided into the solar cells C1, C2,..., and CN by the second through holes TH2 and the third through holes TH3. The solar cells C1, C2,..., and CN are connected to each other in a second direction crossing the first direction. That is, a current may flow in the second direction through the solar cells C1, C2,..., and CN.

[59] That is, a solar cell panel 10 includes the support substrate 100 and the solar cells C1, C2,..., and CN. The solar cells C1, C2,..., and CN spaced apart from each other on the support substrate 100. Further, the solar cells C1, C2,..., and CN are serially connected to each other by the connecting parts 700.

[60] The connecting parts 700 are disposed at an inner side of the second through hole TH2. The connecting parts 700 extend downward from the front electrode layer 500, and is connected to the back electrode layer 200. For example, the connecting parts 600 extend from the front electrode of the first cell C1 and is connected to the back electrode of the second cell C2. That is, the connecting part 600 is connected onto the metal layer 210 disposed on the back electrode layer 200.

[61] Accordingly, the connecting parts 600 connect the solar cells C1, C2,..., and CN adjacent to each other. In detail, the connecting parts 700 connect front electrodes and back electrodes included in adjacent solar cells.

[62] The connecting part 700 may be integrally formed with the front electrode. That is, a material used for the connecting part 600 is the same as a material used for the front electrode layer 500.

[63] As described above, the metal layer 210 is formed on the back electrode layer 200 exposed through the second through holes TH2. The concavo-convex pattern is formed on the surface of the metal layer 210 so that a surface area of the back electrode layer 210 may be enlarged.

[64] In the related art, the front electrode layer and the back electrode layer connected to the each other through the second through holes have mutually different resistances so that connection resistance is increased. Accordingly, since a deposited thickness of the front electrode layer is excessively increased upon depositing the front electrode layer in order to reduce the connection resistance, transmittance and efficiency may deteriorate due to the large thickness.

[65] Accordingly, in the solar cell according to the embodiment, the metal layer having the concavo-convex pattern is formed at a contact part between the back electrode layer and the front electrode layer to enlarge a contact area, so that the contact resistance can be reduced. Therefore, it is not necessary to excessively increase a thickness of the front electrode layer to reduce the contact resistance, so that the transmittance and the efficiency of the solar cell can be improved.

[66] For example, according to the related art, the thickness of the front electrode layer is thick in the range of 500 nm to 1.5 μm. However, according to the solar cell of the embodiment, the thickness of the front electrode layer may be reduced in the range of 300 nm to 1.0 μm.

[67] Further, a process of manufacturing the front electrode layer may be simplified so that the efficiency of a deposition process can be improved and a process cost can be reduced.

[68] Hereinafter, a method of fabricating a solar cell according to the embodiment will be described in detail. FIGS. 3 to 10 are views showing a method of fabricating a solar cell according to the embodiment.

[69] First, Referring to FIG. 3, a back electrode layer 200 is formed on a support substrate 100.

[70] Referring to FIG. 4, a first through holes TH1 are formed by patterning the back electrode layer 200. Accordingly, a plurality of back electrodes, a first connection electrode, and a second connection electrode are formed on the support substrate 100. The back electrode layer 200 is patterned by a laser.

[71] The first through hole TH1 exposes the top surface of the support substrate 100, and may have a width in the range of about 80 ㎛ to about 200 ㎛.

[72] An additional layer such as a diffusion prevention layer may be interposed between the support substrate 100 and the back electrode layer 200. In this case, the first through holes TH1 expose a top surface of the additional layer.

[73] Next, referring to FIG. 5, a light absorbing layer 300 is formed on the back electrode layer 200. The light absorbing layer 300 can be formed through a sputtering scheme or an evaporation scheme.

[74] For instance, various schemes, such as a scheme of forming a $Cu(In,Ga)Se_2$ (CIGS) based-light absorbing layer by simultaneously or separately evaporating Cu, In, Ga, and Se and a scheme of performing a selenization process after a metallic precursor film has been formed, have been extensively used in order to form the light absorbing layer 300.

[75] In detail, the metal precursor layer is formed on the back electrode layer 200 by performing the sputtering process using a Cu target, an In target, and a Ga target.

[76] Then, the selenization process is performed to form the CIGS-based light absorbing layer 300.

[77] In addition, the sputtering process using the Cu target, the In target, and the Ga target and the selenization process can be simultaneously performed.

[78] Moreover, the sputtering process or the selenization process is performed using only the Cu target and the In target or only the Cu target and the Ga target to form CIS-based or CIG-based light absorbing layer 300.

[79] Next, referring to FIG. 6, CdS is deposited through the sputtering process or the chemical bath deposition (CBD), and the buffer layer 400 is formed.

[80] After that, zinc oxide is deposed on the buffer layer 400 through the sputtering process, and the high resistance buffer layer is further formed. The high resistance buffer layer may be formed by depositing diethylzinc (DEZ) and water (H2O).

[81] The high resistance buffer layer may be formed through chemical vapor deposition (CVD), metal organic chemical vapor deposition (MOCVD), or atomic layer deposition (ALD). Preferably, the high resistance buffer layer may be formed through the MOCVD.

[82] Thereafter, referring to FIG. 7, a second through holes TH2 are formed by partially

removing the light absorbing layer 300 and the buffer 400.

[83] The second through holes TH2 may be formed by a mechanical device, such as a tip, or a laser device.

[84] For example, the light absorbing layer 300 and the buffer layer 400 may be patterned by a tip having a width in the range of about 40 ㎛ to about 180 ㎛. Further, the second through holes TH2 may be formed by a laser having a wavelength in the range of about 200 ㎚ to 600 ㎚.

[85] In this case, a width of the second through holes TH2 may be in the range of about 100 ㎛ to about 200㎛. Moreover, the second through holes TH2 are formed to partially expose the top surface of the back electrode layer 200.

[86] After that, referring to FIG. 8, the metal layer 210 is formed on the back electrode layer 200 which is exposed through the second through holes TH2. The metal layer 210 may be formed through the electroplating scheme, a thermal spray plating scheme, or the electroless plating scheme to improve a surface roughness of the back electrode layer 200 exposed through the second through holes TH2. Accordingly, a metal layer having a concavo-convex pattern with a random height and shape is formed on the back electrode layer.

[87] The metal layer may directly make contact with a lateral side of the light absorbing layer 300 exposed through the second through holes TH2. Further, the metal layer 210 may include a metal compound having molybdenum (Mo), nickel (Ni), or silver (Ag). Preferably, the metal layer 210 includes molybdenum (Mo).

[88] The surface area of the back electrode layer 200 exposed through the second through holes TH2 may be increased by the metal layer 210. That is, since the metal layer 210 has the concavo-convex pattern and a surface roughness in the range of 0.1 ㎚ to 1 ㎚, contact resistance between the front electrode layer and the back electrode layer connected at the second through holes TH2 can be reduced.

[89] Next, referring to FIG. 9, the front electrode layer 500 is formed by depositing a transparent conductive material on the buffer layer 400.

[90] The front electrode layer 500 may be formed by depositing the transparent conductive material at an oxygen-free atmosphere. In detail, the first window layer 610 may be formed by depositing AZO at the atmosphere of the inert gas that does not contain oxygen.

[91] Further, the front electrode layer may have a thin thickness in the range of 300 ㎚ to 1.0 ㎛.

[92] The front electrode layer 500 makes contact with the back electrode layer 200 exposed through the second through holes TH2. Preferably, the front electrode layer 500 directly makes contact with the metal layer 210 which is formed on the back electrode layer 200.

[93] As described above, the surface area of the back electrode layer 200 and/or the metal layer 210 may be increased due to the concavo-convex pattern of the metal layer 210. Accordingly, a contact area making contact with the front electrode layer 500 is increased so that contact resistance between the back electrode layer 200 and the front electrode layer 500 may be reduced.

[94] Thus, the front electrode layer may have a smaller thickness. That is, it is not necessary to excessively increase the thickness of the front electrode layer to reduce the contact resistance. As a result, the transmission of the front electrode layer can be improved, and accordingly, the efficiency of the solar cell can be improved.

[95] Referring to FIG. 10, a third through hole TH3 is formed by partially removing the light absorbing layer 300, the buffer layer 400, and the front electrode layer 500. Accordingly the front electrodes and the first cell C1, the second cell C2, and the third cell C3 are defined by patterning the front electrode layer 500. A width of each of the first through holes TH3 may be in the range of about 80 ㎛ to 200 ㎛.

[96] Any reference in this specification to “one embodiment,” “an embodiment,” “example embodiment,” etc., means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of such phrases in various places in the specification are not necessarily all referring to the same embodiment. Further, when a particular feature, structure, or characteristic is described in connection with any embodiment, it is submitted that it is within the purview of one skilled in the art to affect such feature, structure, or characteristic in connection with other ones of the embodiments.

[97] Although embodiments have been described with reference to a number of illustrative embodiments thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this disclosure. More particularly, various variations and modifications are possible in the component parts and/or arrangements of the subject combination arrangement within the scope of the disclosure, the drawings and the appended claims. In addition to variations and modifications in the component parts and/or arrangements, alternative uses will also be apparent to those skilled in the art.

Claims

[Claim 1] A solar cell comprising:
a substrate;
a back electrode layer on the substrate;
a light absorbing layer on the back electrode layer;
a buffer layer on the light absorbing layer; and
a through hole formed through the light absorbing layer and the buffer layer,
wherein a metal layer is disposed on the back electrode layer exposed through the through hole.

[Claim 2] The solar cell of claim 1, wherein a concavo-convex pattern is formed on a surface of the metal layer.

[Claim 3] The solar cell of claim 2, wherein a surface roughness of the metal layer is in a range of about 0.1 ㎚ to about 1 ㎚.

[Claim 4] The solar cell of claim 3, wherein the metal layer comprises at least one of molybdenum (Mo), nickel (Ni), and silver (Ag).

[Claim 5] The solar cell of claim 4, wherein the metal layer directly makes contact with a side of the light absorbing layer exposed through the through hole.

[Claim 6] The solar cell of claim 5, wherein a front electrode layer is disposed on the buffer layer, and a thickness of the front electrode layer is in a range of about 300 ㎚ to about 1.0 ㎛.

[Claim 7] The solar cell of claim 6, wherein the front electrode layer directly makes contact with the metal layer.

[Claim 8] A method of fabricating a solar cell, the method comprising:
forming a back electrode layer on a substrate;
forming a light absorbing layer on the back electrode layer;
forming a buffer layer on the light absorbing layer;
forming through holes through the light absorbing layer and the buffer layer; and
forming a metal layer on the back electrode layer exposed through the through holes.

[Claim 9] The method of claim 8, wherein the forming of the metal layer is performed through an electroplating scheme, a thermal spray plating scheme, or an electroless plating scheme.

[Claim 10] The method of claim 9, wherein a concavo-convex pattern is formed on a surface of the metal layer.

[Claim 11] The method of claim 10, wherein a surface roughness of the metal layer is in a range of about 0.1 ㎚ to about 1 ㎚.

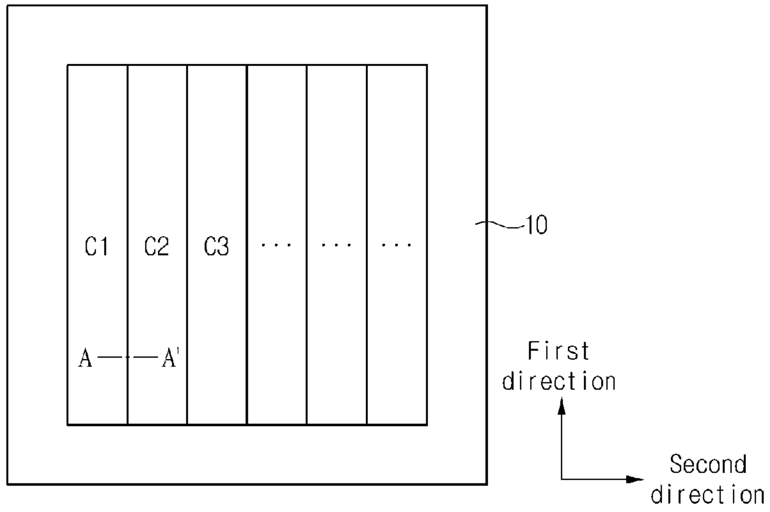
[Claim 12] The method of claim 11, further comprising forming a front electrode layer on the buffer layer after the forming of the through holes, wherein a thickness of the front electrode layer is in a range of about 300 ㎚ to about 1.0 ㎛.

[Claim 13] The method of claim 12, wherein the metal layer comprises at least one of molybdenum (Mo), nickel (Ni) and silver (Ag).

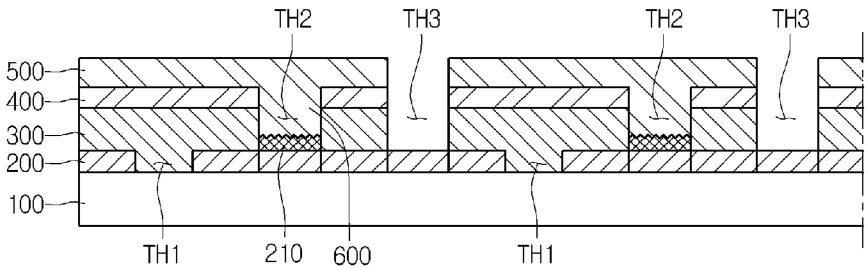
[Claim 14] The method of claim 13, further comprising forming through holes through the back electrode layer after the forming of the back electrode layer on the substrate.

[Claim 15] The method of claim 14, wherein the forming of the metal layer comprises allowing the metal layer to directly make contact with a side of the light absorbing layer exposed through the through hole.

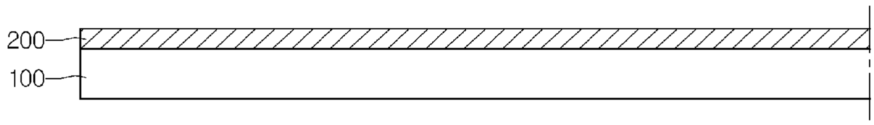
[Fig. 1]



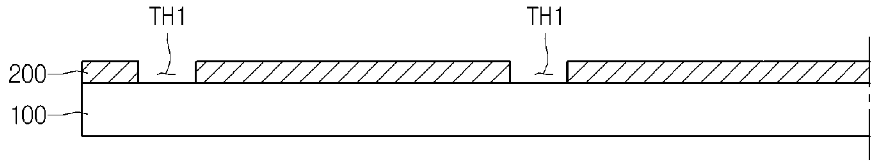
[Fig. 2]



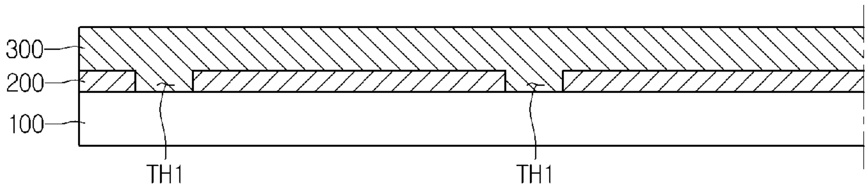
[Fig. 3]



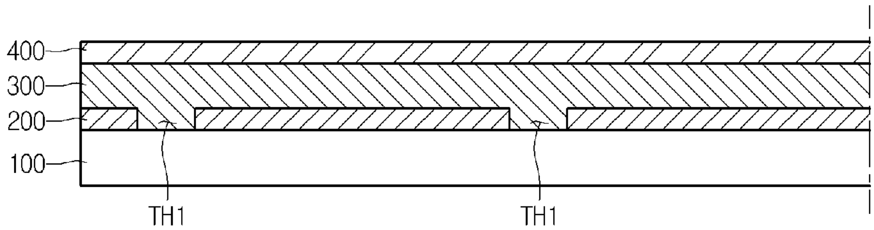
[Fig. 4]



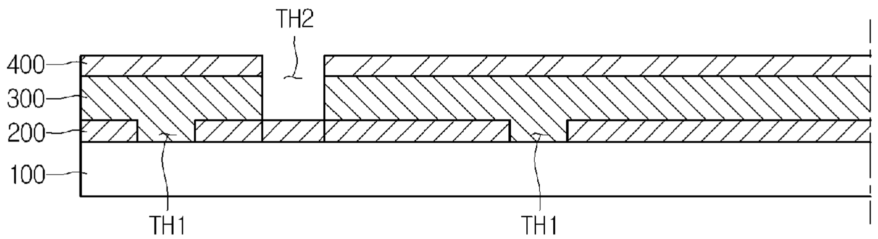
[Fig. 5]



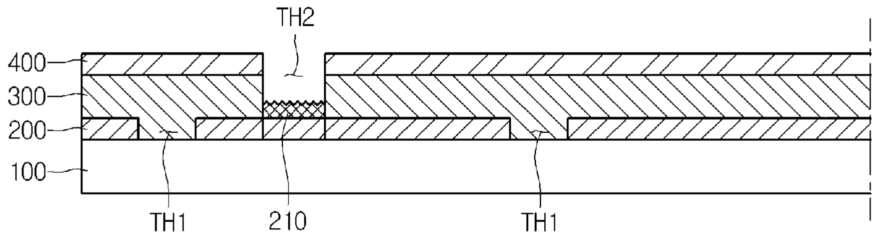
[Fig. 6]



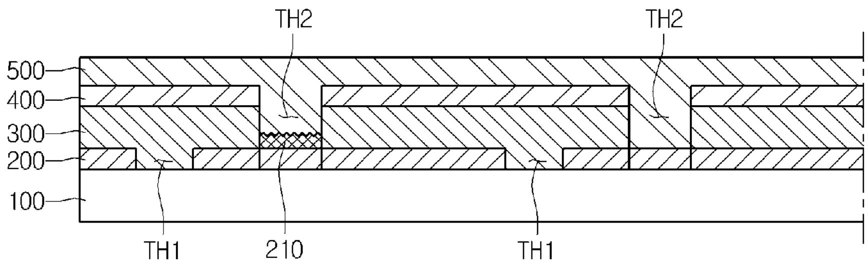
[Fig. 7]



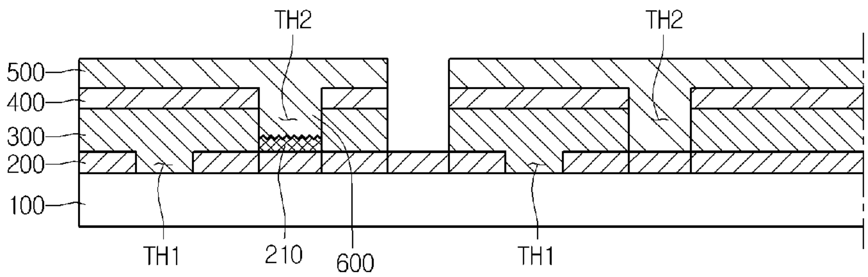
[Fig. 8]



[Fig. 9]



[Fig. 10]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2013/005667

A. CLASSIFICATION OF SUBJECT MATTER

H01L 31/042(2006.01)i, H01L 31/0224(2006.01)i, H01L 31/0236(2006.01)i, H01L 31/18(2006.01)i

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 31/042; H01L 31/0224; H01L 31/04; H01L 31/0236; H01L 31/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: solar cell, through hole, metal layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 02680709 B2 (SANYO ELECTRIC CO., LTD.) 19 November 1997 See column 5, line 5 - column 6, line 17; and figure 1.	1,2,8-10 3-7,11-15
Y	KR 10-2011-0100489 A (LG INNOTEK CO., LTD.) 14 September 2011 See paragraphs [0030]-[0036], [0067]; and figure 1.	1,2,8-10
A	KR 10-2011-0001813 A (LG INNOTEK CO., LTD.) 6 January 2011 See paragraphs [0025]-[0103]; and figures 1-8.	1-15
A	KR 10-2011-0047726 A (LG INNOTEK CO., LTD.) 9 May 2011 See paragraphs [0020]-[0108]; and figure 10.	1-15
A	KR 10-2009-0107803 A (JUSUNG ENGINEERING CO., LTD.) 14 October 2009 See paragraphs [0044]-[0054]; and figure 2.	1-15

☐ Further documents are listed in the continuation of Box C.   ☒ See patent family annex.

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"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
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"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
21 October 2013 (21.10.2013)	**22 October 2013 (22.10.2013)**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2013/005667

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KR 10-2011-0047726 A	09/05/2011	CN 102598301 A	18/07/2012
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